ERDA-1535

Final Environmental Statement

LIQUID METAL FAST BREEDER REACTOR PROGRAM

December 1975

United States
Energy Research & Development
Administration

Volume 3
Of 3 Volumes
Comment Letters and
ERDA Responses

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Administration

Volume 3
(of 3 Volumes)
PFES
Comment Letters No. 57–89
And
ERDA Responses

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Responsible Official:

James L. Liverman
Assistant Administrator For
Environment & Safety

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VOLUME 3

SECTION V

COMMENT LETTERS 57-89

AND

ERDA RESPONSES

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SECTION V

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*This is not a comment letter--it was requested that this material, which is included in the Public Hearing Record, May 27-28, 1975, also be attached to the Final Environmental Statement.

INTRODUCTION TO SECTION V

Section V contains copies of all comments received on the Proposed Final Environmental Statement (incorporated as Section II of this Final Environmental Statement) and ERDA's replies thereto. These comments, contained in eighty-eight letters, were received from Federal, State and local agencies, environmental and public interest groups, members of the academic and industrial communities, and individual citizens. An index to these letters indicating the number assigned to each letter and other pertinent information is provided in Table V-1. The letters and replies numbered 1 through 56 are in Volume 2 and the letters and replies numbered 57 through 89 are in Volume 3. (One letter was withdrawn by the originator.)

TABLE V-1

COMMENT LETTERS RECEIVED ON PROPOSED FINAL ENVIRONMENTAL STATEMENT

Comment Letter No.	Commenter	Organization	Date
1	H. L. Barrows	U.S. Dept. of Agriculture Agricultural Research Service	2/5/75
2	Gaylord and Ilene Younghein	No Affiliation Listed	1/27/75
3	Bessie Simon	No Affiliation Listed	3/4/75
4	Lindsey Grant	Department of State	2/24/75
5	Donald S. Wakefield	Upper Cumberland Development District	3/5/75
6	Glenn M. Brewer	Central Intelligence Agency	3/3/75
7	Letter withdrawn at the request of the writer.		
8	Eugene W. Standley	Federal Energy Administration, Region IX	3/6/75
9	Kathleen A. Girard	No Affiliation Listed	3/14/75
10	Steven C. Sholly	No Affiliation Listed	3/17/75
11	Roger Briggs	No Affiliation Listed	3/14/75
12	Robert W. Long	U.S. Dept. of Agriculture, Office of the Secretary	2/26/75
13	Sidney J. Goodman	No Affiliation Listed	3/17/75
14	Bert Warter	No Affiliation Listed	3/19/75
15	S. Baron	Burns and Roe, Inc.	3/20/75
16	Nat. H. Sauberman	No Affiliation Listed	3/20/75
17	G. M. Millar	Concerned Californians	3/20/75
18	Mrs. Albert Walker	No Affiliation Listed	3/19/75
19	Emma Hartzler	No Affiliation Listed	3/23/75
20	William R. Moore	No Affiliation Listed	3/20/75
21	Mrs. Clayton Sutter	No Affiliation Listed	3/23/75
22	Katherine V. Nelson	No Affiliation Listed	3/24/75
23	Elise Jerard	Independent Phi Beta Kappa Environmental Study Group	3/24/75
24	Esther Landau	No Affiliation Listed	3/24/75
25	Thomas G. Ayers	Breeder Reactor Corporation	3/24/75
26	Mrs. Ralph Negley	No Affiliation Listed	3/25/75
27	Prof. Shunsuke Kondo	University of Tokyo	3/24/75
28	Thomas D. Davies	U.S. Arms Control and Disarmament Agency	3/26/75
29	Betsy Pugh	No Affiliation Listed	3/24/75
30	Herbert Lippman	American Institute of Architects	3/25/75
31	Elizabeth Eielson	No Affiliation Listed	3/24/75
32	W. Standish Miller	No Affiliation Listed	3/27/75
33	Louis J. Lefkowitz	State of New York, Department of Law	3/25/75
34	James E. Heady	No Affiliation Listed	3/27/75
35	Marianne McClelland	No Affiliation Listed	3/31/75
36	Hamilton Treadway	No Affiliation Listed	4/3/75
37	V. A. Keeler	No Affiliation Listed	3/28/75
38	W. Donham Crawford	Edison Electric Institute	3/31/75
39	Mrs. Walter A. Marlow	No Affiliation Listed	4/1/75
40	R. Balent	Atomics International	4/1/75
41	Jeffrey P. Foote	Natural Resources Law Institute	4/4/75 and 5/12/75

TABLE V-1 (cont.)

Comment Letter No.	Commenter	Organization	Date
42	Neva Dawkins	No Affiliation Listed	4/2/75
43	Lynn Seeber	Tennessee Valley Authority	4/4/75
44	J. Leslie Tooher	No Affiliation Listed	4/3/75
45	Royal and Evelyn Bauer	No Affiliation Listed	4/5/75
46	Joan Matheson	No Affiliation Listed	4/3/75
47	Olive Fieud	No Affiliation Listed	4/3/75
48	John T. Edsall	Harvard University	4/3/75
49	L. Douglas DeNike	Zero Population Growth	Undated
50	Unsigned	North Anna Environmental Coalition	Undated
51	J. B. Moore	Southern California Edison Co.	4/8/75
52	John Z. C. Thomas	East Tennessee Energy Group	Undated
53	Richard James Chamberlin	Atlantic Richfield Company	4/7/75
54	Richard E. Graves	No Affiliation Listed	4/7/75
55	J. G. Speth	Natural Resources Defense Council, Inc.	4/9/75
56	Lee V. Gossick	U.S. Nuclear Regulatory Commission	4/9/75
57	Stephen H. Norris	State of Tennessee	4/8/75
58	Roy Dycus	Shirley's Enterprises	4/8/75
59	Catherine T. Quigg	Pollution and Environmental Problems, Inc.	4/5/75
60	Richard F. Hill	Federal Power Commission	4/3/75
61	George Marienthal	Assistant Secretary of Defense	4/8/75
62	George L. Edgar	Morgan, Lewis & Bockius	4/9/75
63	Martha Descotiaux	No Affiliation Listed	4/3/75
64	T. O. Jones	National Science Foundation	4/9/75
65	Marc Messing	Environmental Policy Center	4/10/75
66	Alan McGowan	Scientists' Institute for Public Information	4/8/75
67	Donald P. Geesaman	University of Minnesota	4/9/75
68	Pat Hoffman	No Affiliation Listed	4/8/75
69	Douglas W. Scott	No Affiliation Listed	4/7/75
70	Charles Custard	U.S. Dept. of Health, Education and Welfare	4/8/75
71	Norval E. Carey	General Atomic Company	4/8/75
72	H. M. Barnard	Teledyne Brown Engineering	4/9/75
73	Terry R. Lash	Natural Resources Defense Council, Inc.	4/9/75
74	Ruth Zaat	No Affiliation Listed	4/10/75
75	Gerald P. McCarthy	Commonwealth of Virginia	4/16/75
76	Bobby M. Wilson	No Affiliation Listed	4/14/75
77	Anne Esson	No Affiliation Listed	4/21/75
78	Benjamin O. Davis, Jr.	Office of the Secretary of Transportation	4/17/75
79	Sidney R. Galler	U.S. Dept. of Commerce	4/16/75
80	Willis H. Shapley	U.S. National Aeronautics and Space Administration	4/21/75
81	Mrs. Harold Sandyrath	No Affiliation Listed	4/19/75
82	J. W. Simpson	Westinghouse Electric Corp.	4/18/75
83	Peter Bergel	No Affiliation Listed	4/17/75
84	Sheldon Meyers	U.S. Environmental Protection Agency	4/23/75

TABLE V-1 (cont.)

Comment Letter No.	Commenter	Organization	Date
85	Lillian B. Kolin	Glendale Taxpayers Association	4/19/75
86	Charles H. Badger	State of Georgia	4/21/75
87	Stanley D. Doremus	U.S. Dept. of the Interior	4/24/75
88	Wanda Bollentin	No Affiliation Listed	4/26/75
89	Roger W. Sant	Federal Energy Administration	5/1/75
*	Diane Yale Sauter	Scientists' Institute for Public Information	5/30/75

*This is not a comment letter--it was requested that this material, which is included in the Public Hearing Record, May 27-28, 1975, also be attached to the Final Environmental Statement.

V.57-1

STATE OF TENNESSEE
OFFICE OF URBAN AND FEDERAL AFFAIRS
SUITE 108
PARKWAY TOWERS BUILDING
NASHVILLE 37219
615-741-2714

April 8, 1975

Mr. W. H. Pennington
Assessments & Coordination Officer
Division of Biomedical & Environmental Research
U.S. Energy Research & Development Administration
Washington, D. C. 20545

RE: Proposed Final EIS (WASH-1535)
Liquid Metal Fast Breeder Reactor Program

Dear Mr. Pennington:

As the designated State Clearinghouse for Federal development programs under OMB Circular A-95 guidelines, we have reviewed the proposed final environmental impact statement (EIS) on the above captioned subject program.

We are forwarding comments submitted by the Tennessee Wildlife Resources Agency and the Tennessee Department of Public Health, both of whom address specific topics within their affected areas of expertise. Their substantive remarks merit your thorough consideration in preparation of the final statement.

We appreciate the opportunity to review this proposal. We, or other reviewing authorities, may wish to comment further at a later time.

Both this office and affected regional Clearinghouses will be active in review of site selection, planning, and development of individual project facilities within the LMFBR program.

If our office, as the State Clearinghouse, can be of further assistance, please do not hesitate to contact us.

Sincerely,

Stephen H. Norris
Grant Review Coordinator

SHN: mn

Enclosures

APR 07 1975

TENNESSEE WILDLIFE RESOURCES AGENCY

ELLINGTON AGRICULTURAL CENTER
P. O. BOX 40747
NASHVILLE, TENNESSEE 37204

HARVEY BRAY, Executive Director
ROY H. ANDERSON, Ass't. Director
GARY T. MYERS, Ass't. Director

April 7, 1975

Mr. Stephen H. Norris
Grant Review Coordinator
Office of Urban and Federal Affairs
Suite 108
Parkway Towers Building
Nashville, Tennessee 37219

Re: AEC's Proposed Final EIS - Liquid Metal Fast Breeder Reactor Program

Dear Mr. Norris:

We have reviewed AEC's Proposed Final Environmental Statement concerning the Liquid Metal Fast Breeder Reactor Program (LMFBR).

Description of Program

This seven-volume EIS describes a national program for establishment of a viable commercial breeder reactor option for electricity generation by the early 1990's. It is not specific to the proposed demonstration Clinch River Breeder Reactor at Oak Ridge, Tennessee. The following are characteristics that relate directly or indirectly to fish and wildlife interests:

1. Pilot breeder reactors have been operated at: Los Alamos, N. M. from 1946 to 1953 and from 1961 to 1964, Idaho from 1951 to 1955, Lagoona Beach, Michigan from 1963 to 1966 and from 1970 to 1972. Other industrial nations have given highest priority to their own national breeder reactor programs (pp. 1.1-1, 1.1-2, 2.2-10).

2. The LMFBR can utilize more than 60% of the energy in uranium, including depleted uranium. This compares to 1 to 2% of the energy potentially available in uranium by conventional light water nuclear reactors (p. 1.1-1).

3. The LMFBR has a thermal efficiency of about 40% compared to 33% for the light water reactor (LWR). This results in a proportionally lower thermal pollution potential for the LMFBR (p. 4.2-55, 4.2-56). Projections indicate a 20% differential in waste heat discharge in the year 2020 without the LMFBR (p. 1.9-2).

4. The LMFBR converts excess neutrons to more uranium and plutonium than is utilized for both LWR's and LMFBR's. Without the LMFBR, the utility industry would have to give consideration to phasing out construction of new LWR's by the 1990's (p. 1.6-6). It is a goal of the LMFBR program to provide enough fissile material for all nuclear plants by the early 21st Century (p. 3.1-1).

5. Plutonium provides the following unusual risk features: large quantities will be produced, and toxicity to experimental animals is well illustrated (p. II. G-51). Radioactive half-lives last for over a hundred thousand years (p. 4.7-1).

6. All plutonium and all significant amounts of transuranic compounds that are to be dispersed into the environment will be released into the atmosphere via stacks. Fractions that may released to water are considered mostly inconsequential due to the low solubility of most transuranic compounds (p. 4.7-6). Any effects from LMFBR releases (or from fallout plutonium) is projected to be totally obscured by much larger sources in natural background radiation (p. 4.7-13).

7. The only radioactive waste expected to be carried off in cooling water is tritium (p. 4.2-55). About 90% of available tritium (152,000 curie per year) is expected to be released as a coolant impurity (p. 4.4-43). The use of water recycle and retention methods could reduce this emission rate by a factor of 1,000 (p. 4.4-45).

8. The uranium dioxide section of the fuel fabrication plant will have releases of radioactive materials in their liquid effluents. Annual releases of six isotopes of plutonium will vary from 0.28 (Pu-236) to 73,000 (Pu-241) micro-curies. Annual releases of five isotopes of uranium will be released at rates varying from 0.0076 (U-232) to 240,000 (U-238) micro-curies (p. 4.3-40).

9. Assuming a person eats about one pound of fish per month (from below a fuel fabrication plant), his total body dose of radioactive material would be 0.0017 millirem per year, of which about 86% would be uranium - 238 (p. 4.3-68). The maximum individual total body dose from all exposure routes would be 0.059 millirem per year, which is about the same dose resulting from television viewing, which is 0.1 millirem per year (p. 4.3-69).

Comments

We fail to find a description of tritium nor do we find a description of its environmental impact except that "the magnitude of the need to control tritium is open to argument" (p. 4.4-45). We understand from other references that

tritium: (1) is an isotope of hydrogen, having an atomic weight of 3 (H-3), (2) is found in infinitesimal quantities in nature, (3) is radioactive, and (4) has a half-life of 12.5 years. We recommend further research into the environmental impact of tritium and that releases be substantially reduced at least until questions of its detrimental impact can be resolved.

We conclude that, unless further detrimental effects of tritium are discovered, there would be little likelihood of harmful effect on fish and wildlife from the normal operation of a LMFBR. However, even though several containment systems are available in the event of an accident (Section 4.2.7) significant accidental releases of radioactive material could contaminate entire river systems for many years. We, therefore, urge that the utmost safety precautions be taken in: plant design, plant operation, transportation of radioactive materials, waste disposal, monitoring, and especially in avoidance of human error.

We appreciate this opportunity for comment on this important program.

Sincerely,

Harvey Bray

Harvey Bray, Executive Director
Tennessee Wildlife Resources Agency

RMH/ss

cc: Mr. Reid Tatum
Mr. Harold Hurst
Mr. Hudson Nichols

RAY BLANTON
GOVERNOR

Eugene W. Fowinkle, M.D., M.P.H.
Commissioner

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH
NASHVILLE 37219

April 8, 1975

Mr. Stephen H. Norris, Grant Review Coordinator
Office of Urban and Federal Affairs
Parkway Towers Building, Suite 108
Nashville, Tennessee 37219

Re: Proposed Final Environmental Statement (WASH-1535), Liquid Metal Fast Breather Reactor Program, ERDA

Dear Mr. Norris:

In response to your memorandum of February 19, 1975, staff of our Divisions have reviewed the above referenced project and attached are their comments.

We urge the Energy Resource and Development Administration to take note of the concerns expressed by the divisional comments. We would be very interested in receiving replies to these comments from the responsible agency.

Thank you for the opportunity to comment on this project.

Very truly yours,

C. Ron Culberson

C. Ron Culberson
Bureau of Environmental Health Services

CRC/TA/ccd 2-5

P.S. The information in the April 8, 1975, memorandum from C.F. Weaver, Division of Occupational and Radiological Health, was originally submitted by this office as comments on the Clinch River Breeder Reactor in August 1974. Since this office felt the comments were pertinent as they pertained to the Clinch River Breeder Reactor, they would also be of interest in a general way in regard to this program.

Division of Water Quality Control

ASSESSMENT OF THE FINAL ENVIRONMENTAL STATEMENT OF THE LIQUID METAL FAST BREEDER REACTOR PROGRAM

The Energy Research and Development Administration (ERDA) has invited the Tennessee Department of Public Health, Division of Water Quality Control to comment on the proposed Environmental Impact Statement of the Liquid Metal Fast Breeder Reactor Program (LMFBR). This statement is in compliance with this request.

The reactor is called liquid metal because of the molten sodium used to cool the reactor core, and fast breeder because of the use of high energy (fast) neutrons in the reaction process rather than low energy neutrons. The tremendous heat flux is to be removed by the molten sodium flowing through the core of the reactor. This sodium is violently reactive with air and water. It emerges from the core as an intensely radioactive material heated to approximately 1000°F. The molten sodium transfers the heat to the steam generator. Water is not used as a primary coolant in breeder reactors because it would reduce the temperature below levels necessary to maintain the breeder reaction. However, water is used in large volumes in the condenser cooling process, necessitating the location of breeder plants adjacent to an adequate water supply. The energy conversion process is extremely inefficient, and results in the loss of heat which is dissipated mainly to the aquatic environment.

One of the primary purposes for proposing LMFBRs is that by using U-238 and plutonium, larger amounts of plutonium are formed as products of the reaction than were originally included in the initial core composition, hence the name "breeder" reactor. Large supplies of U-238 are presently available for use in the program from U.S. weapon stockpiles in addition to other sources. The long range assumption is that by this method the plutonium bred in these reactors greatly extends the present uranium supply.

The reactor as discussed above is only part of the overall scheme of the LMFBR program. The fuel cycle involves many facets including fuel fabrication

(2)

plants, transportation systems, fuel reprocessing plants, and waste management facilities. All these systems of the fuel cycle present their own unique environmental impacts.

The fuel fabrication plants manufacture fuel pins and blanket pins and readies these assemblies for the reactor. The fuel reprocessing plant is concerned with the recovery of unspent core material and newly formed fuel. Waste management includes burial of low level wastes, and at the present Retrievable Surface Storage of high level wastes. Wastes will occur at all levels of the fuel cycle. Transportation systems are used in the movement of fuel and wastes between the different points in the fuel cycle.

Reactor Impact

Primary aquatic environmental impacts will occur as a result of the discharges of heated water and liquid wastes. Low level radioactive wastes escape under the normal operating conditions to the environment. Spills of high level radioactive material may occur as a result of equipment failure, natural disasters, and acts of war or sabotage.

As previously stated, LMFBRs require large volumes of water. This dictates that the reactor be located where there is an adequate supply. It is stated in Wash 1535 such intake systems result in large numbers of aquatic biota being entrapped and killed. The statement has little that can be taken issue with since it, in essense, says that the impact will vary from site to site. Many artificial lakes and reservoirs are already in a state of biological imbalance and further change could create irreversible ecological problems. It should be the goal of this program to employ best available methods of water management; e.g., dry cooling systems, to minimize water usage. The loss due to the intake system should be evaluated on a site by site basis by qualified aquatic and fisheries biologists. These determinations should be included in the assessment of the overall environmental impact.

(3)

Chemical Discharge

In section 8.2.1.2 it is stated that "The effects of these chemical discharges (chemicals added to the cooling water to control biological and chemical fouling) on plant and animal life are expected to be minimal." This statement does not give any actual evaluation of anticipated damage. Minimal damage is a very nebulous term and is far too vague.

Chlorine is an important biocide and anti-fouling agent that will be used in this program. Regardless of the form that the chlorine occurs in, i.e., free chlorine or chloramines, there is a similar toxicity. Largemouth bass (Micropterus salmoides) fingerlings have a TLm value of 0.03 mg/L.[1] Brungs determined that the TLm value for rainbow trout (Salmo gairdneri) fry was 0.006 mg/L. From his long term studies he recommends in stream concentrations of Cl_2 should not exceed 0.002 mg/L to protect most aquatic life.[2] The proposed programs environmental report states that 17 metric tons of chlorine will be released to the environment from each 1000MWe breeder plant annually. Should in stream levels exceed 0.002 mg/L significant damage to the aquatic biota will occur. Gross over-chlorination occurs from using the ortho-tolidine method of determinations, hence more sophistocated and accurate methods should be used. Pre-stream dechlorination practices that are currently available minimize the toxic effects of the chlorine.

Other anti-fouling agents which may be used are acroelin, sulfuric acid, chromates, quaternary ammonium compounds, zinc phosphates, and other less significant substances.[3] The impact of additional chemicals in blowdown sill need to be studied on a plant by plant basis. But this should not be overlooked in any assessment of the impact of the entire LMFBR Program.

From cooling tower blowdowns, significant concentrations of dissolved solids (sodium, calcium, chlorides, and other ions) are discharged to surface streams. In those water bodies used for domestic or industrial water supplies, unacceptable dissolved solids concentrations (above 500 mg/L) may be caused. This fact alone may be prohibitive to the location of breeder reactors in many locations.

(4)

Heated Discharge

The release of heat (thermal pollution) to the enviornment is a problem of tremendous proportions, with a potential for even much greater impact than currently exists. Under optimum conditions the projected heat releases would not be expected to be lethal to most of the indigenous aquatic population. However, it must be realized that sudden elevations or depressions in temperature will produce severe stress to the biota. By AEC's own admission in Volume II, Appendix II, H-2, changes in temperature at the outfall of once through cooling systems (the use of which has not been ruled out for the breeder program) of 15°F to 30°F will not be uncommon in any body of water. This type system can only lead to vast damage to the entire biocoenosis. Changes and effects of this magnitude grossly violate Tennessee Water Quality Standard and should never be permitted.

It cannot be assumed that there will be no adverse environmental impact, even from small increments of heat increase. It should be noted that these more subtle heat changes have the potential for equally adverse effects over a longer period of time. Such effects may include:

(a) Increased susceptibility to predation. Laboratory studies of rainbow trout indicate that thermally shocked juveniles were selectively preyed upon by larger fishes.[4]

(b) Early emergence of insects. Below the Hanford Washington Reactor it was noted that with one degree of temperature increase, Hydropsychid caddis flies emerged two weeks earlier than the upstream population.[5] Unfavorable terrestrial conditions during this early emergence could prove fatal to them during this critical stage of their life cycle.

(c) Unseasonable hatching of fish eggs. Fish gonadal development and spawning are highly temperaturo-dependent. Premature

(5)

spawning of any fish species as a result of heated water discharges may put the larval development out of pahse with the development of the normal food supply. By this mechanism, water-temperatures even slightly warmer than ambient in a spawning area may eventually lead to the elimination of a species.[6]

(d) Lowered resistance is conducive to fish diseases and parasite infestation. An outbreak of Columnaris on Center Hill Reservoir was attributed to temperature elevations.[7]

(e) Elimination of a cold period necessary for diapause in certain insects' life cycles. An extended cold period is necessary for some species of aquatic insects to complete their development.

(f) Contributes to eutrophication. The growing season for aquatic nuisance organisms will be extended, thus adding to the already serious problem of eutrophication.

(g) Species substitution. As conditions change, the fish population will change accordingly, almost exclusively with the substitution of less desirable non-game species. As the temperature is elevated and maintained, conditions will become more favorable for bluegreen algae to replace green algae and diatoms. Concentrations of bluegreens are undesirable because: (1) They produce blooms and may create taste and odor problems for downstream water supplies, thus adding to the cost of treatment. They may result in an unpalatable water even after the added treatment; (2) Increase the rate of eutrophication since some bluegreens are nitrogen-fixers; (3) Some are toxic to fish and other animals; (4) They are not desirable as a food for other aquatic organisms.

(h) Insect communities will become less diverse with greater numbers of less desirable species overpopulating.

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(i) Increase the concentration of low-level radionuclides in all components of the food chain that are present. Elevated temperatures increase the solubility of radionuclides.

(j) Increase the toxicity of materials that are already present in the watercourse by increasing the rate of the chemical reaction.

Sanitary Wastes

Sanitary wastes will be generated from each facility. Secondary treatment has been proposed as an adequate level of treatment for these wastes. Tertiary treatment would further reduce such parameters as B.O.D., solids, and bacterial counts. This level of treatment may be necessary to prevent eutrophication in some water courses where reactors will be placed. Low level radionuclides may be concentrated in the biota of biological treatment systems and also in the sludge. Should normal operation of the plant be disrupted, concentrated radioactive material may be discharged with the biological mass returned to the receiving body of water. Thickened sludge may be disposed of by burning or off site disposal. Burning would release these radionuclides to the atmosphere. Terrestrial disposal could also create contaminated areas and add to the overall environmental burden of radioactive material.

Radiological Wastes

In addition to the components of blowdown and sanitary wastes, the effluent from each facility will contain varying concentrations of low-level radionuclides. In Section 8.2.1.2 it is stated that "this slightly contaminated water (that is used to dilute and disperse tritium) will be the only radioactive liquid discharged from the LMFBR power plant." However, in table 9.1-6 it is noted that four isotopes of plutonium and other actinides will be released in the liquid effluent. Obvious additions to this list (but not included) are isotopes of strontium, iodine, and cesium, and possibly others, which would be introduced directly to the stream. There are known areas now below nuclear facilities where radioactivity in the diment

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The effect of the combined low level radioactive wastes was assessed in the WASH 1535 report by using the "Year 2000 Study." It was concluded that no significant public health hazard which would justify a delay or cancellation of the program exists. "The 2000 Study" considered 45 possible pathways to human radiation exposure from routine releases of nuclear facilities. It should be recognized that the study may not be a reliable indication of the conditions in the year 2000. In section 9.1.3.1 a statement of one of the reviewers of the draft says, "Studies of this type are unprovable at one end; difficult to disprove for those without access to large computers, misleading to the uninformed, and most likely incorrect at the other end."

Additional research into radiation effects on man may invalidate any conclusions drawn from this study. Areas of current concern may include:

(a) The effect of tritium as a result of its inclusion into the DNA molecule.

(b) Resolution of the controversy over the "hot particle" therory.

(c) Greater movement of plutonium than has been previously thought. For example, recent Battele Northwest Laboratory studies have indicated that plutonium decay products may be soluble and are subject to long range transport.

(d) Certain new information concerning transport systems and inclusion of radionuclides into the food chain will in all probability bring to light risks to man not covered by the "Year 2000 Study."

Practically all of the information on the cycling and concentration of radionuclides in the food web have resulted from AEC sponsored research. It has been the conclusion of researchers at ORNL that although the primary producers (algae, etc.) in the aquatic environment appear to be the greatest concentrators of radionuclides. They see a decline in rate of concentration of radionuclides at higher levels of the food chain. This decrease is not recognized generally in the scientific community. Radionuclides would not be expected to follow a specific

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pattern, and there is much to learn about their pathways into the food web. A lesson in this regard should be the movement of mercury in the food chain. Based on all available information until the 1960's, the scientific community KNEW that mercury could not be concentrated into the food chain. Later discovery of organic mercury compounds, which are readily transferable between trophic levels was made after discovery of high levels of mercury in organisms at the top of the food chain. Other examples are the concentrations of DDT and PCB's, both of which have been well documented.

Other methods of radioactive contamination of the receiving stream will include site drainage from rainfall, non-routine releases from radioactive clean-up procedures, and accidental spills. Ranifall will act as a cleansing agent on the air, buildings, parking lots, and yard areas in the immediate vicinity of the plant carrying away particles which have been airborne and are deposited as fall out material. Non routine releases from clean-up might include wash water or distillate from intermediate activity clean up areas. and could potentially add considerable concentrations of radionuclides to the effluent. Accidental spills do occur from almost every aspect of the handling of the radioactive material in the plant. All of these add to the burden of radionuclides in the aquatic environment.

"The Year 2000 Study" may be overly conservative in predicting dose level that the public may be exposed to. The release of radionuclides from the reactor alone has the potential of creating serious hazards to the health of large segments of the population. It is felt that benefits from electrical power generation should be more carefully weighed against these potential environmental impacts.

Water Usages

The effect of an LMFBR on water usage can also significantly reduce the benefits derived from the program and the benefits realized by other water users. Municipal and industrial users may experience an increase in the cost of water treatment in part as a result of chemical concentrations in blowdown water to make it suitable

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as both potable and process water. They may also experience periods of interrupted service due to shut downs caused by accidental spills or dumps of radioactive materials from facilities at upstream locations, as has been the case in England in recent years. Another potential water usage loss of great economic concern is that of agriculture at points downstream from these facilities. Livestock watering and irrigation may be lost due to the build up of low level radionuclides in cattle or soil as a result of routine releases or emergency interruptions following accidental spills from the LMFBR facility.

Recreational uses of downstream waters could also suffer comparable declines. The uptake and concentration of the low level radionuclides in aquatic life, especially fish, could render the fish unfit for human consumption, and as a result, essentially shut down that portion of the recreational uses of the waters. Contact recreation such as swimming, skiing, and scuba diving could become unsafe, especially if accidental spills should occur. Wildlife watering from downstream areas and animals which feed on aquatic organisms including fish and fresh water clams, will also be affected by buildups of radionuclides that may be passed to man from game animals taken as food by hunters.

Another area of great concern to the Division of Water Quality Control is ground water contamination in the vicinity of nuclear reactors. In many areas waters downstream from these reactors could act as sources for recharging nearby ground water supplies. This may happen via solution channels where the strata of rock are unstable or where limestone makes up the surrounding matrix. The amounts of radioactive material that have or will reach the biosphere from leaching and uptake by plant roots, earthworms, and burrowing insect larvae from radioactive spills are not well known. Some nuclear facilities are known to significantly contribute to the contamination of major rivers.[8] This is thought to result from discharges of low level radioactive wastes in the ground rather than from spills. Rainfall scrubs the atmosphere and ground and carries radionuclides into the ground water. Leakage of highly radioactive materials from waste storage facilities on

the reactor site could also pose a serious problem for ground water users in the area. Some modern nuclear storage areas have catch-discs to keep the radioactive liquid from penetrating the ground. The AEC says this will not be a problem when they consolidate the liquid wastes into a solid form, but after 30 years they still have not consolidated these wastes. At Hanford, Washington, leakage into the ground still occurs. Some of the radioactive wastes are currently being buried in the ground in trenches. In one of these trenches, the AEC is worried about a nuclear chain reaction from plutonium buried there. Ground water in some places is significantly radioactive.[9]

In many parts of the country wells are used as water supplies for numerous purposes, including potable water. For example, the city of Memphis, Tennessee, with a population of 623,500 obtains its entire domestic water supply from wells. Loss of groundwater sources would be extremely detrimental to a large segment of our population, both economically and from a health standpoint. All these aspects of water usage must be taken into account and carefully evaluated as an important part of the value of the overall LMFBR Program as opposed to the hazards and damages that the program can render. The evaluation becomes more critical when the long range results from demonstration LMFBR plants are projected to the year 2,000 with 800 nuclear plants in the U.S. as a goal. Some 19 nuclear plants are presently in the planning stage for Tennessee.

Monitoring

The WASH 1535 report deals with the monitoring program associated with the reactors in a very brief non-commital statement! Two phases of monitoring are proposed; i.e., pre-operational and operational. The reasons for each phase is explained. The basic reasons involve the gathering of baseline data in order to have a guide for assessing damages. This includes those that are unacceptable, and for use in proving that there will be no damages. Definition of unacceptable changes and clarification of who judges these changes to be acceptable or unacceptable is not

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mentioned. In addition to these two phases. we would recommend a third phase, post-operational. Monitoring should be carried on for a period of time after the breeder has been closed at the end of its 30-40 year life expectancy.

There are several deficiencies in the proposed LMFBR monitoring program. Areas considered to be inadequate include the following:

(a) Failure to explain reasons for choice of sampling stations.

(b) Duration of intensive monitoring program.

(c) Frequency of sampling.

(d) Parameters to be monitored.

(e) Sampling techniques to be followed and analytical methods that will be used for evaluations.

(f) Level of training for the persons carrying out the monitoring program.

(g) Who will sit in judgment of the findings from the monitoring program.

(h) How the overall effect from the LMFBR Program will be monitored and evaluated.

Too many aspects of the monitoring program were left unexplained. For example, there was no mention of what type of aquatic sampling stations would be selected. It is assumed that they intend to monitor, at least to some degree, the receiving waters, but little attention is given to the ground water (wells) monitoring. The report relies on models to anticipate concentrations of radionuclides in the environment. Models are dependent on current information. Current understanding of ground water supplies is limited. It would appear that the public's safety and interest would better be served by including additional monitoring stations other than those in the immediate vicinity of the reactor where problems are expected. It is all too obvious that no damage will be found if assumptions are made that no damage will occur, and monitoring of an area is omitted. Problems approached in this manner will not be noticed until they have already caused serious damage.

It was stated in the report that monitoring will be most intensive in the first two or three years of operation. One of the primary concerns of the Division of Water Quality Control is the long range effects of routinely released radionuclides.

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Intensive monitoring should continue throughout the life of the plant and after it becomes inoperative to protect the public. The significance of long range monitoring of LMFBRs cannot be over emphasized due to the life span and highly toxic nature of some of their wastes. To date there is no satisfactory method of treatment of these wastes or even for safely storing them. Pu-239 has a life of 250,000 years, or roughly 11 times the span of time from the Neanderthal man to the present. There will be sufficient quantities of plutonium in one reactor if (theoretically) properly aerosoled and distributed to cause lung cancer in every person on earth.[10]

It becomes obvious that in a program of this magnitude, both State and Federal agencies will be involved in the monitoring of these facilities. It would also seem logical that these agencies, particularly those involved with environmental controls, should judge the effects of individual reactors. The additional cost to the taxpayers as a result of their involvement in this program should be considered as an increase in the cost of the LMFBR, and hence, become an integral part of any calculation of cost/benefit ratios.

No attention was given in the statement to a comprehensive monitoring system to evaluate the effects to the environment nationwide from LMFBRP. This appears to be a serious omission in view of the projected 800 reactors (including LWRS) for the U.S. by the year 2000. It will be necessary to link all of the facilities of the LMFBRP into an additional monitoring program since the WASH 1535 report is a statement on the environmental impact of the program as a whole.

Fuel Fabrication

According to the estimate in WASH 1535, twenty-eight fuel fabrication plants will be needed to supply the LMFBR fuel cycle. There are two major processes involved in fuel fabrication, consisting of mixed oxide formation (UO_2 - PuO_2) and uranium oxide formation (UO_2). No mixed oxide plants of the size needed for the future (1500 MT/year) now exist. A 200 MG/year plant is planned for 1979. It was

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also stated there will be unavoidable adverse environmental effects from this phase of the fuel cycle. These adverse effects include the release of low level radioactive wastes, chemical releases, namely HF and NH_3, and the evaporation of 210,000 gallons of water per day.

The fabrication plant will require cooling towers. The effect of the blowdown from its system will be similar to that of the reactors cooling tower blowdown. The rate of water discharge in the effluent has been estimated at 1,530,000 gpd. The temperature of the discharge forecast as 90°F. Thermal effects will be similar to those described previously for the reactor.

The uranium dioxide phase of fabrication will have a non-radioactive effluent containing 5,410 mg/L ammonia, 351 mg/L calcium, 0.58 mg/L phosphates, and 0.14 mg/L fluoride. The pH will be approximately 9.0. In WASH 1535 Section 4.3.6.2.2 it is stated, "At most sites, discharges of ammonia would result in unacceptable environmental impacts, both as a result of direct toxicity, and as a result of potential eutrophication caused by increased aquatic nitrogen levels." Even if means of ammonia removal are developed for each facility it will be difficult to meet state and federal water quality standards. The TLm value of ammonia for (Lepomis macrochirus) is approximately 0.3 mg/L. It will be necessary to develop high efficient methods for ammonia removal that will reduce levels well below 0.3 mg/L. This is necessary not only to protect desirable biota, but to avoid eutrophication.

This report states that minimal environmental impact will result if its recommendations are followed concerning the liquid non-radiological effluents from the mixed-oxide portion of the plant. No statement was made as to the environmental impact of the non-radiological effluent from the uranium oxide facility except that if it is constructed as planned it would have an unacceptable impact at most sites. It must be assumed that an environmental impact statement cannot be made at this stage of its development.

Five isotopes of plutonium in addition to other actinides such as uranium, americum, neptunium, and protoactinium will be released in the liquid effluent. The

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potential impcat of these elements was once again dismissed as being of little concern. The radioactive dose was again calculated, and since it is usually less than background levels that humans are normally exposed to, they refer to the effect as minimal They fail to state that most of these actinides are man-made elements and do not occur in nature. Also, they fail to point out that a radionuclide deposited in a human tissue creates a greater actual dose to that tissue than estimated dose rates indicate. Another omitted statement that should have been included is that any radiation increase elevates the potential of having cancer. Therefore, it really does not matter if the dose of radionuclides received from a particular nuclear facility is smaller than that which one receives from normal background, it still contributes to the overall body burden.

Discussion of the environmental impact is limited to planned releases. Accidental spills can and do occur. The director of the local AEC Regulatory office of Zion, Illinois described the accidental release of 1,150 gallons of radioactive laundry waste to the Illinois River as "the latest of a number of abnormal occurrences associated with the failure to properly manage radioactive wastes."[11] Accidental releases of highly radioactive materials as plutonium through fires or spills increase the adverse environmental impact by several orders of magnitude. Without discussing the present means of predicting the frequency of such events it should be recognized that the past record of nuclear power and weapons technologies has not been good. While it would be expected that new safeguards will be developed, human error and mechanical failures compounded by a rapidly expanding nuclear technology indicate that the risk of accidents will not diminish. Part of the conclusions drawn from a 1972 AEC Policy meeting reagrding safety devices: it was concluded that analytical tools used to assess emergency cooling systems are defective; that it is impossible to rely on AEC's results for licensing. It was also concluded that margins of safety in loss of coolant accidents, once thought adequate are now shown to have dwindled in some cases to zero. Accordingly, protection to the public health and safety cannot in this situation be assured.[12]

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Transportation

Transportation is a very important part of the nuclear fuel cycle. Superficially it might appear to have less significance than some other phases of the cycle. However, as nuclear technology grows, so will the rate of transport of materials between facilities.[13] Methods and descriptions are given for different situations, including many different types of accidents. The only reference to effects on the aquatic environment was for the case of loss of UF_6 to water through a transportation accident. It would seem reasonable to expect a statement in this report about the effects of the loss of highly toxic elements such as plutonium, but no such statement was given.

Also omitted was a statement about the effects of possible losses of biocides and anti-scaling agents due to accidents during their transportation. Biocides such as acroelin, chlorine, and anti-scaling agents such as sulfuric acid or orthophosphate, do not create as prolonged a problem, but could cause significant damage if lost to the aquatic or terrestrial environment. These chemicals are an integral part of operation of the LMFBR and should be given consideration due to the potential hazards involved in their transportation.

Waste Disposal

At each stage of the fuel cycle radioactive wastes are generated. There are two general classes of wastes. High level wastes are from the core material; low level wastes include materials contaminated by radiation. These wastes require containment until sufficient time for their decay has elapsed. Several half-lives of a radioactive element must pass before it can be considered safe. Since the half-life of Pu-239 is about 24,400 years, the span of time that it must be confined from human exposure is approximately 500,000 years, which for practical purposes might be considered forever. At present there is no technology for permanent disposal of high level wastes.

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The system pointed out in WASH 1535 is the Retrievable Surface Storage Facility (RSSF). The Hanford Washington site is given as a prototype. This facility utilizes surface storage tanks. Wastes stored in such tanks must be stirred, vented, and cooled by direct air or cooling towers. This is done so that the heat generated by the material does not melt the storage tanks.

In the last 15 years there have been 16 leaks discovered at this site, involving some 307,000 gallons of high level radioactive wastes being released to the environment. The largest volume of these leaks in June, 1973 involved 115,000 gallons of waste material in which there were 40,000 Ci of Cesium^{137} and 14,000 Ci of strontium^{90}. Following a leak of lesser volume, 70,000 gallons, a core drilling was done at the site. They determined that the waste had moved around 45 feet downward. In assessing the impacts of such leaks, WASH 1535 assumes that these wastes are trapped in the soil. However, since tritium and iodine^{131} have been used in tracing ground water movement, it seems unreasonable to assume that such soluble radionuclides would remain bound in the soil. In light of recent studies, it was shown that plutonium has a greater potential for movement in the food chain than had been previously thought. It seems short sighted to dismiss the possibility of the movement of such radionuclides away from these sites into groundwater or surface streams.

They further concluded that it would take about 800 years for the more soluble forms to move in the groundwater at this site to surface levels and that radionuclides would have decayed to safe levels. This does not take into consideration the longer lived radionuclides.

Other impacts of the RSSF considered and dismissed as insignificant were the contamination of the surrounding area through the release of vented air and irradiation of dust particles near the tanks.

The accepted method of waste disposal for the other than high level waste is trench burial. These contaminants are assumed to be bound in the soil with no

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significant movement. However, in the West Valley nuclear fuel reprocessing plant in New York the trenches are not covered until they are full. The radioactive materials are often soaked by snow and rain. During 1970, 1,000,000 gallons of water was pumped from trench #9. NFS estimates that this water contained 40 m Ci of activity or only 1/1,000,000 of the total activity of the trench. Erdmann's Brook upstream from the processing plant and downstream from the burial site contains significant amounts of activity leached from the burial site.[14] The only unavoidable adverse environmental impacts listed are noise and dust from construction excavation and exclusion of access to the area. While the potential impacts of these sites remain to be seen, it might seem self-serving to some to consider the impact of noise and dismiss the possibility of movement of radionuclides from these sites.

Other potential methods of waste disposal considered for development in the future include in the near term disposal in deep caverns excavated in bedded salt formations. In the long term they look to the use of geological formations, transmutation, and extraterrestrial disposal. The environmental impact of such methods, even if found feasible, cannot be discussed at this time.

Conclusion

The greatest unavoidable impact of the LMFBR program has to be the planned release of radionuclides from all phases of the fuel cycle and the potential impact of billions of curies of waste material that require a stable government's concern, care, and money for thousands of years. It must also be realized by that government that with all the human maintenance possible, release of waste through natural disasters and human error could cause irreparable damage to human populations. The great concern over the impact of the release of radionuclides overshadows, but does not eliminate the adverse environmental both aquatic and terrestrial, impact generated by the release of large amounts of heat, biocides, and other chemicals associated with the fuel cycle.

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When considering all the aspects of the LMFBR and the number of each type facility needed to implement the program and to enable it to realize its full proposed potential, it must be remembered that we cannot separate one plant from the whole. We must assume that each plant will produce hazards and problems which will be in addition to and not instead of problems from other facilities or background radiation.

In order to form an accurate view of the future breeder fuel cycle, estimates are useful, but are no substitute for past experience. In waste management, WASH 1535 uses the Hanford Washington plant as an example, a plant notorious for its leaks and spills. In fuel reprocessing, the West Valley plant is given as the only plant of this type from which operating experience can be drawn, it has caused much concern in New York and has released thousands of curies to the creeks adjacent to it. In fuel fabrication one has only to look at the Rocky Flatts plant with its numerous plutonium fires, and in particular the May, 1969 fire and its resulting contamination of the Denver area. In the case of the reactor, the Fermi LMFBR, which during its short operational period, exhibited a partial meltdown of its core, an incident so unlikely as to be nearly impossible in AEC's estimates of safety, shows what may be expected.

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TENNESSEE DEPARTMENT OF PUBLIC HEALTH

OFFICE CORRESPONDENCE

DATE: April 8, 1975

TO: Mr. C. Ron Culberson

FROM: C. F. Weaver, Division of Occupational & Radiological Health

SUBJECT: Final Environmental Statement for the Liquid Metal Fast Breeder Reactor Program

In addition to the statements in my memorandum to you dated March 31; 1975, the following comments may be of interest.

1. The flow of many rivers is very irregular. This is particularly true of the Clinch River. The flow of the Clinch River has been recorded to range from 43,400 cfs to zero cfs and the flow rate of zero lasts for days at a time. It is also noted that thermal convection and discharge from the Fort Loundon Dam can cause surface water to flow up the Clinch River all the way to Melton Hill Dam.

   A discussion is needed of the effects of the above irregularities on the radioactivity near the CRBRP site with particular attention to the dilution factor of White Oak Creek and to the flow upstream of effluent from the ORGDP. The desirability of mandatory reactor shutdown during adverse flow conditions should be discussed.

2. When a breeder reactor site is selected on a drainage system already loaded with radioactive effluent attention should be given to the past accumulation of this material on the river bed. In particular further congnizance should be taken of the fact that a considerable inventory of radioactive material has been deposited in the Clinch River below its confluence with White Oak Creek. This inventory results from past and present releases from the Holifield National Laboratory by way of White Oak Creek. Particular attention should be given to the actual quantity of this inventory, to the question of whether or not non-radioactive chemicals added to the Clinch River could inadvertantly elute a significant part of this inventory, and to the impact of the above items on the monitoring of effluents from the CRBRP

3. Caution should be exercised in selecting a breeder reactor site in a region known to exhibit a high frequency of calms. The CRBRP site is notorious in this regard. The desirability of mandatory shutdown during extended periods of calms should be discussed.

4. Many core and blanket assemblies per year will be shipped to and from breeder reactor sites. There appears to be no list of source and destination of these shipments nor highways they will use even for the first demonstration system (CRBRP). The AEC states [1] "that further research and development effort is required" and that "the U.S. nuclear industry will have had a number of years of experience" when necessary. This subject should be further discussed with emphasis on the question of whether or not the Breeder program is being pushed faster than the state of the art indicates prudent. This discussion should also include the lack of provision for disposal of radioactive metallic sodium waste and of primary cold traps which will contain tritium and may contain corrosion and fission products.

5. Even though livestock drinking water from the Clinch River is not considered a major pathway of radioactivity to man, numbers supporting this contention should be included in the final report. Data on the concentration of radionuclides in the Clinch River, average intake of water per day per animal and the biological half lives for these radionuclides should be available. The numerical demonstration that the Clinch River does not provide a major pathway to humans would be most encouraging to the local public.

6. The possible environmental impact of catastrophic accident during the CRBRP operation should be considered. We emphatically disagree that the probability of this type of accident is extremely low for the following reasons:

   1. The sodium cooled Enrico Fermi Nuclear Plant had a partial core melt down in 1966.

   2. The Soviet Union operated a sodium cooled breeder very similar to the CRBRP and experienced rupture of a large fraction of its fuel pins.

[1] Final Environmental Statement for the Liquid Metal Fast Breeder Reactor Program: V-1, 1.3-2 and V-5, 3-5.

3. Within the last three years research programs designed to investigate the internal corrosion of the stainless steel jacket of the CRBRP fuel pins by fission products such as tellurium and cesium have come to our attention. For example such a program existed in 1973 at the General Electric Laboratory at Vallecitos Nuclear Center, Vallecitos Road, Pleasanton, California 94566 (415-862-2211) under the direction of Dr. E. A. Aitken. Also please refer to the article by C.E. Johnson, et al. in Reactor Technology, Vol. 15, No. 4, pp 303-338, Winter 1972-73.

   If such corrosive rupture is no longer of concern please provide us with copies of the research reports which show beyond a reasonable doubt that such an event is no longer credible.

   In discussing the possibility of a catastrophic accident with this highly experimental device the consequences to other local programs of great national importance should addressed. In particular the evacuation and shutdown of the ORGDP and Y-12 must be considered.

7. We must be assured that radiological releases from the proposed CRBRP will be low enough that those who are operating public water systems will not be required to remove radionuclides from the water in order to comply with Public Law 93-523, 93rd Congress, S. 433, December 16, 1974.

   Although this law was passed in December 1974, it has only recently (2-14-75) come to our attention that EPA is considering increasingly restrictive radiological standards for public water supplies.

   The consequent impact on the operation of the CRBRP should be reviewed as soon as these standards are promulgated.

8. The arrangement of the control and power supply systems for the primary and backup control and cooling units should be discussed for all proposed reactors including the CRBRP. Is it at all credible that the destruction of the control room area or power supply, by fire or otherwise, would simultaneously cause the loss of control and power to both primary and backup systems?

CFW:pgs 5-15

NNESSEE DEPARTMENT OF PUBLIC HEALTH

FICE CORRESPONDENCE

DATE: March 31, 1975

TO: Mr. C. Ron Culberson

FROM: C. F. Weaver - Division of Occupational & Radiological Health

SUBJECT: Final Environmental Statement for the Liquid Metal Fast Breeder Reactor Program

This is a general document and the comments below are also general. More specific comments will be made when the Final Environmental Statement for the CRBRP becomes available.

We believe that the NRC, ERDA, and those agencies which construct nuclear reactors should take strong affirmative action to assure that the interested States are involved in the planning and execution of the environmental monitoring for these installations. Such action seems to have occurred in other States along with federal financial aid, but has not occurred in Tennessee to a significant extent.

We also feel that when several reactors have been assigned to a given drainage system that an overall regional environmental impact statement should be prepared in addition to the individual statements for each site. Such a study is badly needed for the Tennessee river drainage system since at least fifteen (15) reactors, not counting those at the Oak Ridge Complex, are now planned. Since it is unlikely that a statement of this nature will be voluntarily produced, perhaps the members of the Tennessee delegation to Congress should be requested to consider a law making the study mandatory.

CFW:jef 1-6

ASSESSMENT OF THE FINAL ENVIRONMENTAL STATEMENT OF THE LIQUID METAL FAST BREATHER REACTOR PROGRAM

Division of Air Pollution Control

We have reviewed the above statement with regard to areas of our concern and it appears the impact on ambient air quality would be quite low. The power plants would transfer large amounts of waste heat to the atmosphere; however, it does not appear this would be significantly different from present day systems and several different types of cooling systems are available which would allow flexibility to meet conditions at specific sites.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Stephen H. Norris
Grant Review Coordinator
Office of Urban and Federal Affairs
State of Tennessee
Suite 108
Parkway Towers Building
Nashville, Tennessee 37219

Dear Mr. Norris:

Thank you for your letter of April 8, 1975 enclosing comments by several Departments of the State of Tennessee on the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. This document pertains to the LMFBR Program rather than the Clinch River Breeder Reactor (CRBR) facility. A separate environmental statement, taking into account the specific design and location of that plant, will be issued as part of the licensing actions by the Nuclear Regulatory Commission (NRC). The Project Management Corporation has prepared and submitted a specific environmental report on the CRBR to the NRC to facilitate the preparation of the environmental statement on that plant. The site specific comments of the State of Tennessee Department of Health would be more appropriately covered in this environmental statement (rather than in WASH-1535) and we understand that most of these comments have been previously addressed to the CRBR Project and responses have been provided to your office.

The ERDA responses to the comments of the State of Tennessee which are not uniquely related to the CRBR site on the Clinch

River are enclosed. Thank you again for your comments and for your interest in the LMFBR Program. Copies of the Final Environmental Statement are enclosed for your information.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program (6 copies)

ERDA Staff Responses to Specific Comments
by the State of Tennessee

Index:

Enclosure 1 - Tennessee Wildlife Resources Agency Comments of April 7, 1975.

Enclosure 2 - Department of Public Health Comments of April 8, 1975.

Enclosure 3 - Division of Occupational and Radiological Health Comments of April 8, 1975*.

Enclosure 4 - Division of Occupational and Radiological Health Comments of March 31, 1975.

Enclosure 5 - Division of Air Pollution Control Comments (undated).

*Provides comments related to the CRBR plant only.

Comment (pages 2 and 3 of enclosure 1):

"We fail to find a description of tritium nor do we find a description of its environmental impact except that the magnitude of the need to control tritium is open to argument (p. 4.4-45). We understand from other references that tritium: (1) is an isotope of hydrogen, having an atomic weight of 3 (H-3), (2) is found in infinitesimal quantities in nature, (3) is radioactive, and (4) has a half-life of 12.5 years. We recommend further research into the environmental impact of tritium and that releases be substantially reduced at least until questions of its detrimental impact can be resolved."

ERDA Response:

Doses due to the release of tritium were discussed in Appendix II.0 of the LMFBR Program PFES. Methods to control the release of tritium from LMFBR power plants were discussed on pages 4.2-32 to 4.2-43 of the PFES. Doses due to tritium releases were given in Tables 4.2-7, 4.4-9, 4.4-10, 4.4-12, 4.5-33, 4.5-34, 9.1-8 and 9.1-9 of the PFES. Dose conversion factors for tritium releases were listed in Appendix II.E of the PFES.

Comments (pages 2-6 of enclosure 2):

Concern was expressed regarding the effects of intake structures, chemical discharges (especially chlorination) and thermal discharges from operating LMFBR power plants.

ERDA Response:

The type of detailed treatment suggested in these comments would be more appropriate in Environmental Statements for individual LMFBR power plants.

Comment (page 6 of enclosure 2):

> "In Section 8.2.1.2 it is stated that 'this slightly contaminated water (that is used to dilute and disperse tritium) will be the only radioactive liquid discharged from the LMFBR power plant.' However, in table 9.1-6 it is noted that four isotopes of plutonium and other actinides will be released in the liquid effluent. Obvious additions to this list (but not included) are isotopes of strontium, iodine, and cesium, and possibly others, which would be introduced directly to the stream."

ERDA Response:

Table 9.1-6 refers to releases from the entire fuel cycles, not just nuclear power plants. No discharges of strontium, iodine or cesium in liquid effluents are planned for any future LMFBR fuel cycle facilities.

Comment (page 7 of enclosure 2):

> "The effect of the combined low level radioactive wastes was assessed in the WASH 1535 report by using the 'Year 2000 Study.' It was concluded that no significant public health hazard which would justify a delay or cancellation of the program exists. 'The 2000 Study' considered 45 possible pathways to human radiation exposure from routine releases of nuclear facilities. It should be recognized that the study may not be a reliable indication of the conditions in the year 2000. In section 9.1.3.1 a statement of one of the reviewers of the draft says, 'Studies of this type are unprovable at one end; difficult to disprove for those without access to large computers, misleading to the uninformed, and most likely incorrect at the other end.'"

ERDA Response:

As discussed in Section 9.1.3.1, the "Year 2000" model results and other information (see Table 9.1-9) indicate, to the best of our ability to determine them, the presently foreseeable consequences of the LMFBR Program.

Comment (page 7 of enclosure 2):

"Additional research into radiation effects on man may invalidate any conclusions drawn from this study. Areas of current concern may include:

(a) The effect of tritium as a result of its inclusion into the DNA molecule.
(b) Resolution of the controversy over the 'hot particle' theory.
(c) Greater movement of plutonium than has been previously thought. For example, recent Battelle Northwest Laboratory studies have indicated that plutonium decay products may be soluble and are subject to long range transport.
(d) Certain new information concerning transport systems and inclusion of radionuclides into the food chain will in all probability bring to light risks to man not covered by the Year 2000 Study."

ERDA Response:

(a) Tritium release from the LMFBR fuel cycle can be kept to very low values, such that its addition to the large, naturally occurring tritium inventory would be essentially negligible. On this basis, it is difficult to see why this should be an area of concern. In any event, a considerable amount of research on tritium has already been completed.*

(b) The validity of the "hot particle" hypothesis, in addition to being rejected by ERDA, has been rejected by the Los Alamos Scientific Laboratory, the Biophysical Society, the National Radiological Protection Board of the United Kingdom, the Medical Research Council of the United Kingdom, and the National Council on Radiation Protection and Measurements. In view of this overwhelming expression of scientific opinion the issue cannot be considered as being a "controversy" within the scientific community.

(c) Several thoughts are expressed here. The first sentence speaks of the movement of plutonium, while the second sentence addresses recent studies pertaining to the solubility and long range transport of plutonium decay products. The latter point is not clear, since

*For additional information, see, for example - "Environmental Effects of Producing Electric Power," Part 1, Hearings before the Joint Committee on Atomic Energy, Congress of the United States, U.S. Government Printing Office, Washington, D.C., 1969, pages 228 and 229.

plutonium decays either to uranium or americium. If the comment is directed toward americium, ERDA is not aware of new information from the Battelle-Northwest Laboratory pertaining to either the solubility or long range transport of uranium or of americium in addition to that which was discussed in the PFES. ERDA is not aware of additional information regarding the movement of plutonium either.

If, on the other hand, both of these sentences refer to plutonium, and if the term "movement" refers to plant uptake from soil, we assume that the comment is made in reference to a publication by Raymond E. Wildung and Thomas R. Garland (both at the Battelle-Northwest Laboratory) on "Influence of Soil Plutonium Concentration on Plutonium Uptake and Distribution in Shoots and Roots of Barley," Journal of Agricultural and Food Chemistry, Vol. 22, pp. 836-838, September-October, 1974. This reference was the source of an article published in the New York Times, "Plutonium Found in Plants' Roots," October 11, 1974.

During this study plutonium nitrate, a soluble form of plutonium, was added to soil under very specialized laboratory conditions to measure uptake in various portions of the barley plant. These findings cannot be related directly to field studies or to the response of field crops. In fact, a sentence in the New York Times article was omitted in editing; it reads, "The researchers noted that their findings, while indicative, could not be taken as precise evidence of the response of field crops since the experiments were done under special laboratory conditions." These studies, however, are continuing.

Several potential consequences of, and reasons for, the findings in the article are postulated; however, postulations may or may not eventually be verified. Furthermore, the concentration values presented in this article varied from 0.55×10^{-4} to 11×10^{-4} (dry plant/dry soil), at least two orders of magnitude below the value of 0.1 used in the PFES. The use of the very conservative value of 0.1 allows for future findings which might influence the soil/plant concentration factor (e.g., Might microbial action on PuO_2 solubilize the plutonium to a greater extent than is available in studies with $Pu(NO_3)_4$? This appears unlikely at the present time, but is provided for by the conservatism in the factor of 0.1.).

(d) For the long-lived transuranic elements, compensation for future unknowns was made in the PFES by assuming a much larger uptake by plants than is warranted by the available measurements.

Comments (pages 7 to 12 of enclosure 2):

> Concern was expressed regarding the environmental buildup of low-level discharges of radioactivity, the effects of LMFBR power plant discharges on other water users, ground water contamination in the vicinity of LMFBR power plants and LMFBR power plant monitoring.

ERDA Response:

Again, it is our opinion that the type of detailed treatment suggested by these comments would be more appropriate in Environmental Statements for individual LMFBR power plants.

Comments (pages 13 and 14 of enclosure 2):

> The potential impacts of liquid discharges from fuel fabrication plants were mentioned as problems.

ERDA Response:

This is a situation where such comments should be more appropriately treated in Environmental Statements for individual LMFBR fuel fabrication plants.

Comment (page 15 of enclosure 2):

> "Transportation is a very important part of the nuclear fuel cycle...as nuclear technology grows, so will the rate of transport of materials between facilities.[13]... The only reference to effects on the aquatic environment was for the case of loss of UF_6 to water through a transportation accident. It would seem reasonable to expect a statement in this report about the effects of the loss of highly toxic elements such as plutonium, but no such statement was given.
>
> "Also omitted was a statement about the effects of possible losses of biocides and anti-scaling agents due to accidents during their transportation. Biocides such as acroelin, chlorine, and anti-scaling agents such as sulfuric acid or orthophosphate...could cause significant damage if lost to the aquatic or terrestrial environment. These chemicals are an integral part of operation of the LMFBR..."

ERDA Response:

The transportation accident involving the release of UF_6 to the aquatic environment was thought to have the greatest impact of all transportation accidents in the LMFBR fuel cycle with releases to the aquatic environment. Furthermore, accidents involving the release of UF_6 would be unique to the nuclear industry, while accidents involving the release of such materials as chlorine, sulfuric acid and orthophosphate would not be.

Comment (page 15 of enclosure 2):

> "At each stage of the fuel cycle radioactive wastes are generated.... These wastes require containment until sufficient time for their decay has elapsed.... Since the half-life of Pu-239 is about 24,400 years, the span of time...is approximately 500,000 years, which for practical purposes might be considered forever. At present there is no technology for permanent disposal of high level wastes."

ERDA Response:

These are essentially correct statements, but it is overly pessimistic to say "... there is no technology ..." ERDA is studying permanent disposal concepts which would make consideration of continuous institutional stability of secondary importance.

As discussed in the PFES, the evaluation of promising geological formations and sites leading to a pilot geological repository, which in turn could lead to a permanent disposal system, is a major part of the ERDA radioactive waste program. At present, ERDA plans further study of several promising geologic formations other than bedded salt, including study of specific promising sites, to bring the state of knowledge of these other formations up to the same level as that of bedded salt. The goal of this further study is to permit a comparative evaluation of these formations and the selection of the optimum formation or formations for pilot plant operations.

Comment (page 16 of enclosure 2):

> "The system pointed out in WASH 1535 is the Retrievable Surface Storage Facility (RSSF). The Hanford Washington site is given as a prototype. This facility utilizes

surface storage tanks. Wastes stored in such tanks must be stirred, vented, and cooled by direct air or cooling towers. This is done so that the heat generated by the material does not melt the storage tanks.

"In the last 15 years there have been 16 leaks discovered at this site, involving some 307,000 gallons of high level radioactive wastes being released to the environment..."

ERDA Response:

Although the Hanford site was taken as a model RSSF site, the methods used at Hanford for high-level waste storage were not. It was clearly indicated in the LMFBR Program PFES that solidified, not liquid, high-level wastes would be stored at the RSSF.

Comment (pages 16 and 17 of enclosure 2):

"The accepted method of waste disposal for the other than high level waste is trench burial. These contaminants are assumed to be bound in the soil with no significant movement. However, in the West Valley nuclear fuel reprocessing plant in New York the trenches are not covered until they are full. The radioactive materials are often soaked by snow and rain. During 1970, 1,000,000 gallons of water was pumped from trench #9. NFS estimates that this water contained 40 m Ci of activity or only 1/1,000,000 of the total activity of the trench. Erdmann's Brook upstream from the processing plant and downstream from the burial site contains significant amounts of activity leached from the burial site.[14] The only unavoidable adverse environmental impacts listed are noise and dust from construction excavation and exclusion of access to the area. While the potential impacts of these sites remain to be seen, it might seem self-serving to some to consider the impact of noise and dismiss the possibility of movement of radionuclides from these sites."

ERDA Response:

We agree. The migration of radioactivity from commercial burial areas is discussed in the Supplemental Volume of the LMFBR Program Final Environmental Statement and in responses to detailed comments on this topic from EPA and Bobby Wilson. Steps are being taken to minimize the migration of radioactivity from the commercial burial areas in New York State and Kentucky.

Comment (page 18 of enclosure 2):

> "In order to form an accurate view of the future breeder fuel cycle, estimates are useful, but are no substitute for past experience. In waste management, WASH 1535 uses the Hanford Washington plant as an example, a plant notorious for its leaks and spills. In fuel reprocessing, the West Valley plant is given as the only plant of this type from which operating experience can be drawn, it has caused much concern in New York and has released thousands of curies to the creeks adjacent to it. In fuel fabrication one has only to look at the Rocky Flatts plant with its numerous plutonium fires, and in particular the May, 1969 fire and its resulting contamination of the Denver area. In the case of the reactor, the Fermi LMFBR, which during its short operational period, exhibited a partial meltdown of its core, an incident so unlikely as to be nearly impossible in AEC's estimates of safety, shows what may be expected."

ERDA Response:

When past experience is not applicable, estimates are the only available recourse. As discussed above the Hanford "plant" experience was not used as an example and the experience is not applicable to the LMFBR fuel cycle. The West Valley fuel reprocessing plant is not typical in that future fuel reprocessing plants will not have routine discharges of radioactivity in liquid effluents. The Rocky Flats plant experience is not applicable to the fabrication of plutonium oxide fuel and the May, 1969 fire did not lead to contamination of the Denver area, as reflected in the following statement by the Colorado Department of Health: "... the analysis of 325 soil samples taken within a six-mile radius of the Dow Chemical Company's Rocky Flats plant show no hazardous buildup of plutonium in soils." Finally, the Fermi accident is not particularly relevent to the LMFBR since it employed a metallic fuel, not an oxide, and had design features not being used in the LMFBR.

Comment (page 1 of enclosure 4):

> "We believe that the NRC, ERDA, and those agencies which construct nuclear reactors should take strong affirmative action to assure that the interested States are involved in the planning and execution of the environmental monitoring for these installations. Such action seems to have occurred in other States along with federal financial aid, but has not occurred in Tennessee to a significant extent."

ERDA Response:

We agree that the States should be involved in the planning and execution of environmental monitoring for nuclear power plants and believe that the NRC and others are trying to obtain such involvement.

Comment (page 1 of enclosure 4):

> "We also feel that when several reactors have been assigned to a given drainage system that an overall regional environmental impact statement should be prepared in addition to the individual statements for each site. Such a study is badly needed for the Tennessee river drainage system since at least fifteen (15) reactors, not counting those at the Oak Ridge Complex, are now planned. Since it is unlikely that a statement of this nature will be voluntarily produced, perhaps the members of the Tennessee delegation to Congress should be requested to consider a law making the study mandatory."

ERDA Response:

ERDA agrees that such studies are desirable. The "Year 2000" studies discussed in Volume I of the LMFBR Program Proposed Final Environmental Statement constitute one possible approach (see page 3.6-4). Note that a study for the Tennessee Valley region is in progress.

Comment (page 1 of enclosure 5):

> "We have reviewed the above statement with regard to areas of our concern and it appears the impact on ambient air quality would be quite low. The power plants would transfer large amounts of waste heat to the atmosphere; however, it does not appear this would be significantly different from present day systems and several different types of cooling systems are available which would allow flexibility to meet conditions at specific sites."

ERDA Response:

We agree.

SHIRLEY'S ENTERPRISES
ROUTE 2 BOX 121F
BLUE RIDGE, GEORGIA 30513

April 8, 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and
Environmental Research

Subject: Letter of comment to AEC (ERDA) on Liquid Metal Fast Breeder Reactor WASH 1535

Dear Mr. Pennington:

I certainly do have some comments on the 2300 pages of the proposed final environmental statement on the LMFBR. I will not try to point counter point, section by section, but will show the credulity of the nuclear establishment in their unreasonable considerations, first, you hide behind bureaucratic anonymity, taking an unfair advantage, you sign none of your statements, while we sign ours.

Second, in Volume 1, page 1.6-3 under your statement other considerations--you contend it is perfectly fair to keep the nations energy budget unbalanced in favor of nuclear systems. LMFBR, because it is the product of a high-cost technology and in the final and most costly stages of its development. The section continues with "for other technologies, such as solar energy, geothermal, and wind power, the research and development costs are estimated to be considerably less and the annual funding levels should be correspondingly lower." In other words, you give priority to a program not on its merits, or low fuel costs, but because it uses the most tax dollars to develop.

On page 4.2-256 you chart WASH 1400 statistics calculating the chances of an accident at one in a billion per reactor year. Using the fault-three and event-three method of calculation. I am sure if the same method had been used to calculate the chances the cities of Hiroshima and Nakisaka being destroyed with the first Atom bombs the statistics would have predicted a "low probability of occurrance, event considered incredible. Statistics are harmless, when they come true people die. One in a billion?

I remember vividly Mr. McNamara on TV with charts and graphs from the Defense Department, Air Force, and other expert predictors-assuring and convincing American viewers the United States could not

lose in Vietnam, because we had logistical superiority. From all appearances the fault three and event-three were used to arrive at these predictions.

Hundreds of billions of dollars later, with a cost of fifty-five thousand young American lives, the Defense Department, Air Force, Pentagon, Congress, Senate, everybody agrees, it was a big mistake and we should walk away and forget it.

If a plutonium economy based on LMFBR's absorbs hundreds of billions and costs thousands of lives we and our descendants, cannot walk away. One does not walk away from ten thousand generations of high-level radioactive waste surveillance--it's like molasses on a childs' fingers--we have to eat it.

Let the nuclear establishment spend the same amount of tax dollars on solar, wind, and methane that was spent on Shippingport, Yankee, Fermis, The Bonus, Hallam, Elk River, Piqua, Pathfinder, Carolina-Virginia, Peach Bottom, La Crosse, Big Rock Point, San Onofre, Haddam Neck, Ft. St. Urain, with as many test and design changes, and then see which is the best energy system to proceed with.

There is no challenge to building breeder reactors. The challenge lies not in building. To research and harness the wind, tide, geo-thermal, methane, solar and other untried energy sources. Developing these to a high degree before other nations. Let others develop the costly nuclear breeder technology. If we see we need it, we can import the technology.

After much thought on the subject, I have come to one conclusion, the AEC (ERDA) knows breeder reactors breed more than radioactivity. They breed the absolute guarantee the AEC (ERDA) will stay in business for 250 thousand years. This can be the only logical reason the AEC (ERDA) is cramming the Plutonium Economy down the American peoples throats via the Price-Anderson Act.

If the material and skills to manufacture 80,000 high-level radioactive cannisters, thousands of cladding hulls, shipping casts, drums, were diverted into Home Conversion Units to convert the leaves, grass clippings, human wastes into methane for on site use in homes, billions of BTU's of electrical energy would not have to be produced-plus releaving the burden on our sewerage plants and garbage systems. But you would never give priority to such ideas as this, why? Because no giant energy combine could collect from a meter attached to the house. No dangerous by-products are produced, just clean methane fuel and fertilizer residue, and not nuclear wastes.

The billions you will spend to develop the LMFBR would put thousands to work developing, building and installing wind powered alternators on top of each transmission tower in all our windswept western plains. The billions you will get from Congress and the Senate would put thousands more to work developing, building solar cell breeders with a doubling time of one year, not 60. The billions you will use

for the LMFBR would develop solar heating in factories, homes, schools, from Washington to San Francisco saving billions of BTU's of energy. Your rationale escapes me. Would you tell a ships captain to reverse his bilge pumps to save his sinking ship? That is what we are. We are fast approaching a trillion dollar Federal debt, that will sink any ship or country.

After reading WASH 1535, I see there is no way a plain citizen could possibly change your priorities, because of the particular mentality of the AEC (ERDA). You build an ever lasting fire near a forest, useing tax dollars as fuel. A citizen reminds you, the fire will set the forest ablaze. Do you put out the fire? No, you take more of our tax dollars and hire guards to watch the forest. More citizens alert you, the guards will go to sleep allowing the forest to burn. Do you put out the fire? No, you take more of our tax dollars and hire a batallion of doctors to give the guards sleeping pills, on and on. There is no way to rationalize with the AEC (ERDA). The first word is atomic, and Atomic Energy has precedence, the LMFBR and other nuclear programs were funneled into wind, solar, geothermal, tidal, and the other sources of alternate energy, millions of new jobs would be created for people of minimum skills and training, thousands of jobs for maintenance, and services, now--not 1985.

Ladies and Gentlemen, if this seven volume Environmental Impact Statement was on alternate energy programs many pages would be blank. There would be no impact on the environment. No risks from radiological gases, no risks from sabatage, no dangers from high level radioactive wastes, no transuranic alpha emitters, no depletion of our uranium ore reserves, no shipments of highly dangerous radioactive materials, no enrichment energy wasted. No thermal polution. By no stretch of the imagination can the nuclear power energy system claim this number of advantages.

In Volume two you describe the water basin concept RSSF criteria outlining the plans for storing 80,000 one foot by ten feet high level radioactive cannisters. That must be kept in working order regardless of war, aircraft crash on site, sabatage, human error, earthquake, meteor impact, any and all acts of man or God, or the basin water begins to boil in 16 hours, the basin water completely evaporates in 6 to 7 days and the basin, cannisters, liners, concrete, all melts in one or two weeks, 10,000 Kw of electric energy must be maintained into the site or the above will happen. You print that so blaze: 80,000 cannisters, each radiating 3.25 Kw of heat-each filled with plutonium toxic wastes, each must undergo hundreds of operations from reactors to the storage site without error or accident-

You maintain you can keep the high level radioactive wastes contained for 250,000,000 years, yet you could not keep high level radioactive wastes contained for thirty years at Richland, Washington. It's the same old stuff, under the same hitching rack.

In Volume 2 page 4.6-41 you solve the problem of an enemy hitting your high level radioactive waste storage faculty with massive missiles, with this. I quote "Low probability of occurrance, event considered incredible. Site location would not be in commercial aircraft flight path."

Any tweleve year old mentality would reason an enemy would strike this target first. Multiplying the missiles destructive power. Event considered incredible. The only thing incredible, is the credulity of the AEC(ERDA). Nobody could possibly believe anything else. Beware of false prophets which come to you in sheep's clothing, but inwardly they are ravening wolves. Ye shall know them by their fruits. Do men gather grapes of thorns, or figs of thistles? False prophets?

If the Congress and Senate lets you build a high level waste storage faculty at Richland, Washington and a breeder reactor at Oak Ridge, Tennessee, any enemy needs only two warheads to completely destroy our continent with plutonium. Our weather moves from west to east. Tons of exposed plutonium at these two sites will spread slowly over the entire U.S.A.

The United States is not without enemies. Many persons would like nothing better than to see a small band of determined espionaged trained sabateures, land on the unguarded, unpopulated coastline of Oregon or Washington, and make their way to any point 40 miles from the tank farm at Richland,Washington, with small surface to surface heat seeking missiles, they released deadly plutonium for the winds to carry eastward. Can you not see the havoc? God gave mankind a choice, you are not giving mankind any choice. To you, he can have it no other way. But the deadly nuclear radioactive concept.

The Nuclear Communities rhetoric continues assuring us they are not afraid of the reactors being hit from the air, but on November 11,1972, the AEC(ERDA) shut down their reactor at Oak Ridge,Tennessee, and ran like hell, when skyjackers said they would crash into the plant, if this had been a solar concentrator magnetohydrodynamic plant, your radiological worries would have been nil. They would not have considered it a target.

A.J. Lehman Director, Division of Pharmacology at the Bureau of Biological and Physical Sciences at the FDA, compiled information establishing humans are six times as sensitive to toxicity as dogs. Yet, the AEC(ERDA) are useing hundreds of dogs in their toxicity tests. An exercise in futility.

Dogs have the ability to manufacture ascorbic acid in any amount needed to combat toxicity, humans due to their biological make up, do not have this marked advantage.

If the nuclear establishment plans to make sure each individual in our population injests a minium of five grams of ascorbic acid daily, then their dog controls might be comparable. Millions of our citizens are constitutionally inadequate, making these individuals much more sensitive to radioactive toxicity than your many workers reported in the impact statement as remaining healthy after being exposed.

With blessings and funds from the Congress and Senate, the Atomic Energy Commission created the Savannah River Atomic Energy Reservation, a place destined to house the basic components of the Nuclear Parks, planned by the nuclear scientists to furnish atomic energy for the future.

Us red-necked, ignorant Georgians who populate the surrounding country side became the guinea pigs. We recieved the radioactive affluents generated and released into the wind and water by the nuclear fuel reprocessing and reactors, we recieved and injested through the crops raised on our own land radioactive nuclides from both the weapons tests fallout and the fallout from SRP. That's not all. We recieved radioactive dosage from the shipments by rail and highway of highly dangerous radioactive materials with names unheard by most Georgia citizens.. Trains and trucks with nuclear wastes, noble gases, spent atomic fuels, criss-crossed our great state unbeknowing to the large percentage of the 3,444,578 Georgians in the early 1950's. Radioactive material to the plant, radioactive wastes to burial grounds.

In 1954, the SRP became operational and keeping records of the estimated releases of nuclides to the atmosphere. That's right, estimated. They assume about fifty percent of the plutonium 239 released by SRP was transported to the surrounding country side. They don't know how much and how far. Due to the particle size difference, they estimate eighty-five percent of plutonium 238 released fell on the peoples land, outside SRP, at Aiken,S.C. Contractor, E.I.DuPont de Nemours and Co.

Concerned with the consequencies of this new input of foreign elements into the soil and air of Georgia, I decided to see if the population in the Savannah River Counties on the East border of Georgia, Burke,Chatham,Effingham,Screven,Richmond,Lincoln,Warren,Jenkins, and Hancock, would have a higher death rate from cancer, strokes, heart diseases, fetal deaths than the average, Georgian.

This does not mean Georgia's population would have no increase due to radiation pollution, no, they will, but due to the distance some are from main rail lines, truck lines and the SRP they should have less.

Statistics of population,deaths from cancer,celebrovascular, heart disease,fetal deaths, are from Georgia's records of the U.S.Dept. of Health, Education and Welfare Vital Statistics Records. Both open to the public. And one important point must be made, regarding Georgia's statistics.

Dr. Alen Dever,Director of Health Services Research,Dept. of Human Resources, stated in 1974, in a newspaper article that due to a lag in the reporting of deaths: "I know that roughly 5,000 of those in 1974 have to be allocated back to 1973 and 1972, and so on." In other words the total of 50,124 deaths reported in Georgia, in 1974 should be about 56,000 deaths.

American Cancer Society estimated Georgia would have in 1974, 6,300 cancer deaths; with a rate of 130. per 100,000. ; But in 1973, we passed that with 6,532 and a rate of 139.9

Twenty years after SRP began operations, Georgia total death from all causes was estimated to be 58,00,in 1974, 10,000 above what our annual death total should be, by comparison to other states, with straight line, none fluxuating death totals. Georgians recieved plutonium 239 in 1954 released from SRP-- try as I might, I could not get dates radioactivity was released. How much, wind direction, at time of release- Is this conspiracy to obstruct justice? The people of Georgia recieved 239 Pu, causing radiological introduced diseases and death, can their love ones who survive, bring the AEC(ERDA) and E.I.DuPont to court?

These counties around and below SRP invariably have a higher cancer death rate, higher celebrovascular rate, heart disease, fetal-- than Georgia as a whole, even with these county totals included in the state average. This was not monitored and made public as the AEC(ERDA) maintains they will do with the LMFBR. Will they? Even when asked specifically for data the AEC(ERDA), at Savannah River Plant, Aiken,S.C., gave nothing signed, authenticated, guaranteed to be correct and proper, nothing but estimations, assumptions, accompanied with a notice of irresponsibility.

NOTICE

This report was prepared as an account of work sponsored by the Unites States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Will this notice relieve the AEC(ERDA) of being a Legal Abetter in the 90.8 fetal deaths per 100,000 in Savannah River Counties above the Georgia yearly average 1973 ?

STATISTICS AVAILABLE

SEPTEMBER, 1975

Year,&Co.	Pop.	DEATHS: Fetal	Heart	Cancer	Strokes
1974-Burke	19000				
Chatham	178000				
Effingham	15200				
Screven	13900				
Richmond	137200				
Lincoln	6500				
Warren	6500				
Jenkins	8200				
Hancock	9900				
Total					
Rate Savannah River Co.					
Georgia's Rate					
1973-Burke	18600	24	58	30	53
Chatham	174400	523	686	296	203
Effingham	14900	20	35	13	19
Screven	13600	22	63	29	24
Richmond	139900	424	457	204	215
Lincoln	6300	4	28	8	13
Warren	6600	9	25	12	9
Jenkins	8200	14	31	14	18
Hancock	9100	6	48	16	9
Total	390600	1046	1432	682	563
Rate Savannah River Co.		267.8	366.6	159.2	144.1
Georgia's Rate		177.0	321.8	139.9	126.4
		90.8	44.8	19.3	17.7

Year,& Co.	Pop.	DEATHS: Fetal	Heart	Cancer	Strokes
1972-Burke	18100	9	80	34	51
Chatham	177700	281	632	319	259
Effingham	14500	22	31	15	11
Screven	12300	7	58	22	27
Richmond	141200	233	485	219	175
Lincoln	6000	5	25	13	12
Warren	6900	4	16	8	8
Jenkins	8200	4	31	11	20
Hancock	8900	5	42	15	4
Total	393800	570	1400	656	567
Rate Savannah River Co.		144.7	355.5	166.5	144.0
Georgia's Rate		106.7	307.8	134.1	125.2
		38.0	47.7	32.4	18.8
1971-Burke	17900	14	72	25	61
Chatham	179400	293	637	315	249
Effingham	14300	17	41	17	71
Screven	12200	7	65	16	26
Richmond	140200	223	449	201	159
Lincoln	5800	5	13	5	5
Warren	6900	7	24	4	8
Jenkins	8400	6	38	9	21
Hancock	8900	6	36	10	3
Total	394000	578	1375	602	603
Rate Savannah River Co.		147.0	349.0	152.8	153.0
Georgia's Rate		87.4	293.3	131.9	118.6
		59.6	55.7	20.9	34.4
1970-Burke	18255	9	56	32	52
Chatham	187767	288	645	307	232
Effingham	13632	13	42	21	12
Screven	12591	8	74	13	16
Richmond	162437	213	474	181	153
Lincoln	5895	3	11	4	11
Warren	6669	4	28	6	15
Jenkins	8332	8	31	10	23
Hancock	9019	3	48	12	2
Total	424597	549	1409	586	516
Rate Savannah River Co.		129.3	331.8	138.0	121.5
Georgia's Rate		73.5	299.9	129.9	119.0
		55.8	31.9	8.1	2.8

In the early 1950's, the Savannah River Counties show no statistical difference from Georgia's averages, and before 1950 Georgia was in the statistical range of Alaska, Utah, below 1 person per 100,000 dying from cancer. But after SRP began operations the statistical difference accelerated, and when the 1974 statistics become available the full impact of radiation introduced disease deaths will be seen.

Year,& Co.	Pop.	DEATHS: Fetal	Heart	Cancer	-8- Strokes
1969-Burke	20500	9	78	21	72
Chatham	183100	258	670	302	281
Effingham	13600	14	48	13	19
Screven	13400	16	71	25	33
Richmond	150900	200	429	195	165
Lincoln	6300	2	18	15	13
Warren	7000	3	28	6	10
Jenkins	8800	7	31	9	19
Hancock	9900	6	51	15	8
Total	413500	505	1424	601	620
Rate Savannah River Co.		122.1	344.4	145.3	150
Georgia's Rate		60.8	288.9	123.3	123
		61.3	55.5	22.0	27
1968-Burke	20700	11	68	21	61
Chatham	180000	204	656	293	308
Effingham	13000	15	40	14	15
Screven	13700	176	70	14	25
Richmond	149900	176	435	193	191
Lincoln	6000	1	22	8	10
Warren	7100	15	28	13	10
Jenkins	9000	11	26	11	22
Hancock	9800	9	57	8	7
Total	409200	438	1402	575	649
Rate Savannah River Co.		107.3	342.6	140.5	158.6
Georgia's Rate		56.7	300.0	121.1	127.6
		50.6	42.6	19.4	31.0
1967-Burke	21700	19	59	19	
Chatham	176700	214	643	294	
Effingham	13200	11	30	10	
Screven	15300	4	54	18	
Richmond	147200	152	484	198	
Lincoln	6000	2	27	7	
Warren	7700	5	25	11	
Jenkins	9700	4	39	18	
Hancock	10500	5	34	11	
Total	408000	416	1395	586	
Rate Savannah River Co.		102.0	341.9	143.6	
Georgia's Rate		49.5	287.1	122.4	
		52.5	54.8	21.2	
1966-Burke	21400	19	62	24	
Chatham	183700	181	620	263	
Effingham	13700	13	37	11	
Screven	15200	17	54	20	
Richmond	143800	170	440	209	
Lincoln	5900	2	17	10	
Warren	7600	3	24	8	
Jenkins	9500	6	34	9	
Hancock	10300	9	43	8	
Total	411100	420	1331	562	
Rate Savannah River Co.		102.2	323.8	136.7	
Georgia's Rate		54.5	287.7	118.0	
		47.7	36.1	18.7	

You assure the American public plutonium will have very little effect on mankind, citing studies, bolstering this concept and theory-- that's all it is--theory. Mankind is not biologically adaptable to radioactivity and until he has lived with this new element in his environment for at least a thousand years-- you cannot postulate the end result.

Allied-Gulf Nuclear Fuel Services Plant at Barnwell,South Carolina, promised the citizens of S.C. and Georgia they could control their radioactive materials, but DuPont at Aiken, South Carolina released 50 grams of Tritium in May of 1974, plus Plutonium and Iodine in 1973 and 1974 to be fallout on Georgia's farms that raise our food and give us larger cancer, heart disease, stroke and fetal death rates in 1980's 1990's.

Twenty years after citizens of Savannah,Georgia began drinking the affluent from the Savannah River Installation they had the distinction of the highest incidence of stroke in the United States. That is assertained by Regional Records. If DuPont can't control accidental releases of wastes how can Allied-Gulf ? Ladies and Gentlemen, you know it is impossible.

A SMALL EXPERIMENT

In the county of Dawson, which has the town of Dawsonville,Georgia, the AEC(ERDA) carried out an experiment of radiating plant life to determine it's effects long term and short term, the poor ignorant people were assured this was all very safe. They were in no immediate danger. They wasn't. This happened in the 1950's.

Now lets look at the statistics of Dawson County, twenty years later. 1970, Dawson had a rate per 100,000 of 250.0 1971 a whopping 333.3 rate by cancer. The state average was 131.9 Isn't this odd ?

PLANT SAFETY

In the last days of March,1975, an anti-establishment group sabotaged the cooling system of a substation in San Jose,California.- This is one step away from sabotage of a LWR cooling system, the next the LMFBR.

Liquid sodium to cool the LMFBR burns on contact with air or water. Simplifing the procedures for sabotage. If you are smart enough to build it, they are smart enough to destroy it. In the closing days of March,1975, a small candle flame closed the Browns Ferry Nuclear Plants in Alabama. Accomplishing more than we thousands, who opposed their construction and liscensing. Again luck prevailed where fools had trod.

LEGAL ASPECTS

Incased in the globe of history are moments in time when man decided individual rights recieved a higher priority than profit rights, the Magna Carta and Etc.

Again man has come to the moment of decision! Does a few Men of the Nuclear Scientific Community, sitting in tax supported office buildings, have the right to decide for me and my fellowman, what technologies will furnish my energy requirements? Will their decisions be legal, without the vote of the people? If they decide to use the LMFBR, and people die, can they be held accountable? Can men in responsible positions in government agencies be brought before the Bar of Justice for arming a Utilities Company with a weapon with a twenty year death delay? Do they have the right to arm the Utilities Companies with such for the sake of profit? If I shoot someone with a gun and the bullet kills within one twentieth of a second, I am indicted for murder-- Am I any less guilty if the bullet takes twenty years? Can a legal notice of irresponsibility as printed on the inside front page of the Rassmussen Report Reactor Safety Study absolve the perpetrating parties? The same on the DPSPU 74-30-1 Annual Report Environmental monitoring Savannah River Plant E.I.DuPont de Nemours & Company, Aiken, S.C.

Can the Supreme Court of the United States force in the future, the Utilities, AEC(ERDA)from imposing on 10,000 future, yet unborn American citizens, the responsibility and expense of maintaining high level waste storage faculities for 250,000 years? If in 1985, a case comes before the Supreme Court and all hundreds of nuclear plants has to be closed, can you not see the ramifications? These legal profound questions have not been investigated by the Nuclear Community. I assure you they will come before the courts.

You the AEC(ERDA) have Senator Nunn, Talmadge, and the majority of Georgia's Congressmen on your political side of the scale. They are known to be pro nuclear. You have Senator Baker from Tennessee, the flag bearer of the nuclear banner. But do you have the Supreme Court? I have seen men convicted by a jury of murder on less circumstantial evidence than is now self evident as the cause of premature death to thousands of my fellow Georgians. These are real people, with lovers, and sisters and brothers, not numbers on a piece of paper.

I protest this infringement upon the rights of my fellow Georgians by you the AEC(ERDA) abetting the posioning of our native soil, water and our bodies, by the activities of SRP and construction of the LMFBR sixty miles upwind from my habitat.

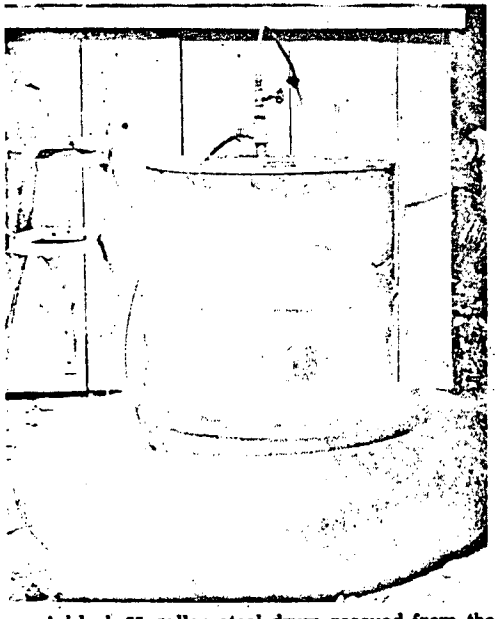
I expect these words to change not the decision you make to build the LMFBR. I hope scholars and historians in the next century will peruse and judge for themselves your conduct and rationale.

Sincerely,

Roy Dycus

Roy Dycus
Blue Ridge, Georgia 30

April 8, 1975



A black 55 gallon steel drum rescued from the waters of Blue Ridge Lake, becomes the first methane gas generator in Fannin County. When filled with old hay, shredded dry leaves, grass clippings, one gallon chicken litter, gallon cow dung, one gallon methane material, ten gallons of warm water, and sealed tight.

The gas is produced when organic matter is digested without the presence of air (anaerobic) the smart boys call it. As pressure builds a tractor tube, (used, compliments Bill Mason) collects the gas. The storage tank (tube) holds gas for one hour on one burner.

It would be better to put ¾ inch pipe from drum to stove, but the copper tubeing was for propane, so I just left it.

A Post Feature

Blue Ridge Summit Post

In Pursuit Of Energy

By Roy Dycus

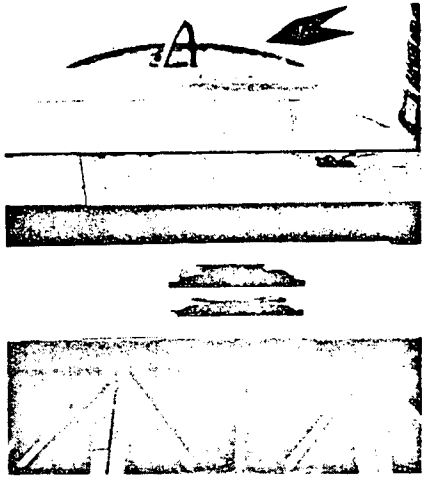
Having read, been bombarded, with propaganda on the so called (Energy Crisis) I decided to do some research on types of energy, solar energy, atomic energy, all the rest. Last came a little used method called Methane Gas Generation.

Did you know if all the methane from cattle lots, sewerage disposal treatment plants garbage disposal sites, grass clippings, leaves from people's yards, if all these were digested, and the methane compressed and liquified, it would heat half the homes in the U.S. A., and the residue effluent is a safe, uneable fertilizer? Very low BOD, flies will not lay eggs in it, has no odor and all pathogens and cuniforms are eliminated.

If I with no resources, no money, and just about half smart, can make a digester methane generator, from scrap materials, that produces a clean fuel from wastes and garbage, can you guess what a team of smart boys, like the unemployed NASA Engineers could do? They could if the Federal Government directed, create a small appliance 3 feet square to intercept garbage, sink waste, sewerage under the homes, and with a hopper grinder, to dispose of leaves and grass clippings. All could be converted to methane; compressed and liquified for use as cooking and heating fuel, and the inert digested material packaged, ready for the garbage collector to haul away to farms or fertilizer or the home owner to use on their yard.

If these were produced on a mass scale the cost would be very low per unit. Eliminating sewerage disposal plants because nothing leaves the home but clean filtered water. This would leave only industrial sewerage pollution, to be cleaned up at each industrial plant. The present archaic idea of intercepting sewerage at the river, treating and dumping, is the only one step up from the pioneers who put the outhouse over the creek - what is needed at the highest plateau of governmental sewerage and garbage programs is bold new thinkers, not leaders who continue the same ideas used for a hundred years. Bigger, more costly treatment plants, bigger garbage burial grounds to pollute underground water for years to come. New ideas like – A small grinder capable of grinding and packaging anything, tin cans, glass, plastic, the family could grind and bag garbage for recycling and be paid for their garbage instead of unsightly garbage cans, neat stacks of reuseable resources.

Any nation who can design equipment to put two men on the moon, return safely to earth time after time, can build a home waste conversion unit. But they won't, because you and I don't make them.



This stove burner is operating on g as made in the steel drum (arrow) outside. When the weather varies from 60 degree. at night to 90 in the daytime, one hours burning of gas is made every 24 hours. Boy, if I had two more drums, and about eight more of Coot Mason's used tractor tubes, I could manufacture my owncooking gas.

V.58-11

Georgians Dying Faster?

By DONNA LORENZ

Did 36 per cent more Georgians die during the first four months of this year than in the same period of 1973? And if it's true, why?

Neither the state or federal governments can answer those questions, although vital statistics compiled by the state and issued by the U.S. Public Health Service (PHS) show an appalling 5,812 more deaths in the first quarter of 1974 than in the first quarter of 1973—an increase of 36 per cent.

A prominent Pittsburgh physicist and outspoken critic of nuclear proliferation saw these figures and telegraphed Gov. Carter urging an investigation into the possibility that the state's spiraling mortality rate is a result of radioactive releases from the Atomic Energy Commission's Savannah River nuclear installation.

Dr. Ernest J. Sternglass, a radiological physicist at the University of Pittsburgh School of Medicine, alerted Carter by telegram late last week that the "Savannah River nuclear facility may have had a severe effect on the people of Georgia," and quoted the high mortality figures.

Sternglass sent the telegram to the governor's energy planner in the Office of Planning and Budget, where a spokesman confirmed receipt of the message Monday.

Jack Burris of that office said the telegram will be relayed to the governor.

Carter's office said the governor is interested in Sternglass' concerns and will investigate the matter.

But a top-level health statistician for the state said the death figures are "provisional," and therefore not an accurate basis for Sternglass' assumptions.

Dr. Alan Dever, director of health services research for

Turn to Page 4A, Column 5

GEORGIA DEATHS

Continued From Page 1A

the state Department of Human Resources (DHR), said there was no increase in deaths this year despite what the statistics say. But he said accurate data are not yet available.

Dever said a "lag" in the state reporting system caused many deaths that actually occurred in 1973 to be reported in 1974, resulting in the apparent increase.

"I know that roughly 5,000 of those in 1974 have to be allocated back to 1973 and '72 and so on. It's an improbability to assume that 5,000 more people died in 1974 than in the previous year. It's just not possible barring a disaster," Dever said.

A spokesman for the National Center for Health Statistics in Maryland, which released the data, said, "That's what was reported to us by the state." The center's public information officer said that the figures are not comparable from year to year because of some changes Georgia made some years ago in its reporting system.

Dever, however, blamed the inaccuracy on delays by hospitals and county health departments in reporting deaths.

The state reported 21,998 deaths in Georgia for January through April of this year and only 16,156 for the same period of 1973 and 15,941 for the first quarter of 1972.

A statistician for the Atlanta office of PHS said such an increase is "not to be expected at all."

Sternglass' telegram pointed out that the death rates in all the states surrounding Georgia have declined, and added that Georgia has the highest cancer rate in the entire South Atlantic region.

The physicist told the Journal that some recent studies have shown that the danger from long-term exposure to radiation is not genetic damage, as previously believed, but cell damage.

Sternglass said that radiation, in combination with existing physical weaknesses, such as high cholesterol levels, can cause heart disease, strokes, hypertension and cerebral disease, according to some studies.

Although the PHS report did not categorize causes of death, Sternglass predicted the increase would be in these areas.

Sternglass said although similar increases in morality rates have been observed in other areas of the country near nuclear installations, the Georgia report is "the largest single incident I have ever come across."

Informed of Denver's response that the figures on which his alarming diagnosis were based are faulty, Sternglass said, "That's very strange because there was no such irregularity in the past or anyplace else and I think the burden is certainly on the state to explain this. Five thousand deaths like this is not a small fluctuation."

The Savannah River plant is a national defense installation which produces nuclear elements for weapons and is operated by the Dupont Co. under contract with the AEC.

The plant, which was built in 1950, is in South Carolina across the Savannah River from Georgia just south of Augusta. Sternglass claimed that evidence of damage to South Carolinians has also turned up in their death and disease rates.

C. M. Patterson, a health physicist for DuPont, called Sternglass' charges "typical" of the long-time opponent of nuclear power.

Patterson said the plant has only released a "major" amount of radioactive material once in recent years. Last May, a gas cloud of about 50 grams of tritium was released, accidentally, from a smoke stack.

The AEC reported at the time that the release posed no danger to humans. Dr. Sternglass differed, however, charging that the amount was extremely dangerous.

In addition, small amounts of iodine and plutonium have been released from the plant in August 1974 and May 1973, Patterson said.

Those were accidental releases, But the plant routinely leaks small amounts of radioactive material.

Page 10 - THE NEWS-HERALD - Thursday, November 8, 1973

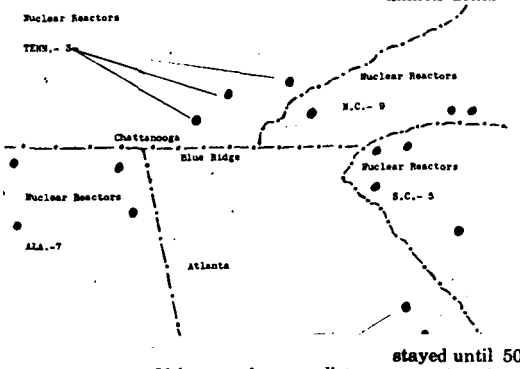
Roy Dycus Feature

Living Is Dangerous In Fannin–

Fannin countians are noted for their reserved concepts, we like to play it safe, knowing our children have plenty to eat, a good warm house in the winter. We like being conservative, to be able to see the same mountains our forefathers saw, knowing we will not leave them unless we choose, but the AEC and the Power Companies are changing all that, they intend to make us live dangerously. Do you want to live dangerously? No!

I know most of the readers of this are thinking, no I do not! Well my friends you will. By 1980 Fannin County will be ringed with Nuclear Power Reactors, and the owners and operators protected by the Price-Anderson Act of 1957, which states no utilities company, no owner operators of a Nuclear Power Plant can be held responsible for more than 560 million of dollars, most of which is paid by the tax payers themselves through Congress and the Senate.

That doesn't sound too bad does it? In 1957 a study was made by an accredited scientific group, their report called (WASH 740) ascertained 34,000 people would be killed, 43,000 injured, 150,000 square miles would be contaminated with a price tag of 7 billions of dollars. You and I pay the difference, by losing our homes having to move away from our land, because people near the plant having the accident gets paid first, and 560 million dollars would reach



only a few miles from the site. That's with an accident in the plants designed before 1957, newer plants are much larger, more dangerous. All this to boil water.

How Could An Accident Happen

A modern nuclear power plant has more than 600 valves, and operators have been known to close wrong valves, an earthquake, airplane crash, saboteur planting an explosive deivce in the right place, pipe break in the cooling system, control rods in backwards, like happened at the TVA's Browns Ferry Plant #1 in Alabama this past July. Many other ways too numerous to mention.

In the U.S.A. last year more people died than live babies were birthed, yet the Power Utilities Companies are rushing to complete nuclear power reactors, as if our population were exploding. Why? I know some of you readers who are still with me have decided the best thing to do is run. Move, get out of the country. Forget it. The AEC plans to have 1,000 nuclear power plants in the next 25 years. There is nowhere you can go. Nowhere.

One ounce of plutonium can produce lung cancer in everyone on earth, yet the AEC plans to use tons by the year 2,000. Can you imagine what will happen if some nation decided to drop a small warhead on a nuclear power reactor with tons of plutonium? With Russian MIRV's overhead, N-plants on all sides. Good by world!

If that sounds scarey, listen – each nuclear reactor produces high-level radioactive waste, that must be cooled and contained in leak-proof containers for 24,400 years, at tax-payers expense of course, for all spent fuel becomes property of the AEC-think, 24,400 years, your childrens children and mine, for generations, to boil water today.

That's not all, Senator Sam Nunn's office sent me AEC documents showing plans, asking Congress for hundreds of millions to build a storage facility to hold four score thousands of iron men (80,000 same number Solomon used to destroy the forests of Lebanon, 2000 years ago.) Each one foot in diameter, ten feet long, each radiating 5 kw of heat that must be kept cooled regardless of earthquakes, storms, plane crashes, war, any conditions. If not kept cool the canisters will melt, releasing the radioactivity into the environment, one hit on such a site would destroy the U.S.A. You had enough? You would like to see the building of Nuclear Power Plants stopped? Sorry, no way. Senators Talmadge, Nunn, each votes year after year for the AEC's appropriation without question. You can write both if you want, but you will get no commitments to help stop the building of nuclear power plants. Just nice letters in return.

A majority of citizens wanted the U.S. out of Vietnam, yet the government stayed until 50,000 brave young Americans will see the sun rise no more. I predict it will take a nuclear accident killing 40 to 50,000 Americans in all walks of life, before our Senators proclaim from the highest roof tops, "We don't want any nuclear power plants in Georgia."

Within the next decade nuclear power plants will become the most controversial issue within the Federal Government, and a woman will take the blame. A nice lady named Dr. Dixie Lee Ray runs the AEC. When the facts come out, Watergate will look like a boyscout meeting, because for years the AEC was hid and suppressed reports showing how dangerous N-plants are. Heads will roll, congressmen and senators will bluster and act after thousands have died from leukemia and other cancer, maybe even a radiation leak from a reactor killing thousands will have to happen before our representatives in Washington will act.

All this is quite futile anyway, atomic scientists have predicted, at the present rate or irradiating fuel, we will have nothing but irradiated left by the year 2000. We will have used all the unirradiated fuel, turning it into high-level waste. What this means is, we are trading 25 years of electric toothbrushes, and air conditioners for 500,000 years of cooling, monitoring and guarding tons of wastes. And there is no insurance against this, try getting radiation coverage for your property.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Roy Dycus
Shirley's Enterprises
Route 2, Box 121F
Blue Ridge, Georgia 30513

Dear Mr. Dycus:

Thank you for your letter of April 8, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Energy Research and Development Administration (ERDA) staff responses to your specific comments are enclosed herewith. Your comments, along with all other written comments received on the PFES, as well as testimony presented at the Public Hearing held on May 27-28, 1975, have been taken into consideration in preparing the Final Environmental Statement. A copy of the Statement is enclosed for your information.

Thank you again for your comments.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Responses to Comments by Roy Dycus

Comment (page 1):

> "...you contend it is perfectly fair to keep the nations energy budget unbalanced in favor of nuclear systems. LMFBR, because it is the product of a high-cost technology and in the final and most costly stages of its development.... In other words, you give priority to a program not on its merits, or low fuel costs, but because it uses the most tax dollars to develop."

ERDA Response:

ERDA is concerned about the use of the taxpayer's money. It is our goal to use tax dollars in a way that will return the greatest benefits to the taxpayers. It is precisely for this reason that we believe the breeder program must be moved ahead as rapidly as possible. Regarding the funding of the breeder reactor program and alternative energy development programs, a central responsibility of ERDA is the setting of research and development priorities among competing energy source options. You are referred to Section II, 11.2 and Section III F of the Final Environmental Statement for cost-benefit analyses justifying the expenditures for the LMFBR program.

Comments (pages 1 and 2):

> "On page 4.2-256 you chart WASH 1400 statistics calculating the chances of an accident at one in a billion per reactor year. Using the fault-three and event-three method of calculation. I am sure if the same method had been used to calculate the chances the cities of Hiroshima and Nakisaka being destroyed with the first Atom bombs the statistics would have predicted a 'low probability of occurrance, event considered incredible. Statistics are harmless, when they come true people die. One in a billion?'"

ERDA Response:

Fault tree and event tree analyses, as used in reactor safety evaluations, are useful and valid tools. They have been used extensively in the U.S. space program, where they have fully demonstrated their value. However, they have not been, nor were they intended to be, used in military situations such as the bombings of Hiroshima and Nagasaki.

Comments (pages 2 and 3):

> "Let the nuclear establishment spend the same amount of tax dollars on solar, wind, and methane that was spent on Shippingport, Yankee, Fermis, The Bonus, Hallam, Elk River,

Piqua, Pathfinder, Carolina-Virginia, Peach Bottom, La Crosse, Big Rock Point, San Onofre, Haddam Neck, Ft. St. Vrain, with as many test and design changes, and then see which is the best energy system to proceed with.

...Let others develop the costly nuclear breeder technology. If we see we need it, we can import the technology."

ERDA Response:

ERDA agrees that development of alternative energy systems should be vigorously supported. Although the environmental review of the LMFBR program has led ERDA to conclude that continuation of research, development and demonstration of the LMFBR concept is needed, continuation of the LMFBR Program will not be at the expense of alternative power generation and conservation concepts. Indeed, these other technology options are receiving substantially increased appropriations in the current fiscal year and are proceeding at a pace limited only by the need to build up new programs efficiently and effectively. We believe the breeder has the potential for a major role in providing for our future energy supply. We conclude that it would not be to the benefit of the U.S. to rely solely on other countries to develop this technology. The problems we are concerned about are (1) balance of trade and (2) safety and licensing.

Comments (page 2):

"One does not walk away from ten thousand generations of high-level radioactive waste surveillance--it's like molasses on a childs' fingers--we have to eat it.

ERDA Response:

ERDA is studying permanent disposal concepts which would make long term surveillance unnecessary. As discussed in the PFES, the evaluation of promising geological formations and sites leading to a pilot geological repository, which in turn could lead to a permanent disposal system, is a major part of the ERDA radioactive waste program. At present, ERDA plans further study of several promising geologic formations other than bedded salt, including study of specific promising sites, to bring the state of knowledge of these other formations up to the same level as that of bedded salt. The goal of this further study is to permit a

comparative evaluation of these formations and the selection of the optimum formation or formations for pilot plant operations.

Comment (page 3):

> "In Volume two you describe the water basin concept RSSF criteria outlining the plans for storing 80,000 one foot by ten feet high level radioactive canisters. That must be kept in working order regardless of war, aircraft crash on site, sabatage, human error, earthquake, meteor impact, any and all acts of man or God, or the basin water begins to boil in 16 hours, the basin water completely evaporates in 6 to 7 days and the basin, canisters, liners, concrete, all melts in one or two weeks, 10,000 Kw of electric energy must be maintained into the site or the above will happen. You print that so blaze: 80,000 canisters, each radiating 3.25 Kw of heat-each filled with plutonium toxic wastes, each must undergo hundreds of operations from reactors to the storage site without error or accident-"

ERDA Response:

Parts of this comment are in error. For example, as discussed in Section 4.6.3.1.5 of the LMFBR Program PFES, emergency water sources and a standby electrical power system are available on site. Furthermore, the canisters come from the fuel reprocessing plants, not the reactors, and there are only a few operations required between canister loading at reprocessing plants and storage at the water basin concept RSSF, not hundreds.

Comment (page 3):

> "You maintain you can keep the high level radioactive wastes contained for 250,000,000 years, yet you could not keep high level radioactive wastes contained for thirty years at Richland, Washington."

ERDA Response:

As discussed in the PFES, the commercial high-level wastes would be solidifed prior to storage. The wastes that leaked at Hanford were high-level liquid wastes (See Appendix II.F of the PFES).

Comments (page 4):

"In Volume 2 page 4.6-41 you solve the problem of an enemy hitting your high level radioactive waste storage faculty with massive missiles, with this. I quote 'Low probability of occurrance, event considered incredible. Site location would not be in commercial aircraft flight path.'

"Any tweleve year old mentality would reason an enemy would strike this target first. Multiplying the missiles destructive power. Event considered incredible. The only thing incredible, is the credulity of the AEC(ERDA)."

ERDA Response:

The PFES discusses the possibility of acts of war against U.S. nuclear fuel cycle facilities in Volume IV, Section 7.4.4.1. The concluding paragraph of that section reads:

"The consequences to the United States of any possible attack must be viewed as part of a major nuclear strike. The additional effect from the attack on the nuclear facilities would be masked by the overall consequences of a massive strategic attack. Given direct hits on the facilities, casualties would at worst be of the same range of magnitudes as those produced by the weapons themselves. When viewed in the context of large-scale strategic war, the additional fallout from the attacked facilities are unlikely to greatly increase casualties."

With respect to this overall conclusion, and to the LMFBR in particular, we invite your attention to comments on the PFES from the Deputy Assistant Secretary of Defense for Environmental Quality (a copy of whose letter is reproduced elsewhere). In part, these comments are:

"We have reviewed the document with special emphasis on the national security aspects of safeguards and believe the statement has reasonably considered the factors to balance the predicted environmental cost against the potential gains to our society. The impact of a military attack directed toward the LMFBR has been adequately discussed, and we concur in the findings that the LMFBR will not significantly add to the problems confronting the nation if we are involved in a war."

Comments (page 4):

"A. J. Lehman Director, Division of Pharmacology at the Bureau of Biological and Physical Sciences at the FDA, compiled information establishing humans are six times as sensitive to toxicity as dogs. Yet, the AEC(ERDA) are useing hundreds of dogs in their toxicity tests. An exercise in futility.

"Dogs have the ability to manufacture ascorbic acid in any amount needed to combat toxicity, humans due to their biological make up, do not have this marked advantage.

"If the nuclear establishment plans to make sure each individual in our population injests a minium of five grams of ascorbic acid daily, then their dog controls might be comparable. Millions of our citizens are constitutionally inadequate, making these individuals much more sensitive to radioactive toxicity than your many workers reported in the impact statement as remaining healthy after being exposed."

ERDA Response:

The comment concerning the relative toxicity of man and dog presumably refers to a single table, without accompanying text, submitted by Dr. A. J. Lehman to the Quarterly Bulletin of the Association of Food and Drug Officials of the United States, Vol. XVIII, No. 2, p. 66, April 1954, as a "Topic of Current Interest." By comparing average body weight, the weight ratio of the animal species to man, and the "drug dose ratio" of the animal species to man, relative "sensitivities" were derived.

Conversations with Dr. Lehman, now retired, indicate that his table did not refer to or include radioactive materials, nor did it pertain to cancer induction following long latent periods after administration, nor did it refer to acute toxicity levels. In fact, the table itself refers only to undefined "drug toxicity" and "sensitivity" which, according to Dr. Lehman, means the first response, of whatever nature, of the species to whatever chemical pharmaceutical is being considered.

Furthermore, Dr. Lehman disclaims any association with the statements made regarding ascorbic acid, and ERDA is not aware of the experimental data which would support such claims with respect to modifying any biological response to plutonium.

Comment (page 5):

> "We recieved the radioactive affluents generated and released into the wind and water by the nuclear fuel reprocessing and reactors, we recieved and injested through the crops raised on our own land radioactive nuclides from both the weapons tests fallout and the fallout from SRP. That's not all. We recieved radioactive dosage from the shipments by rail and highway of highly dangerous radioactive materials with names unheard by most Georgia citizens. Trains and trucks with nuclear wastes, noble gases, spent atomic fuels, criss-crossed our great state... Radioactive material to the plant, radioactive wastes to burial grounds."

ERDA Response:

A monitoring program to evaluate the environmental effects of Savannah River releases of radioactive materials has been in operation since 1951, prior to the startup of SRP nuclear operations. Since 1961, data obtained from this program has been made available on a routine basis to the news media, to federal and state environmental health agencies, and to the public. This program basically measures the quantity of radionuclides released from SRP operations and the distribution of these nuclides in the environment.

Radiation levels offsite have generally proven to be too small to distinguish from background, and similarly the amount of radionuclides added by SRP to the offsite environs has been, for the most part, too small to be distinguished from natural background and fallout from worldwide nuclear weapons tests. An exception is the tritium and the very small amounts of other nuclides in the SRP release water and swamps. However, even for tritium, the average concentration in air at the plant perimeter is normally less than 0.1% of the concentration guide specified in 10 CFR Part 20. Concentrations of alpha emitting radionuclides in air, water, and food crops collected near SRP are not statistically different from control samples obtained at greater distances.

Generally, the offsite radiation doses from SRP releases are too low to be measured directly. These doses have been calculated from the source releases (which can be measured with good accuracy), the measured dispersive characteristics of the atmosphere and the known major pathways of exposure to man. The calculated dose to an individual who resided continuously at the plant perimeter since the startup of SRP (21 years) would be 39 mrem, and the dose he would have received from natural sources of radiation during the same period would be 2500 mrem. The calculated SRP dose to an individual residing 50 miles

from SRP during these 21 years would be 4-5 mrem. Total SRP atmospheric release doses to the population out to a distance of 50 miles from the SRP perimeter were approximately 6400 man-rem or 0.4% of the population dose from natural sources during the same period. To this must be added 460 man-rem (0.3% of natural dose) to downstream population groups consuming Savannah River water containing radioactive materials of SRP origin.

The average dose to people in the Central Savannah River Area from natural sources is about 117 mrem per year but ranges up to three times this value for people living on the Piedmont Plateau bordering the Atlantic Coastal Plain northwest of Augusta, Georgia. Thus, contributions of SRP releases to the radiation dose of the public is very small in comparison to the average natural radiation dose and small in comparison to the variation of natural radiation dose in this area.

Nuclear wastes, noble gases, and spent fuels are not normally shipped from SRP to other locations in the United States. Nuclear wastes from SRP operations are either stored in tanks (liquid form) or stored in a burial ground (solid radioactive wastes) on the site. Dose to the public from this waste handling is negligible. Noble gases are released to the atmosphere and normally result in individual (at the plant perimeter) and 100 km-radius population annual doses of 0.2 mrem and 17 man-rem, respectively (1974 data). Spent fuels generated in SRP reactors are processed in chemical separations plants on the SRP site. The only exception to this was a limited number of spent fuel shipments that were made by rail to Idaho in the 1950's for processing at the Idaho Chemical Processing Plant.

The primary shipments of radioactive materials to the plant are uranium feed materials for manufacture into reactor fuel and target elements. The primary shipments of radioactive materials off the plant are low-radiation level plutonium, tritium and uranium. The exposure rate from these shipments are 1 mrem/hr (and less) at six feet from the side of trucks and railway cars.

Shipments of higher level radioactive materials requiring shielding are made to and from SRP on an infrequent basis. These consist of irradiated fuels from off-site and byproducts (^{252}Cf, ^{244}Cm, ^{238}Pu, ^{60}Co, etc.) of normal SRP operation.

The Department of Transportation (49 CFR 171-178) limits shipments of all these materials by common carriers to exposure rates of 10 mr/hr at 6 feet from the side of the transport vehicle. SRP shipments have ranged from less than 1 mrem/hr to 5 mrem/hr at 6 feet, well within the D.O.T. regulations.

Because of the variety of the shipments and the low levels of radiation, the possible dose from SRP shipments has to be calculated. This calculation gives an upper level exposure of less than 1 man-rem per year for all SRP shipments.

Comment (page 5):

> "In 1954, the SRP became operational and keeping records of the estimated releases of nuclides to the atmosphere. That's right, estimated. They assume about fifty percent of the plutonium 239 released by SRP was transported to the surrounding country side. They don't know how much and how far. Due to the particle size difference, they estimate eighty-five percent of plutonium 238 released fell on the peoples land, outside SRP, at Aiken, S.C. Contractor, E. I. DuPont de Nemours and Co."

ERDA Response:

The Savannah River Plant has been keeping records of measured releases of radioactive materials to the environment since startup. The estimates referred to are presumably in reference to data SR supplied on calculations of offsite versus onsite deposition of the measured plutonium releases. This calculation was based on average meteorological dispersion conditions and deposition velocities of plutonium particles representative of SRP emission points. Because of differences in characteristic ^{238}Pu and ^{239}Pu particle parameters, it was calculated that 50% of ^{239}Pu particles were transported by the atmosphere beyond the plant perimeter and 85% of the ^{238}Pu beyond the plant perimeter. A soil monitoring program performed in 1973 indicates that these meteorological dispersion calculations are adequate, within the degree of accuracy of such calculations, to describe the transport of SRP plutonium by the atmosphere. Results of the soil monitoring program[1] are compared with the calculated transport in the following table.

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[1] McClearen, H. A., "Plutonium in Soil at the Savannah River Plant," DPSPU 74-30-14, Savannah River Plant, April 1974. (A paper presented at the Second AEC Environmental Protection Conference, Albuquerque, NM, April 16-19, 1974 and published in "Proceedings of the Second AEC Environmental Protection Conference," WASH-1332 (74), Volume 1, July 1974).

Plutonium Deposition, Curies

Isotope	Curies Released	On Site: Calculated[a] Transport	On Site: Measured[b] Deposition	Off Site: Calculated[a] Transport	Off Site: Deposition[c]
^{238}Pu	0.6	0.09	0.2 (33%)	0.51	0.4 (67%)
^{239}Pu	2.9	1.45	1.24 (42%)	1.45	1.7 (58%)

(a) Calculated from meteorological dispersion.
(b) Determined from soil analyses.
(c) Data in this column was obtained by subtracting measured onsite deposition from the measured release.

The soil analyses[1] performed in 1973 indicated measurable SRP contribution to plutonium soil content to a distance of 2 km from the chemical separations areas, well within the plant boundary. Beyond 2 km, total plutonium in soils on plants and nearby locations off plants were no greater than amounts from world-wide fallout in this region. (See following table.)

[1]McClearen, H. A., "Plutonium in Soil at the Savannah River Plant," DPSPU 74-30-14, Savannah River Plant, April 1974. (A paper presented at the Second AEC Environmental Protection Conference, Albuquerque, NM, April 16-19, 1974 and published in "Proceedings of the Second AEC Environmental Protection Conference," WASH-1332 (74), Volume 1, July 1974.)

Perimeter and Off Site
Plutonium in Soils, 1973

	Deposition, mCi/km^2* ^{239}Pu	Deposition, mCi/km^2* ^{238}Pu	Total
SRP Perimeter	1.78 ± 0.65	0.08 ± 0.05	1.86
160 km radius	1.69 ± 0.49	0.12 ± 0.09	1.81
Raleigh, N. C.	2.4	0.10	2.5
Tulsa, Okla.	2.2	0.09	2.3

*Measured in the top 30 cm of surface soil.

Results of studies conducted in 1974 and 1975 indicate that trace quantities of plutonium from SRP operations may contribute to the total plutonium in the environment, even though the total concentrations of plutonium were within normal background ranges for this region.

Comment (page 5) :

"Statistics of population, deaths from cancer, celebrovascular, heart disease, fetal deaths, are from Georgia's records of the U.S. Dept. of Health, Education and Welfare Vital Statistics Records. Both open to the public. And one important point must be made, regarding Georgia's statistics.

"Dr. Alen Dever, Director of Health Services Research, Dept. of Human Resources, stated in 1974, in a newspaper article that due to a lag in the reporting of deaths: 'I know that roughly 5,000 of those in 1974 have to be allocated back to 1973 and 1972, and so on.' In other words the total 50,124 deaths reported in Georgia, in 1974 should be about 56,000 deaths."

ERDA Response:

This last sentence is obviously a misinterpretation of Dr. Dever's statement. The total number of deaths in Georgia in 1974 should be about 45,000.

Comment (pages 5-9):

Mr. Dycus claims that SRP has contributed heavily to increased mortality rates in Georgia counties along the Savannah River extending from Richmond County (Augusta, Georgia) to Chatham County (Savannah, Georgia).

ERDA Response:

Death rates in these counties from cardiovascular diseases and all causes of death are in fact higher than the average for Georgia as a whole, as Mr. Dycus' data indicates. However, contrary to Mr. Dycus' statement, the nine Georgia counties, referred to as "Savannah River Counties," also showed death rates greater than Georgia in 1950, prior to SRP startup. The following data is taken from the same Georgia mortality tables used by Mr. Dycus.

1950 Death Rates[1]

		Death Rate/100,000 Population				
	Population	Total	Fetal[(a)]	Heart	Cancer	Strokes
Savannah River Counties	349,000	1037.2	70.5	352.1	93.1	143.0
Georgia	3,454,000	880.6	58.7	267.5	96.7	118.6

(a) Listed as stillbirths and are not directly comparable to data published in later years.

Mr. Dycus may have hesitated to use the Georgia data before 1966 because the bases for the statistics changed several times in 1950-1966 period, but the same pattern is also documented in several epidemiological studies for the 1949-1951 and later periods.[2,3,4,5]

Currently, an epidemiological survey is being made by a university epidemiologist-health demographer of the population in areas surrounding SRP and a population downstream from SRP that consumes treated Savannah River water. The epidemiological survey is incomplete but preliminary analysis of data led to the following statement in a recent technical paper:[6]

"Some people have expressed concern that the low level of radiation given off by nuclear reactor installations such as the Savannah River Plant or nuclear generating plants such as the one planned for Calloway (MO) may possibly cause an increase in deaths. The Savannah River Plant is located in Aiken County, South Carolina, near Augusta, Georgia. We have already reported that areas in South Carolina, Georgia, and adjacent states have among the highest death rates in the entire country. You may well ask: could radiation be the cause. Our findings may be summarized by two approaches: (1) In periods prior to the operating of the Savannah River Plant, 1949-1951 and 1952-1954, this area already had high rates (Table 2). (2) Both in 1949-1951 and in more recent periods, the area with high rates extends roughly from eastern Alabama, to Norfolk, Virginia, between the Fall Line and the Atlantic Ocean. Georgia counties northwest of Augusta tend to have either below-average or very low rates. Available evidence provides a substantial basis for rejecting radiation as a cause."

Table 2

Death Rates for Selected Causes by Distance From Savannah River Plant, 1952-1954[6]

(Average annual death rates per 100,000 population, age-sex-race-adjusted by the indirect method, using the U.S., 1949-1951, as the standard community. The Savannah River Plant began operation in 1954-55.)

Distance from Savannah River Plant	All Causes	Cardio-vascular Renal Diseases	Cancer (All Forms)	Other Diseases (Except ICD 750-795)
Less than 50 miles:				
Aiken County, S. C.	1076	578	122	182
Augusta -- Richmond Co., Ga.	1074	635	144	173
Rural Georgia	984	522	107	172
Rural S. C.	1025	579	126	157
50-99 miles	967	549	125	148
100-149 miles	935	529	118	145
United States	908	483	140	148

A study[7] by the South Carolina State Board of Health of infant mortality rates in counties in South Carolina for the period 1943-1970 came to the following conclusion:

> "In summary, a comparison of infant mortality rates of these seven counties contiguous to or close by SRP show that six counties have experienced a change in rate of decline* of mortality rates before SRP operations. One county did not experience the break until approximately 1960. All the counties surveyed show downward trends in infant mortality over the period studied. The hypothesis that counties contiguous to or close by the Plant would show increased incidences of infant mortality with the incidence of Plant operation must be rejected."

*Rate of decline decreased.

1. "Georgia Natality and Mortality Statistics - 1950," Georgia Department of Public Health.

2. Sauer, H. I., G. H. Payne, C. R. Council, and J. C. Terrell, "Cardiovascular Disease Mortality Patterns in Georgia and North Carolina," Public Health Reports, Vol. 81, No. 5, May 1966.

3. Sauer, H. I., "Geographic Differences in the Risk of Premature Death," Business and Government Review, May-June, 1970.

4. Sauer, H. I., "Epidemiology of Cardiovascular Mortality - Geographic and Ethnic," American Journal of Public Health, Vol. 52, No. 1, January 1962.

5. Sauer, H. I. and F. R. Brand, "Geographic Patterns in the Risks of Dying," The Geological Society of America, Memoir 123, 1971.

6. Sauer, H. I., "Environmental Factors Associated with the Risks of Dying," Department of Community Health, University of Missouri, Columbia, Missouri. (A paper presented at the Missouri Academy of Science Meeting, April 26, 1975, Liberty, Missouri.)

7. Priester, L. E., "A Study of Infant Mortality in Selected Counties," South Carolina State Board of Health, October 1971. (A statement to the Special Committee Studying Nuclear Facilities in South Carolina.)

Comments (page 9):

"You assure the American public plutonium will have very little effect on mankind, citing studies, bolstering this concept and theory--that's all it is--theory. Mankind is not biologically adaptable to radioactivity and until he has lived with this new element in his environment for at least a thousand years--you cannot postulate the end result.

"Allied-Gulf Nuclear Fuel Services Plant at Barnwell, South Carolina, promised the citizens of S.C. and Georgia they could control their radioactive materials, but DuPont at Aiken, South Carolina released 50 grams of Tritium in May of 1974, plus Plutonium and Iodine in 1973 and 1974 to be fallout in Georgia's farms that raise our food and give us larger cancer, heart disease, stroke and fetal death rates in 1980's 1990's."

ERDA Response:

On May 2, 1974, 50 grams (479,000 Ci) of tritium gas were released from a Savannah River exhaust stack to the atmosphere over a period of four minutes. The release resulted from a metallurgical failure of a process valve in a tritium processing facility. This release was the largest single release of tritium gas in the 21-year operating history of SRP. The radiation dose from inhalation by people exposed to highest concentrations of the gas in air were less than 0.05 mrem as determined by analysis of urine samples. Press releases were made at the time of the incident and a detailed account of the environmental effects of the release were published in November 1974.[1] Modifications to the equipment to completely contain the release from such valve failures are being proposed for budgetary consideration.

Small amounts of other radionuclides, including iodine and plutonium, are released to the atmosphere during normal operations of SRP. The amounts of the releases and the resulting population doses are reported annually[2] to the news media, federal and state health agencies, and interested members of the public. These releases result in public doses

1. Marter, W. L., "Environmental Effects of a Tritium Gas Release from the Savannah River Plant on May 2, 1974," DP-1369, Savannah River Laboratory, November 1974.
2. "Environmental Monitoring in the Vicinity of the Savannah River Plant," DPSPU-75-30-1, Savannah River Plant, 1975. (This is the latest in a series of reports made available to the public since 1961.)

that are a small fraction of 1% of the dose received annually in the Central Savannah River Area from natural sources of radiation exposure. People in many areas of the United States receive natural radiation doses several times that received in the Central Savannah River Area with no detectable biological effects. The small amount of radiation dose received by the public in the Central Savannah River Area from SRP releases is small when compared to natural radiation dose and it is concluded that the biological effects are negligible.

Comment (page 9):

> "Twenty years after citizens of Savannah, Georgia began drinking the affluent from the Savannah River Installation they had the distinction of the highest incidence of stroke in the United States. That is assertained by Regional Records. If DuPont can't control accidental releases of wastes how can Allied-Gulf? Ladies and Gentlemen, you know it is impossible."

ERDA Response:

The citizens of Savannah, Georgia have a history of highest stroke incidence in the United States and also of high mortality rates from all causes. This condition was observed prior to operation of SRP, as discussed previously. The domestic water supply of the City of Savannah, Georgia is from deep wells. Provision is made to supply Savannah with water from the Savannah River (from Cherokee Hill Water Treatment Plant, Port Wentworth, Georgia) during unusual peak water demands in the summer. However, such use has been infrequent. Even if river water consumption had been continuous since plant startup, the body dose to an average individual over the 21-year period would have been less than 20 mrem or less than 1% of the natural radiation dose during the same period. The inference that the citizens of Savannah have the highest stroke incidence in the United States twenty years after drinking effluent from the Savannah River installation (the inference of a relationship between these facts) is unfounded.

During the 1960's, some radioactive materials from SRP releases (primarily cesium-137) were deposited in about 1.7 square miles of offsite swamp downstream from SRP.[1] Gamma radiation exposure rates ranged from 5 to 120 uR/hr in affected areas of the swamp.[2] There are no permanent residents

1. Marter, W. L., "Radioactivity from SRP Operations in a Downstream Savannah River Swamp," DP-1370, Savannah River Laboratory, September 1974.
2. "Environmental Monitoring the Vicinity of the Savannah River Plant," DPSPU-75-30-1, Savannah River Plant, 1975.

in the swamp. An incremental radiation dose above background to hunters and fishermen who spend a few hours to a few hundred hours in the swamp would range from less than 1 mrem to a few tens of mrem per year. The contaminated sediments are relatively immobile and are expected to remain so. No increase in exposure rates is expected from current releases of radioactivity. However, the swamp will be monitored at least annually in the future to provide a basis for continued evaluation.

Comment (page 9):

> "In the county of Dawson, which has the town of Dawsonville, Georgia, the AEC (ERDA) carried out an experiment of radiating plant life to determine it's effects long term and short term, the poor ignorant people were assured this was all very safe. They were in no immediate danger. They wasn't. This happened in the 1950's.
>
> "Now lets look at the statistics of Dawson County, twenty years later. 1970, Dawson had a rate per 100,000 of 250.0 1971 a whopping 333.3 rate by cancer. The state average was 131.9 Isn't this odd?"

ERDA Response:

During the 1950's the Lockheed Aircraft Corporation constructed and operated an unshielded reactor for the U.S. Air Force in Dawsonville, Georgia. In order to take advantage of this situation, the Atomic Energy Commission supported scientists at Emory University who monitored, studied and recorded the effects of the radiation from this reactor on the surrounding biota. To our knowledge, no member of the general public received any exposure from this operation.

Comment (page 9):

> "In the last days of March, 1975, an anti-establishment group sabotaged the cooling system of a substation in San Jose, California.- This is one step away from sabotage of a LWR cooling system, the next the LMFBR.
>
> "Liquid sodium to cool the LMFBR burns on contact with air or water. Simplifing the procedures for sabotage. If you are smart enough to build it, they are smart enough to destroy it. In the closing days of March, 1975, a small candle flame closed the Browns Ferry Nuclear Plants in Alabama. Accomplishing more than we thousands, who opposed their construction and licensing. Again luck prevailed where fools had trod."

ERDA Response:

The PFES gives full recognition in Section 7.4 to the possibility of attempted sabotage against nuclear fuel cycle facilities. Protection against sabotage is an integral part of the present safeguards system, and will continue to be emphasized as strengthened safeguards are developed for the future.

Comments (pages 9 and 10):

> "Again man has come to the moment of decision! Does a few Men of the Nuclear Scientific Community, sitting in tax supported office buildings, have the right to decide for me and my fellowman, what technologies will furnish my energy requirements? Will their decisions be legal, without the vote of the people? ..."

ERDA Response:

ERDA came into being on January 19, 1975. Its mission as mandated by Congress and the President is to generate an array of safe, sound, environmentally compatible energy technology options for selection and use by the country as a whole. ERDA conceives of its role not as imposing anything on anybody or dictating which choices are to be made. Rather ERDA's function is to assure that choices can be made by the people of this Country and their representatives. The decision to continue the LMFBR Program through the research, development and demonstration stages at least has been made by the Administrator of ERDA. An ERDA decision obviously does not preclude or foreclose public debate or a presidential or congressional decision to continue or terminate the program.

DATE: April 5, 1975

TO: W.H. Pennington
Division of Biomedical & Environmental Research
U.S. Energy Research & Development Administration
Washington, D.C. 20545

FROM: Catherine T. Quigg
Vice president
Pollution & Environmental Problems, Inc.
54 S. Brockway
Palatine, Illinois 60067

SUBJECT: The Liquid Metal Fast Breeder Reactor (LMFBR) Program

To read the U.S. Atomic Energy Commission's Proposed Environmental Statement on the LMFBR is to be overwhelmed...overwhelmed by the magnitude of the assumptions of the breeder's proponents. It dawns on the review that millions of Americans are being asked to make one of the most important decisions - affecting the quality and length of their lives - based on assumptions that are biased, imprecise and overly-optimistic. Some of the AEC's blithe assumptions have already proved erroneous; others will take years to disprove. But can we afford this luxury of time when the risk involved is our health and our lives and that of future generations.

FALSE ASSUMPTION #1: THAT THE LMFBR IS SAFE TO OPERATE.

> "...the expectation that HCDAs (hypothetical core disruptive accidents) will not be energetic enough to cause breaching of primary or secondary containment in properly designed plants so that public health and safety consequences are estimated to be small." (WASH-1535; Dec. 1974)

THE FACTS: Engineers have yet to solve the problem of precisely spacing the thousands of stainless steel rods holding the fissionable material in the reactor's core. Unless the sodium can freely flow around the rods, dangerous overheating and melting result, as demonstrated by the failure of the small experimental Fermi breeder near Detroit.

FALSE ASSUMPTION #2: THAT SODIUM IS A WISE CHOICE AS A COOLANT FOR THE LMFBR.

> "The negative aspects of sodium were outweighed by its outstanding advantages." (WASH-1535, Dec. 1974)

THE FACTS: There is one outstanding advantage of sodium - its availability. As the AEC report states, "...U.S. industry has a well-established capability for producing high grade sodium in large quantities." It looks like economics over safety.

The negatives of sodium, so readily discounted by the AEC, are these...chemical reactivity with air and water, activation under irradiation, opacity, and lack of technical experience.

The truth is that sodium is an extremely dangerous and hard-to-control substance. Liquid sodium is used to carry the scorching heat of the breeder through a series of independent loops to the plant's turbo-generators. The super-heated fast reactions can lead to explosions. It requires elaborate safeguards to prevent a mishap that could leak radioactive materials. Since the sodium is at about 620 deg.C, and becomes intensely radioactive -- fueling and other operations on the reactor have to be carried on blind. This constitutes a further chemical hazard with respect to failures

in circulation pumps, pipes or heat exchangers.

There is no experience with large, central station, sodium-cooled fast breeder reactor systems. These larger plants will require a much broader technology than now available. The state of the art for detecting, locating, and containing sodium water reactions is rudimentary.

FALSE ASSUMPTION # 3: THAT PLUTONIUM DOES NOT REPRESENT A CONSIDERABLE THREAT TO HUMAN LIFE AND THE ENVIRONMENT.

> "...a substantial basis for believing that potential health consequences associated with the persistence and accumulation of transuranic elements released by the LMFBR fuel cycle would be small in comparison with many other risks that are accepted by society." (WASH 1535, DEc.1974)

THE FACTS: The breeder reactor program will produce massive amounts of dangerously radioactive plutonium. There will be some 2,500 pounds of plutonium inside the core of the typical commercial-sized reactor.

Plutonium-239 is the deadliest substance known to man. The unavoidable release of plutonium during normal operation of breeders could expose local populations to the risk of cancers. It is known from animal experiments that a particle containing less than one ten-millionth of an ounce of plutonium - a man-made product virtually unknown in nature - contains enough radioactivity to produce lung cancer when inhaled. Scientists are debating over whether an amount 100,000 times smaller will do the same.

Wilson Clarke in Energy for Survival writes:

> "Plutonium is fiendish in its toxicity, more poisonous even than anaerobic bacteria, which cause botulism, and 35,000 times more lethal than cyanide poisoning by weight. Professor J.S. Neilands of the University of California at Berkeley notes that there are "20 million mortal doses in a weight of the element equivalent to the weight of an American five-cent piece (5 grams). Dr. A.B. Long of the AEC's Argonne National Laboratory says that "in light of data accumulated over the past 10 years, a serious question exists as to whether the risks associated with the present limits of plutonium oxide inhalation are indeed justified by the benefits derived from activities involving the production or use of plutonium."

The nuclear experts Willrich and Taylor exposed the magnitude of the combined economic and human threat posed by nuclear proliferation and the plutonium economy. For instance:

> "The dispersal of very small amounts of finely divided plutonium could necessitate evacuation and decontamination operations covering several square kilometers, for long periods of time and costing tens of hundreds of millions of dollars...A nuclear explosion with a yield of 1 kiloton could destroy a major industrial installation or several large office buildings, costing hundreds of millions to billions of dollars. The hundreds of thousands of people whose health might be severely damaged by dispersal of plutonium or the tens of thousands who might be killed by a low yield explosion ...represent an incalcuable cost..."

FALSE ASSUMPTION #4 : THAT THE RELEASE OF TRITIUM TO THE ENVIRONMENT SHOULD BE ACCEPTED BY THE AMERICAN PUBLIC UNTIL RESEARCHERS LEARN HOW TO RESTRICT IT.

> "Research on ways to reduce the release of tritium from the LMFBR power plants is being planned." (WASH 1535, Dec. 1974)

THE FACTS: Tritium is toxic. It can be built into all the organic materials of our bodies just as if it were hydorgen. When we ingest tritium, some of it will be built into our genetic material,

DNA. The radioactivity from tritium in the DNA can easily damage the genes. Such damage can either impair physiological processes such as blood regulation by the liver, or, if involving reproductive tissues, can lead to magnified genetic defects in our children's children.

Tritium is a special problem at reprocessing plants. Dr. Edward Radford at Johns Hopkins University in Baltimore estimates that the maximum permitted tritium release level at the New York reprocessing plant, "if continuously ingested, would lead to 3,300 new mutations per year in the U.S.".

What if further research proves that tritium does irreversible and considerable damage to man's genetic structure, what will the AEC and the utilities do to remove the tritium alrady dumped in our water? What can they do?

FALSE ASSUMPTION #5 : THAT PROSPECTS ARE GOOD FOR A SOLUTION TO THE PROBLEM OF RADIOACTIVE WASTE DISPOSAL.

> "A development program is going forward on permanent disposal of such wastes in geological formations, which could make long-term surveillance and maintenance unnecessary."
> (WASH 1535, Dec. 1974)

THE FACTS: The AEC's favorite theoretical solution has been disposal of nuclear wastes in geological formations, and extensive research has been carried out on a site at Lyons, Kansas. In 1971, the AEC was forced to abandon the site as unusable, despite the fact that the Commission had just requested $25 million from Congress to proceed with actual waste burial. The site was rejected after

the accidental discovery of old gas and oil bore holes penetrating the Lyons salt mine and the underground loss of 100,000 gallons of water from mining operations of the salt company, both of which might have led to a flooding of the repository and dispersal of wastes.

Meanwhile, under AEC regulations, high-level commercial weapons wastes are to be solidified after five years of storage and shipped to a federal repository -- but such a repository does not now exist and may not exist for some time.

The past performance of the AEC in regulating storage of nuclear weapons does not inspire confidence in their ability to contain wastes for even a few years. Last year, for example, leaks of radioactive materials from storage tanks in Hanford, Washington went undetected for seven weeks. When finally discovered, 115,000 gallons of radioactive wastes had seeped into the ground. All told, nearly 500,000 gallons have leaked out at that installation alone.

The radioactive waste leakage at Hanford includes large quantities of plutonium, and is true with breeder reactors, the potential for an uncontrolled chain reaction is a distant but very real possibility.

FALSE ASSUMPTION #6: THAT ADEQUATE SAFEGUARDS AND SAFETY STANDARDS WILL PROTECT RADIOACTIVE MATERIALS FROM TRANSPORTATION ACCIDENTS, SABOTAGE, WAR AND ACTS OF GOD.

> "Primary reliance for safety in transportation of radioactive material is placed on the packaging...The safety of the transportation system is backed up by a continuing program of designing and testing packages under severe conditions to ensure that in the event of an accident, the likihood of releases of any radioactive material would be quite small."
>
> (and)
>
> "Preliminary analysis of the consequences of sabotage of LMFBR materials in transport has been performed to provide early guidance toward the development of additional safeguards measures for the future."
>
> (and)
>
> "With regard to the impact of the LMFBR on the hazards of war, the AEC has concluded that there would be no significant change on those hazards for any reasonable prediction of wartime events." (Above quotes from WASH 1535, Dec. 1974)

THE FACTS: Within 25 years, according to its proponents, breeder reactors may be supplying nearly one-half of our nation's electricity and producing several million pounds of plutonium every year to be transported by rail, truck or plane.

The chance of a transportation accident that would release hazardous levels of radioactive cesium, strontium and krypton to the atomosphere and the surrounding land area at least once each year would be reasonably good. A single mishap could cause major tragedy. Doses of radioation to the population might be quite high in local areas. The decontamination costs of such an accident could be in the millions of dollars.

The Illinois Atomic Energy Commission in their 1973 report to the legislature warns "...of all the types of shipments, spent fuel rods and high-level waste present potentially the highest risk to the citizens of the State."

The AEC's projected breeder economy for the year 2020[1.] entails 100 railway cars daily loaded with liquid-metal-cooled casks of spent fuel on the way to and from reprocessing plants. The high capital costs of holding up the contained plutonium may lead to a shortening of the pre-shipment cooling period from the present 150 days to 30 days - with activity of the fuel of one 1000-mWe breeder at some half-a-billion curies. Shipping casks designed to withstand a 30-ft. fall or a 30-minute fire may not do so well with a 31-ft. fall or a 31-minute fire; and the consequences of a ruptured fuel cask could be immense. A 1968 AEC study states "it is virtually impossible to design a package to survive any possible accident."

There are many unanswered questions involving the transportation of radioactive materials and the response to radiological accidents. Here are some of them:

1. What emergency measures have been planned to care for prospective transportation accident victims?

2. Have all hospitals along the various spent fuel routes been alerted to the possibility of radiation victims and trained and equipped to care for them?

3. Have Civil Defense units along the transportation routes been alerted and trained in emergency measures to cope with irradiated truck accidents and possible victims?

4. What is the maximum credible transportation accident? Is there insurance available to cover costs to communities and/or victims of such an accident -- or lesser accidents?

5. Why is the fire standard for spent fuel packages set at 1475 degrees since a fire of that temperature is not a very hot fire? Building materials have to be designed to withstand much hotter fires than that. Minimum fire-rated walls designed for residences are required to withstand 1500 degree temperature fires for one hour (ASTEM Standard E119). The temperatures generated by flamable liquid, which normally propels trucks, is higher. Flamable liquid fires can rapidly yield immediate temperatures exceeding 2000 degrees F.

With respect to sabotage, there is the risk that plutonium, which is one of the fissionable materials out of which bombs can be made, may be stolen or acquired through some black market for making an atomic weapon. The process of making a bomb is no longer a secret. Scientists say anyone having the knowledge and the plutonium - could make a crude but effective bomb in a basement workshop.

The AEC's apparent lack of concern over the danger of enemy attack on a nuclear facility is phony and transparent. In April, 1975 they rushed to Vietnam to dismantle and destroy a nuclear reactor. Why?

FALSE ASSUMPTION #7: THAT THE STATE AND LOCAL GOVERNMENT WILL TAKE RESPONSIBILITY FOR RADIOLOGICAL TRANSPORTATION ACCIDENTS.

> "The AEC radiological assistance function is soley advisory. The full responsibility for control of accidents actually rests with local and state authorities. The AEC's principal contribution is to provide the technical capabilities of personnel and instrumentation for assessing the significance and extent of an incident and providing advice regarding the proper procedures to ensure that public exposure is minimized. The AEC also assumes responsibility and control if the occurrences involve its own radioactive materials; even in these cases, however, full cooperation is maintained with the states affected." (WASH 1535, Dec. 1974)

THE FACTS: What are the facts? When are the radioactive materials considered to be AEC materials and their responsibility? Are the Are the spent fuel rods being shipped many miles across the country from the nuclear reactors to the reprocessing plants the responsbility of the AEC or the state and local authorities?

State and local authorities have been told so many times that a radiological accident won't happen that they have no plans at all in the event of a nuclear plant or a train, truck or plane accident involving radioactive materials. The AEC confronts a major problem here: how can it convince people to prepare themselves for an event it wants them to believe won't happen?

Given the non-existent status of most plans, it hardly seems reasonable to assume 90 percent of the population would be evacuated as postulated in the recent Rasmussen report. Ask your local civil defense officials, fire departments, police departments and

emergency hospital personnel regarding preparations for evacuation in the event of a serious radiation accident. Their response, unfailingly, is "What evacuation plans?"

FALSE ASSUMPTION #8: THAT OUR PAST EXPERIENCE JUSTIFIES OUR CONFIDENCE IN THE BREEDER.

THE FACTS: An experimental reactor, the Enrico Fermi plant near Detroit, Michigan, suffered the worst failure of any nuclear reactor to date. In 1966, a coolant line became clogged and the reactor core melted. The reactor was subsequently shut down forever. It had had a total of 30 days of peak power generation at a cost of about $130 million.

Of three breeders operated in the U.S., two have suffered fuel meltdowns. Although no significant radiation escaped either facility, the record doesn't say much for the promise of the technology.

FINAL FALSE ASSUMPTION: THAT THE UNITED STATES SHOULD PROCEED WITH THE LMFBR PROGRAM.

THE FACTS: An AEC that can not produce a safe light water reactor has no business trying to produce fast breeder reactors.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Ms. Catherine T. Quigg
Vice President
Pollution & Environmental Problems, Inc.
54 S. Brockway
Palatine, Illinois 60067

Dear Ms. Quigg:

Thank you for your letter of April 5, 1975 commenting on the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Responses to your specific comments are enclosed. We hope that review of the Energy Research and Development Administration staff responses will serve to correct a number of misapprehensions you have and alleviate your concerns about the LMFBR program.

A copy of the Final Environmental Statement is also enclosed for your information. Thank you again for your comments and for your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Responses to Specific Comments by Catherine T. Quigg

Comment (pages 1 and 2):

"FALSE ASSUMPTION #1: THAT THE LMFBR IS SAFE TO OPERATE.

THE FACTS: Engineers have yet to solve the problem of precisely spacing the thousands of stainless steel rods holding the fissionable material in the reactor's core. Unless the sodium can freely flow around the rods, dangerous overheating and melting result, as demonstrated by the failure of the small experimental Fermi breeder near Detroit."

ERDA Response:

Safety is, of course, not an assumption but an absolute requirement from both the standpoints of responsibility to the public and assurance of continued viability of the LMFBR program. It is expected that R&D efforts will in the near future provide a basis for the conclusion that core disruptive accidents resulting in the generation of significant amounts of mechanical energy are physically unrealizable. Nevertheless, the safety and licensability of LMFBRs do not have to await this R&D result since it is possible to contain significant amounts of mechanical energy from a disruptive accident.

The safety approach as described in Section 4.2.7 of the PFES provides sufficient flexibility considering both the safety R&D program and the design approach of utilizing multiple levels of defense such that safety problems which currently exist or are anticipated can be accommodated by design options for commercial LMFBR plants if not fully resolved by the R&D program for early demonstration and near-commercial plants.

There are no major problems or uncertainties that are not amenable to orderly and planned resolution by the safety R&D program. Apparently these points were inadequately emphasized in the PFES since several commentors appeared to be basing their comments on the premise that an LMFBR cannot be designed to be adequate from the safety standpoint.

While it is true that it is necessary for sodium to be able to flow freely around the fuel rods, there is no problem of spacing. The failure in the Fermi reactor, which is described in Annex C to Section 4.2.7 of the PFES, resulted from a blockage which would not be possible in an LMFBR of current design.

Comment (pages 2 and 3):

"FALSE ASSUMPTION #2: THAT SODIUM IS A WISE COOLANT FOR THE LMFBR.

'The negative aspects of sodium were outweighed by its outstanding advantages.' (WASH-1535, December 1974)

"THE FACTS: "... The negatives of sodium, so readily discounted by the AEC, are these...chemical reactivity with air and water, activation under irradiation, opacity, and lack of technical experience.

"The truth is that sodium is an extremely dangerous and hard-to-control substance. Liquid sodium is used to carry the scorching heat of the breeder through a series of independent loops to the plant's turbo-generators. The super-heated fast reactions can lead to explosions. ... fueling and other operations on the reactor have to be carried on blind. This constitutes a further chemical hazard with respect to failures in circulation pumps, pipes or heat exchangers.

"There is no experience with large, central station, sodium-cooled fast breeder reactor systems. These larger plants will require a much broader technology than now available. The state of the art for detecting, locating, and containing sodium water reactions is rudimentary."

ERDA Response:

Sodium systems have operated routinely in the reactor industry for about 20 years, and the properties of sodium are well understood. As stated in Section 4.2.7.4.1 of the PFES, the primary sodium coolant in an LMFBR is isolated from the water in the steam generating portion of the plant by a complete intermediate (non-radioactive) sodium system. Failures in the steam generator which would permit the contact between secondary sodium and steam or water are recognized as a possibility and design provisions are made to accommodate such failures. Because sodium burns when exposed to air, the primary coolant system, even though it is designed for zero leakage, is normally contained in inerted vaults to preclude sodium burning even in the unlikely event of a sodium leak. Since fuel handling within the reactor vessel is done remotely with the reactor head in place, due to the combustibility of sodium in air, opacity is not an additional problem. Many sodium heated steam generators have been built and successfully operated.

Nevertheless, leakage occurred in some early units and development of steam generators with higher reliability has a high priority in the on-going part of the LMFBR program. Recent successful testing of a modular steam generator and its adoption as the CRBR reference design is an indication of progress being made for this key component. While

it is true that there is no experience with large, central station, sodium-cooled fast breeder reactor systems, attaining such experience is one of the prime objectives of the demonstration plant phase of the LMFBR Program. It should also be noted that experience along these lines is being attained for operation of EBR-II in this country and demonstration plants in France, Russia and England.

Comments (pages 3 and 4):

"FALSE ASSUMPTION #3: THAT PLUTONIUM DOES NOT REPRESENT A CONSIDERABLE THREAT TO HUMAN LIFE AND THE ENVIRONMENT.

> '...a substantial basis for believing that potential health consequences associated with the persistence and accumulation of transuranic elements released by the LMFBR fuel cycle would be small in comparison with many other risks that are accepted by society.' (WASH-1535, December 1974)

"THE FACTS: The breeder reactor program will produce massive amounts of dangerously radioactive plutonium. ...

"Plutonium-239 is the deadliest substance known to man. ... It is known from animal experiments that a particle containing less than one ten-millionth of an ounce of plutonium - a man-made product virtually unknown in nature - contains enough radioactivity to produce lung cancer when inhaled. Scientists are debating over whether an amount 100,000 times smaller will do the same.

"Wilson Clarke in Energy for Survival writes:

> 'Plutonium is fiendish in its toxicity, more poisonous even than anaerobic bacteria, which cause botulism, and 35,000 times more lethal than cyanide poisoning by weight. Professor J.S. Neilands of the University of California at Berkeley notes that there are '20 million mortal doses in a weight of the element equivalent to the weight of an American five-cent piece (5 grams). ...'

"The nuclear experts Willrich and Taylor exposed the magnitude of the combined economic and human threat posed by nuclear proliferation and the plutonium economy."

ERDA Response:

The often-repeated claim that plutonium is the deadliest substance known to man is incorrect, no matter how the administration of plutonium

occurs. By intraveneous injection, the toxicity of plutonium is such that about 20 μCi (0.33 mgms of plutonium-239) per kilogram of body weight is required to kill 50% of the exposed animals within 30 days (the $LD_{50/30}$). Similarly, the $LD_{50/30}$ for inhaled plutonium is about 20 μCi deposited in the pulmonary region of the lung per kilogram of body weight; the estimated quantity inhaled required to achieve this is about 1.3 milligrams per kilogram of body weight. In contrast, comparisons for other substances* are:

botulinus toxin - 7×10^{-9} μgm/kg body weight
tetanus toxin - minimum lethal dose = 10^{-6} μgm/kg
diptheria toxin - minimum lethal dose = 0.3 μgm/kg
cyanide - immediate death - 0.3 mgm/ℓ in air for 1 min.
lead arsenate - minimum lethal dose = 1.4 mgm/kg
curare - minimum lethal dose = 0.5 mgm/kg

Thus it is apparent that other substances are considerably more toxic or "deadly" than plutonium. It should also be pointed out that most of these substances are lethal within seconds, minutes, hours or a few days.

It must be kept in mind that the risk resulting from inhalation or ingestion of microgram quantities of plutonium is a long-term one in which a potential cancer might develop after a latent period of up to 20 to 30 years or more. If quantities of plutonium of respirable size particles were to be inhaled such that acute lethality is the endpoint (as is the case with botulinus toxins, tetanus toxins, cyanide, etc.), extrapolation of data from animal species to man indicates that relatively large quantities of plutonium (in the range of nearly a hundred milligrams) must be inhaled. This is orders of magnitude greater than the toxic levels of the other substances (e.g., a few breaths of cyanide in a concentration of 0.3 mg/ℓ of air will cause almost immediate death). Considering the time factors involved and assuming that "lethal" means acute lethality, as is the case with sufficient quantities of cyanide, the data upon which the figure of 35,000 is based is not readily apparent; nor is evidence presented providing data upon which the botulism statement is based. Placing the relative risks in a different perspective, it has been calculated that a teaspoonful of the botulinus toxin would be sufficient to kill about 140 million persons if distributed to people equally and taken orally; on the other hand, a teaspoonful of plutonium taken orally would be about half enough to kill one person.

*Data obtained from references furnished by the National Academy of Sciences Advisory Center on Toxicology, the Edgewood Arsenal, and Science, Vol. 144, pp. 1100-1110, May 29, 1964.

The comparison of Professor J. S. Neilands is theoretically correct only IF the plutonium equivalent of the maximum permissible lung burden - 16 nCi - of the International Commission on Radiation Protection and the National Council on Radiation Protection and Measurements is in fact a "mortal" dose, and IF the following are also true:

1) That all of the plutonium is contained in optimally respirable sized particles.

2) That the 5 gms of plutonium is dispersed equally and exclusively to the 20 million people.

3) That each person inhales, and retains in the lung parenchyma, the allocated quantity of plutonium; however, since the lungs retain only a portion of what is inhaled, this is not possible.

4) That the induction of lung cancer is a function of the total quantity of plutonium in the lung and not of the concentration of plutonium per gram of lung.

5) That each person lives long enough to develop any potential cancer. The maximum permissible lung burden has not been shown to be a "mortal" dose, or a cancer-producing dose, even though a number of persons have been exposed to lung burdens greater than this for nearly 30 years.

Furthermore, it is apparent that items 2, 3 and 5 are either totally unrealistic or clearly impossible; item 1 is unrealistic, but possible; item 4 is under investigation to determine which of the two parameters is the dominating one. Again it must be kept in mind that "mortal" as used regarding plutonium relates to the possibility that lung cancer might develop 10, 20 or more years after exposure, while "mortal" with respect to other toxic substances refers to acute or immediate death. Therefore, experience and physical and physiological realities relegate the statement to a numbers exercise with little reality to the real world.

We would also point out that, if distributed equally among persons, five grams of:

a) botulinus toxin would kill about 10^{13} persons (10 trillion people);

b) tetanus toxin would kill about 10^{9} persons (nearly a billion people);

c) diptheria toxin would kill about a quarter of a million persons.

Such number exercises have little relationship to reality.

It should also be pointed out that if plutonium were as fiendishly toxic as is claimed, the greater than 5 tons dispersed by means of atmospheric weapons testing would have been expected to have caused catastrophic effects by this time. Thus far, only one part in about 10^8 parts of atmospherically released plutonium has found its way into man (about one part in 10^{17} parts per person)--after up to about 30 years continuous exposure. Similarly, many tons of plutonium have routinely been handled by literally thousands of persons employed in nuclear weapons complexes. Thus far this group of potentially exposed workers has not exhibited a single health effect which can be related to plutonium. Therefore, while plutonium is toxic in the sense that, in sufficient quantities, it will produce cancer, just as other substances are toxic and exposure to them will result in an acute death, the fact that a substance is toxic does not mean a priori that x grams of the substance will result in y deaths or health effects.

As was pointed out in the PFES, the "release of plutonium during normal operation of breeders" is extremely small. The major release of plutonium from normal operation of the LMFBR fuel cycle would be from the fuel reprocessing plant. There a "worst case" situation is assumed in that it is postulated that the entire release is in the form of respirable size particles of plutonium dioxide. Such a release is evaluated in the PFES in terms of the potential health consequences.

It is not known from animal experiments that a particle containing less than one ten-millionth of an ounce of plutonium contains enough radioactivity to produce lung cancer when inhaled. While it is true that this quantity of inhaled plutonium has been known to produce lung cancer, it should be pointed out that the total activity inhaled was contained in literally tens of thousands of particles; it was not contained in "a particle." There has not been any experiment which assessed the effect of a single inhaled particle containing the quantity of plutonium indicated. In fact, a single particle containing this quantity of plutonium-239 would be too large to inhale and be deposited in the pulmonary region of the lung.

The term "scientists are debating" implies that there is widespread discussion and debate of this matter throughout the scientific community, whereas in fact, except for the NRDC, there is essentially uniformity of opinion not only in this country but also in the United Kingdom that the "hot particle" hypothesis is not a justifiable one. This opinion

has been expressed by every organization which has reviewed the "hot particle" hypothesis: ERDA, the Los Alamos Scientific Laboratory, the National Radiological Protection Board of U.K., the Medical Research Council of U.K. and the National Council on Radiation Protection and Measurements. In every case the validity of the "hot particle" hypothesis has been rejected.

In Volume IV, Section 7.4, the PFES gives full recognition to the potential threat of illegal acts against the nuclear fuel cycle which could result in deliberate releases of plutonium, or even nuclear explosives. Additional information on the safeguards program is provided in Section III C of the FES. The fact that such threats are considered to exist is the reason for the existence of strong and effective safeguards to protect the public and the Nation as a whole. ERDA believes that while a "threat" may exist today and can be expected to continue to exist in the future, the probability of occurrence of these events is so small that the overall risk to the public is very low.

Comment (pages 4 and 5):

"FALSE ASSUMPTION #4: THAT THE RELEASE OF TRITIUM TO THE ENVIRONMENT SHOULD BE ACCEPTED BY THE AMERICAN PUBLIC UNTIL RESEARCHERS LEARN HOW TO RESTRICT IT.

'Research on ways to reduce the release of tritium from the LMFBR power plants is being planned.' (WASH 1535, Dec. 1974)

"THE FACTS: Tritium is toxic. It can be built into all the organic materials of our bodies just as if it were hydrogen. ...

"What if further research proves that tritium does irreversible and considerable damage to man's genetic structure, what will the AEC and the utilities do to remove the tritium already dumped in our water? What can they do?"

ERDA Response:

Researchers have already learned how to reduce the release of tritium from nuclear power plants and fuel reprocessing plants. Doses due to the release of tritium were discussed in Appendix II.0 of the LMFBR Program PFES. Methods to control the release of tritium from LMFBR power plants were discussed on pages 4.2-32 to 4.2-43 of the PFES. Methods to control tritium releases from fuel reprocessing plants were

discussed on pages 7.3-2, 4.4-45 and 4.4-35 to 4.4-37. Doses due to tritium releases were given in Tables 4.2-7, 4.4-9, 4.4-10, 4.4-12, 4.5-33, 4.5-34, 9.1-8 and 9.1-9 of the PFES. Dose conversion factors for tritium releases were listed in Appendix II.E of the PFES. It is felt that the health effects of tritium are well enough known that tritium dose and health effects estimates can be made with confidence.

Comment (pages 5 and 6):

"FALSE ASSUMPTION #5: THAT PROSPECTS ARE GOOD FOR A SOLUTION TO THE PROBLEM OF RADIOACTIVE WASTE DISPOSAL.

"THE FACTS: The AEC's favorite theoretical solution has been disposal of nuclear wastes in geological formations, and extensive research has been carried out on a site at Lyons, Kansas. In 1971, the AEC was forced to abandon the site as unusable, despite the fact that the Commission had just requested $25 million from Congress to proceed with actual waste burial. The site was rejected after the accidental discovery of old gas and oil bore holes penetrating the Lyons salt mine and the underground loss of 100,000 gallons of water from mining operations of the salt company, both of which might have led to a flooding of the repository and dispersal of wastes.

"Meanwhile, under AEC regulations, high-level commercial weapons wastes are to be solidified after five years of storage and shipped to a federal repository — but such a repository does not now exist and may not exist for some time."

ERDA Response:

The preceding discussion contains a number of serious errors and misconceptions. The disposal of radioactive wastes in geological formations has been advocated by many individuals or groups other than the AEC (or ERDA). In early 1971, the AEC did request Congress to authorize and appropriate $25 million for disposal of such wastes in a salt mine. However, this request did not include a final choice of the Lyons site for actual waste burial. The selection of Lyons was described in the request as tentative and subject to the satisfactory completion of certain additional tests and studies.

Old oil and gas bore holes were not accidentally discovered after the date of the authorization request. Their existence was known at the time, and their exact location and plugging was one of the tasks to be

accomplished in changing the selection of the site from tentative to final. Further, none of them actually penetrated the Lyons mine; they were merely in the general vicinity. Also, the loss of water from mining operations was not in the Lyons mine itself, but in a nearby mine.

In mid-1972 (not just after the request to Congress) the AEC decided that the technical questions as to the safety of Lyons might not be satisfactorily resolved in a reasonable period of time, and that a different site or sites should be sought for geological disposal, not necessarily limited to sites in bedded salt. This search is in progress. As discussed in the PFES, the evaluation of promising geological formations and sites leading to a pilot geological repository, which in turn could lead to a permanent disposal system, is a major part of the ERDA radioactive waste program. At present, ERDA is studying several promising geological formations other than bedded salt, including a study of specific promising sites, to bring the state of knowledge of these other formations up to the same level as that of bedded salt. Comparative evaluation of these formations and selection of the best site or sites for pilot plant operations would follow. We believe that the Lyons problems were specific to that site and that the prospects of an acceptable permanent disposal system have been delayed, but not invalidated, by the Lyons history. We believe the critics of the ERDA permanent disposal program are primarily critical of the intensity of the effort and do not question that geological disposal can be achieved.

The intent of the reference to "high-level commercial weapons wastes" is not clear. Radioactive wastes from the production of nuclear weapons are found only at Government sites, and the cited regulation pertains to wastes from the processing of spent fuel from commercial nuclear power production. The mandatory shipment to a Federal repository is ten years after processing the fuel, not the five years indicated.

Comment (page 6):

"The past performance of the AEC in regulating storage of nuclear weapons does not inspire confidence in their ability to contain wastes for even a few years. Last year, for example, leaks of radioactive materials from storage tanks in Hanford, Washington went undetected for seven weeks. When finally discovered, 115,000 gallons of radioactive wastes had seeped into the ground. All told, nearly 500,000 gallons have leaked out at that installation alone.

"The radioactive waste leakage at Hanford includes large quantities of plutonium, and is true with breeder reactors, the potential for an uncontrolled chain reaction is a distant but very real possibility."

ERDA Response:

The statements are highly misleading, even if the opening reference to "storage of nuclear weapons" is assumed to mean "storage of wastes from the production of nuclear weapons." The reference to leakage at Hanford omits several vital facts. First, the radioactivity in the leaked waste was absorbed in the soil close to the points of leakage, and thus did not produce any radiation exposure to the public. Second, all the Hanford leaks have been from an older type of single-wall tank which is no longer being constructed. Third, there have been no leaks of liquid waste into the soil from tanks of the newer double-wall design which have been used in all new tank construction at both Hanford and Savannah River for some years; also, there have been no leaks of waste into the soil from the tanks within vaults used at the Idaho site. Finally, the Nuclear Regulatory Commission has taken the position that either double-walled tanks or tanks within vaults will be required for storage of high-level liquid waste at commercial spent fuel reprocessing plants.

For these reasons, it is wrong to imply that the Hanford leak experience must be expected at future commercial plants, during the limited period in which high-level liquid waste storage is permitted at those plants.

It is true that typical high-level radioactive waste may contain unrecovered plutonium up to about one-half of one percent of that in the fuel. This plutonium is dispersed through a very much larger bulk of nonfissionable material in the waste. Concentration of such wastes in the quantity and purity required for fissioning, through a leak or any other accidental mechanism, is not considered credible.

Comment (pages 7-9):

"FALSE ASSUMPTION #6: THAT ADEQUATE SAFEGUARDS AND SAFETY STANDARDS WILL PROTECT RADIOACTIVE MATERIALS FROM TRANSPORTATION ACCIDENTS, SABOTAGE, WAR AND ACTS OF GOD.

11

"THE FACTS: "... The AEC's projected breeder economy for the year 2020 entails 100 railway cars daily loaded with liquid-metal-cooled casks of spent fuel on the way to and from reprocessing plants. The high capital costs of holding up the contained plutonium may lead to a shortening of the pre-shipment cooling period from the present 150 days to 30 days - with activity of the fuel of one 1000-mWe breeder at some half-a-billion curies. Shipping casks designed to withstand a 30-ft. fall or a 30-minute fire may not do so well with a 31-ft. fall or a 31-minute fire; and the consequences of a ruptured fuel cask could be immense. A 1968 AEC study states 'it is virtually impossible to design a package to survive any possible accident.'

"There are many unanswered questions involving the transportation of radioactive materials and the response to radiological accidents. Here are some of them:

1. What emergency measures have been planned to care for prospective transportation accident victims? ...

2. Why is the fire standard for spent fuel packages set at 1475 degrees since a fire of that temperature is not a very hot fire? Building materials have to be designed to withstand much hotter fires than that. Minimum fire-rated walls designed for residences are required to withstand 1500 degree temperature fires for one hour (ASTEM Standard E119). The temperatures generated by flammable liquid, which normally propels trucks, is higher. Flammable liquid fires can rapidly yield immediate temperatures exceeding 2000 degrees F."

ERDA Response:

With regard to shipping casks, ongoing tests (such as 2000' drops) with obsolete casks indicate that casks designed to meet the requirements of the standards will maintain their integrity under conditions more severe than those likely to be encountered in transportation accidents. As stated on page II.A-10 of the LMFBR Program PFES, concerning transportation accidents involving fires:

"Severe transportation fires seldom last more than 1/2 hr, except in ships and storage depots,[15] because either the fuel is exhausted or the fire is extinguished by fire-fighting crews. Although flame temperature of liquids such as jet fuel or kerosene may reach 1800 to 2000°F, such peak temperatures are reached only very locally on the surface of material

involved in the fire. Only under very unusual circumstances is more than 50% of a package surface likely to be exposed to the flame for as long as 1/2 hr. Even in a longer fire, the package may be in a location where the fire has little or no effect on it. In addition, packages in fires that have burning surface areas smaller than about 400 ft^2 are frequently able to 'see' through flames to cooler surrounding areas. Fires that have burning surface areas greater than about 2000 ft^2 may suffer from oxygen starvation in the interior of the fire. In petroleum fires, both situations could cause reduced heat inputs to the packages."

A discussion of information related to emergency measures to be taken following transportation accidents was presented in Appendix II.M of the PFES. Basically, the Nuclear Regulatory Commission (NRC), with support from the Department of Defense and ERDA, will provide assistance to anyone requesting it following such accidents.

Comment (page 9):

"With respect to sabotage, there is the risk that plutonium, which is one of the fissionable materials out of which bombs can be made, may be stolen or acquired through some black market for making an atomic weapon. The process of making a bomb is no longer a secret. Scientists say anyone having the knowledge and the plutonium - could make a crude but effective bomb in a basement workshop.

"The AEC's apparent lack of concern over the danger of enemy attack on a nuclear facility is phony and transparent. In April, 1975 they rushed to Vietnam to dismantle and destroy a nuclear reactor. Why?"

ERDA Response:

Your comment implies that the fabrication of an illicit nuclear weapon using stolen plutonium would be a relatively easy task. While we recognize that what would be difficult or even impossible for a particular individual or group might conceivably be easy for another, we believe that this question can be put into its proper perspective only by an objective consideration of the particular tasks to be performed and the skills required for successful completion of these tasks. Section 7.4.5.1.1 discusses some of the problems involved. The general conclusion reached is that the overall probability of any successful explosion of an illicit nuclear weapon is very low.

In March 1975, ERDA personnel removed the nuclear fuel from a research reactor facility at Dalat, South Vietnam, and took action to have the fuel returned to the U.S. These personnel did not dismantle or destroy the facility. The reactor facility had been provided to South Vietnam some years earlier, under the Atoms for Peace program. The fuel itself was owned by the U.S. and leased to South Vietnam. The March 1975 action was requested and approved by the Department of State. The purpose of the action was to prevent the nuclear fuel from falling into the hands of unauthorized persons. At the time of its removal, the fuel had been thoroughly cooled so that its residual radioactivity was minimal. Thus there would have been essentially no risk of widespread contamination if the facility had come under military attack.

Comment (pages 10 and 11):

"FALSE ASSUMPTION #7: THAT THE STATE AND LOCAL GOVERNMENT WILL TAKE RESPONSIBILITY FOR RADIOLOGICAL TRANSPORTATION ACCIDENTS.

> 'The AEC radiological assistance function is solely advisory. The full responsibility for control of accidents actually rests with local and state authorities. ...

"THE FACTS: What are the facts? When are the radioactive materials considered to be AEC materials and their responsibility? ...

"State and local authorities have been told so many times that a radiological accident won't happen that they have no plans at all in the event of a nuclear plant or a train, truck or plane accident involving radioactive materials. ...

"Given the non-existent status of most plans, it hardly seems reasonable to assume 90 percent of the population would be evacuated as postulated in the recent Rasmussen report. ..."

ERDA Response:

Since September of 1972, State and local government authorities have been formally receiving emergency planning guidance from the former AEC-Regulatory arm (now NRC) and other Federal agencies. A series of four seminars entitled "State Emergency Planning in Relation to Licensed Nuclear Facilities" were conducted by the former AEC and other

involved Federal agencies between September of 1972 and May of 1973. The seminars were attended by emergency planning representatives from all fifty States.

On November 16, 1973, the AEC published its "Interim Guide and Checklist for the Development and Evaluation of State Radiological Emergency Response Plans for Fixed Nuclear Facilities" for use by State and local government personnel involved in emergency plan development. On December 1, 1974, the AEC revised the "Interim Guide and Checklist" and published it as "WASH-1293", "Guide and Checklist for Development and Evaluation of State and Local Government Radiological Emergency Response Plans in Support of Fixed Nuclear Facilities." A copy is attached for your information.

Many of the essential planning elements identified in WASH-1293 are also applicable to developing emergency plans to cope with the consequences of transportation accidents involving radioactive materials. The NRC is currently involved in developing additional guidance to cope with the unique characteristics of the transportation accident. A "Guide and Example Plan for Development of State Emergency Response Plans and Systems for Transportation - Related Radiation Incidents" has been developed under contract with the NRC and published by the Western Interstate Nuclear Board and (State) Regional Training Committee, Region VIII. This document is currently being evaluated by other States, the NRC and other Federal agencies.

A training program in "Radiological Emergency Response Planning" for State and local government emergency planning personnel has been established at the Defense Civil Preparedness Agency (DCPA) Staff College in Battle Creek, Michigan by the NRC and other involved Federal agencies (a Federal Interagency group). Approximately 50 State and local government emergency planning personnel have attended this one-week course and eight courses are planned for FY-76.

In addition to the formal training and guidance provided by NRC and other involved Federal agencies, the Federal Interagency group provides field assistance in radiological emergency response plan development and improvement directly to the States upon their request. This is accomplished via a "Federal Interagency Field Training Cadre."

Most States now have active programs underway to improve their radiological emergency response posture and plans. The NRC, and other involved Federal agencies, recognize that certain improvements need to be made in State and local government radiological emergency response plans. By virtue of the above outlined activities, the NRC is actively pursuing a multi-faceted program of providing guidance, assistance and training to State and local governments.

Research and development efforts on several aspects of these problems are underway at several of the National Laboratories and by the NRC and ERDA headquarters staffs. Examples include the Atmospheric Release Advisory Capability (ARAC) at the Lawrence Livermore Laboratory, the Clinch Valley Study at the Oak Ridge National Laboratory, and a rapid version of the Aerial Radiation Monitoring System (ARMS) being considered for development by the headquarters staffs. In addition, studies of the evaluation of risks of evacuating population groups are underway within EPA.

NRC responsibilities and actions have been mentioned in the previous paragraphs. ERDA is responsible for shipping nuclear materials that are primarily for use in ERDA test and production reactors or for nuclear weapons.

Comment (page 11):

"FALSE ASSUMPTION #8: THAT OUR PAST EXPERIENCE JUSTIFIES OUR CONFIDENCE IN THE BREEDER.

"THE FACTS: An experimental reactor, the Enrico Fermi plant near Detroit, Michigan, suffered the worst failure of any nuclear reactor to date. In 1966, a coolant line became clogged and the reactor core melted. The reactor was subsequently shut down forever. It had had a total of 30 days of peak power generation at a cost of about $130 million.

"Of three breeders operated in the U.S., two have suffered fuel meltdowns. Although no significant radiation escaped either facility, the record doesn't say much for the promise of the technology."

ERDA Response:

As indicated earlier, the failure in the Fermi reactor is described in Annex C to Section 4.2.7 of the PFES, and resulted from a blockage which would not be possible in an LMFBR of current design. Both the Fermi Reactor and the EBR-I are quite different in design from planned LMFBR's. For example, the fuel was metallic (relatively low melting point) compared with the oxide fuel (melting point around 5000°F) used in current light water reactors and planned LMFBR's.

Although, as you correctly point out, the Fermi Reactor is no longer in operation, it was in operation until 1972. The decision to decommission rather than refuel the reactor (for economic reasons) was announced on

November 29, 1972. The EBR-I was an early experimental reactor and meltdown occurred during experimentation of a type which would not be conducted in a commercial reactor.

Comment (page 11):

"FINAL FALSE ASSUMPTION: THAT THE UNITED STATES SHOULD PROCEED WITH THE LMFBR PROGRAM.

"THE FACTS: An AEC that can not produce a safe light water reactor has no business trying to produce fast breeder reactors."

ERDA Response:

We believe that the light water reactor safety record speaks for itself and that this record will be maintained for reactors of all types.

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

April 3, 1975

Mr. W. H. Pennington
U. S. Energy Research and
Development Administration
Assessments and Coordination Officer
Division of Biochemical and Environmental Research
Washington, D. C. 20545

Dear Mr. Pennington:

We appreciate the opportunity to comment on the U. S. Energy Research and Development Administration's Proposed Final Environmental Impact Statement on the Liquid Metal Fast Breeder Reactor Program which was circulated for comment on January 24, 1975. The Bureau of Power by letter dated May 16, 1975 from Mr. T. A. Phillips commented on the Draft Environmental Impact Statement. A copy of that letter and response related thereto are included in the proposed final statement.

The FPC staff views the Liquid Metal Fast Breeder Reactor (LMFBR) as having the potential for improving the critical energy supply situation. Recent experiences regarding energy shortages and prospects for continuing and increasingly serious problems emphasize and point to the urgent need for the timely development of all our potential energy sources while giving full consideration to overall environmental interests.

The staff of the Federal Power Commission has examined the Proposed Final Statement and continues to believe that the LMFBR program, if brought to fruition, would contribute toward the reliability and adequacy of bulk electric power systems. However, the demonstration plant schedule has slipped since we commented on the Draft Environmental Impact Statement, as have the projected additions of light water reactor capacity, so that some of the generating capacity data given at that time are out of date. Although it now appears that, through 1980, actual demands may be below the projections of the 1970 National Power Survey, the Bureau of Power believes it is quite possible that electric loads by 1990 would equal or exceed the National Power Survey projections if there

is extensive substitution of coal and nuclear energy, via electricity, for present oil and natural gas applications. We believe that the long term need for the LMFBR has not been diminished by the current slowdown in load growth.

The Proposed Final Environmental Statement assumes a base case growth of electricity production by the year 2020 to a level about 15 times the current level. That amount of electricity would account for 65 percent of the annual consumption of all energy resources in that year, compared with 25 percent today. The assumed growth is equivalent to a compound rate of about 6 percent per year, which is possible, but lower growth rates are also possible. In its cost-benefit study, however, the Statement examines a growth rate 50% below the base case; thus, we consider that the Statement adequately covers a range of reasonable growth possibilities.

The Statement notes that the AEC recently estimated that high grade U. S. uranium resources amount to about 2.4 million tons of U_3O_8, two-thirds of which remain to be discovered, but that these will be fully committed for the lifetime uranium requirements of nonbreeder nuclear plants estimated to be in operation by the early 1990s. This depletion of uranium resources is reflected to the base case projection for 2020, which indicates that of the 76 percent of electric generating coming from nuclear plants in that year, about 2/3 would be derived from LMFBRs. The generation from fossil sources in 2020 would be 3½ times the total U. S. generation in 1974, indicating a rate of coal consumption for electric power approximately 6 times the current rate, or about 2,400,000 tons per year. Consequently, the projection recognizes the potential for expanded use of coal even though indicating that about one-third the Nation's total energy supply in 2020 would be derived from LMFBRs. We consider this projected expansion of fossil generation to be reasonable.

The probable availability of uranium for non-breeder reactors without the LMFBR, the possibilities of other forms of fission reactors and the prospects for fusion reactors are not topics on which we are sufficiently well informed to offer comment. We agree with the Statement's general observation that declining supplies of oil and

natural gas place principal emphasis upon coal as the fossil fuel technology alternative to the LMFBR, but that environmental problems place obstacles to greatly expanded coal use and that exclusive use of coal as the energy source for electricity could deplete the Nation's reserves in less than a century.

We do not disagree with the Statement's evaluation of the various estimates of U. S. coal resources and of the range of costs involved in their development. The Statement forecasts that total coal production will be in the neighborhood of 2,000 million tons annually by the year 2000, more than three times the current rate, of which about half, or 1,000 million tons annually, would be used in electric power plants. We believe this projection to be within the range of reasonable possibilities, but that power plant use of coal by the year 2000 could be somewhat higher than 1,000 million tons per year. The 1970 National Power Survey projected utility coal consumption in 1990 at 700 million tons per year, before the shortfall in oil, natural gas and nuclear power was evident.

The Statement's projection of oil and natural gas use for electricity generation, embodied in Table 6A. 2-13, is reasonable, although the government's efforts to restrict oil use are aimed at considerably lower levels of utility oil consumption by 1980 and 1985. The Statement does note that the oil estimates were prepared in 1972 and are subject to revision in view of events that have transpired since. We agree that oil from shale or tar sands is unlikely to be significant for electric power generation.

The Statement's discussion of hydroelectric potential and the declining role of hydro in respect to total power supply is based upon FPC reports and publications and requires no comment.

There is considerable discussion of geothermal power in the Statement, including resources and technology development, with the conclusion that geothermal power could become an important source of energy in some western regions by the end of the century, but that it is questionable whether it will become of national significance in the foreseeable future. Solar energy is also discussed at some length, with the conclusion that despite the inexhaustible

supply its only potentially significant energy role in this century is as thermal energy for buildings, and that this use will not materially reduce the demand for electricity. Wind power is evaluated as a potentially useful source of energy for small communities, but not as a supplement for large power systems. The commercial feasibility of ocean thermal-gradient power plants is described as uncertain, tidal energy is evaluated as too small and costly to be a significant energy supply factor and energy from organic wastes, while practicable and useful for waste disposal, is considered to be too small a resource to have a large energy impact. We have no disagreement with these general observations.

The Statement also discusses internal combustion engines, gas turbines, binary cycles, fuel cells, batteries, thermoelectric converters, thermionic convertors and magnetohydrodynamics. Its characterizations of the technology status and potential uses in electric power supply of these concepts is realistic.

The Statement includes a discussion of conservation options and their potential with respect to future demand for electricity. This section is regarded by staff as a fair appraisal of the question. We would, however, suggest caution when discussing the relative efficiencies of space heating by electricity compared to direct combustion of fossil fuels. The actual operating efficiencies are dependant on a large number of variables and a general statement to the effect that one system is more efficient than another by a certain amount is not possible.

Based upon an evaluation of these comments we believe that the LMFBR program is a vital element in the national energy effort.

Sincerely,

Richard F. Hill
Acting Director, Office of
Energy Systems.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Richard Hill
Acting Director
Office of Energy Systems
Federal Power Commission
Washington, D. C. 20426

Dear Mr. Hill:

Thank you for your letter of April 3, 1975 on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. We agree that the LMFBR has the potential to become an important energy option in the national energy effort. We particularly appreciate the FPC staff review of the assumptions used in respect to energy resources and their projected utilization. It is most encouraging to have the FPC judgment that these assumptions generally have been within reasonable bounds.

We appreciate the Commission's continuing interest in the LMFBR program. A copy of the Final Environmental Statement is enclosed.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

HEALTH AND
ENVIRONMENT

8 APR 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
U. S. Energy Research & Development
Administration
Washington, D. C. 20545

Dear Mr. Pennington:

This is in response to the Council on Environmental Quality's request of February 3, 1975, for our review of Energy Research and Development Administration's final environmental impact statement on the liquid metal fast breeder reactor (LMFBR) program. We have reviewed the document with special emphasis on the national security aspects of safeguards and believe the statement has reasonably considered the factors to balance the predicted environmental costs against the potential gains to our society. The impact of a military attack directed toward the LMFBR has been adequately discussed, and we concur in the findings that the LMFBR will not significantly add to the problems confronting the nation if we are involved in a war.

The possibility of theft or diversion of plutonium is a major concern. Current safeguards must be improved to keep pace with the growing non-breeder reactor program. We believe it is essential to carry out plans to do this in the near term, and that the system of interrelated safeguard measures used to protect nuclear facilities can continue to protect against terrorist or other criminal efforts to obtain special nuclear materials when the LMFBR is a major element in the nation's economy.

The long term hazardous waste management problems for both high level radioactivity and other wastes are still not resolved. This should continue to receive high R&D priority in the ERDA program.

We appreciate the opportunity to review the final environmental impact statement.

Sincerely,

George Marienthal

George Marienthal
Deputy Assistant Secretary of Defense
for Environmental Quality

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. George Marienthal
Deputy Assistant Secretary of Defense
for Environmental Quality
Washington, D.C. 20301

Dear Mr. Marienthal:

Thank you for your letter of April 8, 1975, which provided comments on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor Program.

We concur completely with your comments on the need for current and continued strengthening of safeguards against theft and diversion of plutonium, and on the need for resolution of long term hazardous waste management problems. The Energy Research and Development Administration (ERDA) is conducting vigorous research and development programs in both areas. These programs are being coordinated with the Nuclear Regulatory Commission to assure timely reflection of new technology into the commercial segments of the nuclear fuel cycle. We are confident that these and other ERDA R&D efforts will permit the continuing orderly development of safe and reliable commercial nuclear power as required to meet the Nation's needs.

In response to the written comments received on the PFES and the testimony presented at the May 27-28, 1975 Public Hearing, a Final Environmental Statement has been prepared. A copy is enclosed for your information. We appreciate your participation in the final review.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

MORGAN, LEWIS & BOCKIUS
COUNSELORS AT LAW
1140 CONNECTICUT AVENUE, N. W.
WASHINGTON, D. C. 20036
TELEPHONE: 202 872-5000
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April 9, 1975

Mr. W. H. Pennington
Assessment and Coordination Officer
Division of Biomedical and Environmental
Research
U.S. Energy Research and Development
Administration
Washington, D.C. 20545

Re: Proposed Final Environmental Statement -
Liquid Metal Fast Breeder Reactor Program

Dear Mr. Pennington:

On behalf of Project Management Corporation (PMC), we present our comments in relation to the proposed final environmental statement on the LMFBR program. We have reviewed the statement and wish to commend the Commission for its thorough analysis of the complex issues associated with the LMFBR program.

We should emphasize that the proposed final environmental statement establishes a compelling case for priority pursuit of the nation's LMFBR program. The statement analyzes all segments of the LMFBR fuel cycle, compares that fuel cycle with alternative energy strategies, and demonstrates that the LMFBR will produce enormous benefits to consumers of electric power, minimal environmental impact, and no undue risk to the public health and safety. In addition, the statement directly addresses all comments in a responsive and forthright manner. We do not believe that any energy development project other than the LMFBR program has received a comparable degree of scrutiny.

We believe that the assessment of the merits of the LMFBR program has now reached a critical point. Further

analysis can only strengthen the compelling case for priority pursuit of the LMFBR program. We urge the Administrator to take prompt and favorable action on the LMFBR program.

Very truly yours,

George L. Edgar
Attorney for Project
Management Corporation

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. George L. Edgar
Attorney for Project
Management Corporation
Morgan, Lewis and Bockius
1140 Connecticut Avenue, N.W.
Washington, D. C. 20036

Dear Mr. Edgar:

Thank you for your letter of April 9, 1975 concerning the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. We appreciate the favorable comments on the Statement and your support of the LMFBR Program.

A Final Environmental Statement has been prepared which takes into account the written comments received on the PFES as well as the testimony presented at the May 27-28, 1975 Public Hearing. A copy is enclosed for your information.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

Marsha Descotiaux
Rt 2 Box 543
Clatskanie Ore. 97016
April 3, 1975

Dear W. H. Pennington,

Please do not lead us into more nuclear economic and safety follies I do not want to be a part of their odds game. Lets study the question for no less than 20 years, in light of the fact that the cancers it's leaks produce seem to take 20 years or more to appear. Please put the money into nice stable solar cells. Lets leave a legacy to the next Generation of something besides radioactive and plastic garbage

Sincerely
Marsha Descotiaux

04323

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Ms. Marsha Descotiaux
Rt. 2, Box 543
Clatskanie, Oregon 97016

Dear Ms. Descotiaux:

Thank you for your letter of April 3, 1975 in which you expressed your views on the use of nuclear energy. The Energy Research and Development Administration (ERDA) recognizes that safety and protection of the public health are important considerations in the use of nuclear power, and accordingly ERDA is conducting the necessary programs to ensure that the public is not endangered.

As you recognize in your letter, radioactive materials can pose a cancer risk. However, this risk is well understood and nuclear facilities are designed to limit the release of nuclear material to low levels that do not expose the public to unacceptable levels of risk. Naturally occurring radiation is always present in the environment, and the radiation exposure resulting from nuclear power is equivalent to a very small fraction of that due to naturally occurring radiation.

Commercial nuclear power plants have been operating in the U.S. for nearly two decades and during that period they have demonstrated that nuclear power can produce low cost electricity without endangering the public. In order to extend the benefits of nuclear power over many centuries, ERDA is engaged in research, development and demonstration of the Liquid Metal Fast Breeder Reactor (LMFBR) concept. In support of that effort and to meet the requirements of the National Environmental Policy Act a Final Environmental Statement (FES) for the LMFBR Program has been prepared. Section II of this document addresses your concerns in great detail and we have enclosed a copy of the FES for your information.

You state that you feel development funds could be better spent on solar cells. Although our environmental review of the LMFBR Program has led ERDA to conclude that continuation of research, development and demonstration of the LMFBR concept is needed, continuation of the LMFBR Program will not be at the expense of alternative power generation and conservation concepts, which must be developed on a priority basis. Indeed, these other technology options including solar energy, which are examined in Section II of the Final Environmental Statement, are receiving substantially

increased appropriations in the current fiscal year and are proceeding at a pace limited only by the need to build up the new programs efficiently and effectively.

It is hoped that your review of the enclosed Final Environmental Statement will alleviate your concerns, and we thank you for your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE
ASSISTANT DIRECTOR
FOR NATIONAL AND
INTERNATIONAL PROGRAMS

April 9, 1975

Mr. W. H. Pennington
Assessments and Coordination
Officer
Division of Biomedical and
Environmental Research
U. S. Energy Research and
Development Administration
Washington, D. C. 20545

Dear Mr. Pennington:

Through the Foundation's Committee on Environmental Statements, we have reviewed WASH-1535-Liquid Metal Fast Breeder Reactor Program. The comments received on WASH-1535 are attached. Should you wish to contact the individuals who submitted these comments to the Committee, please call John Giacomini on 632-7360.

Sincerely,

T. O. Jones
Deputy Assistant Director for
National and International Programs

Attachment

COMMENTS ON WASH-1535

LIQUID METAL FAST BREEDER REACTOR PROGRAM

1. The Environmental Impact Statement must be accepted as a sincere and competent effort to address the environmental consequences of the LMFBR in the total context of our society. Because of the scope of this endeavor there is a lag between when the report is written and when it is reviewed. As a result much of the data used to predict future events is outdated before it can be published. This is particularly true in regard to future demand projections and the potential impacts of energy conservation programs. The cost-benefit analysis of the LMFBR in the EIS is based upon a development cost on the order of $5 billion and an introduction date of 1987. The Wall Street Journal (1-27-75) reports that the current estimates are for a development cost of $10 billion and an introduction date in the 1990's. Reportedly, the GAO has studied the total costs of the program. These results should be updated in the EIS.

There are two aspects of the LMFBR that do not receive sufficient attention in the EIS. First, the question of "net energy" is not resolved. Second, the question of "public acceptance" of the LMFBR is not considered fully. Even if all of the economic, technical, and environmental problems of the LMFBR might be successfully solved, the solutions will be academic if the proponents of the LMFBR are unable to gain public acceptance for the construction of the power plants. This could be a crucial issue. The public could still say "no" after all questions have been answered. The emotional tone should be one of acceptance.

2. The ERDA legislation includes a mandate from Congress that net energy be considered in energy research and development. The primary conceptual flaw in the document is the neglect of the question of potential net energy production by the LMFBR relative to alternative power systems. In other words, what are the total energy costs of the program relative to the potential energy production by the system? We understand that a number of preliminary calculations by groups in both the U.S. and U.K. suggest the LMFBR will yield net energy at a ratio of 3:1 or less which would be inferior to alternatives such as various coal powered systems.

3. An impact statement should present a series of projections of macroeconomic effects and microeconomic costs of different scenarios with the LMFBR with some attempt made to assess the range of reasonable estimates and some explanation of the basis for these estimates and how they relate to existing literature. The author might wish to touch base with the FEA on this matter.

The crucial question on the benefit side is what happens to the economy if we postpone committing ourselves to producing a significant portion of our energy from the LMFBR? A good answer would show estimates of the growth rates, the rates of inflation, the effects on different income groups, the regional impacts, the dependence on imports from insecure sources, etc. The impact statement shows us historically that energy consumption and national income has grown together in the past. But in the past energy prices were declining and even with declining prices the ratio of energy to GNP declined. In other words we needed less energy input for more output of goods and services despite a declining incentive to conserve on energy. If this was the case historically, how much conservation will take place when energy prices rise? Dale Jorgenson, Edward Hudson, David Wood, etc., a large number of the best analysts working in this area expect significant reductions in energy growth due to higher prices and substitution of coal for oil and natural gas. The impact statement should address this issue directly.

There are some unsupported statements in this report, such as: "A conclusion of the cost-benefit analysis is that about 1.7 trillion dollars (undiscounted) will be available through the year 2020 to the citizens of the U.S. for 'goods and services' if the LMFBR is developed for electric energy generation instead of relying on other generation systems." (What generation systems? Is LMFBR superior to coal powered plants? How much certainty can we attach to these estimates of capital requirements?)

4. 1. Part 2, Background, of the subject report gives an excellent review of the relationship of the LMFBR program to the U.S. energy economy and the history of the LMFBR program.

2. Part 3, LMFBR Program, of the subject report gives a very good review of the objectives and considerations leading to the status of the project as of December 1974. This part of the report shows the influence of strong research, development, and engineering guidance. However, concern is raised about the last portions of this part.

3.

a. Page 3.5-6 needs to be amended to cover changes which have taken place in the Project Management Corporation since the subject report was prepared.

b. Pages 3.5-8 through 3.5-11 covers specific economic and doubling time considerations. The recent advances made by other countries in the LMFBR effort ought to receive due attention in resolving the U.S. position. The matter of reactor safety ought to be one of the highest priorities here.

c. Section 3.6, LMFBR Supporting Studies, deals in part with the environmental considerations. It appears that these considerations have lagged behind the thorough effort given to the technical research, development, and engineering of the LMFBR itself. On matters of radiological studies, spent fuel shipping, and thermal effects, studies are under way and some reports are written. A position might be taken that these considerations ought to have been covered at an earlier date stepwise with the technical progress of LMFBR. Waste, in particular, should get as much attention and emphasis as R & D for the LMFBR has received to date.

3. A review of Part 1 leads to the following points:

a. On page 1.1-6, second paragraph, it is disturbing to read, "In the past few years, exploratory drilling has not added greatly to uranium reserves, and no new producing areas in the U.S. have been discovered in the past 17 years." This raises the question: How can we have a nuclear power program without information on new sources of uranium?

b. On pages 1.3-3 and 1.3-4, reference is made to the technology to be used on radioactive wastes from the LMFBR fuel cycle and to new technology under development. One may conclude that the waste management for both LWR's and the LMFBR needs to be advanced and implemented before further commitment of funds on the LMFBR.

c. At the top of page 1.4-3 reference is made to this statement, "Proper design and operation of blowdown discharge systems easily provide for the dilution of discharged chemicals to acceptable concentrations in the environment." This is not a satisfactory means of disposal

in 1975. Adequate treatment would provide for removal of undesirable constituents.

d. Section 1.4-2.1 page 1.4-3 deals with an estimate of added annual population radiation dose due to specific operations. It raises the question: Who has the right to do this?

e. The matter of transportation of radioactive materials is considered on pages 1.4-4, 1.4-5, 1.4-7, and 1.4-8. More consideration should be given to centralizing facilities to reduce the risks of transportation.

f. In the last paragraph, on page 1.5-1 there is an indication that " . . . . nuclear plants are usually built in rural locations." Some other wording, such as low population areas, may be more appropriate here because these rural areas in many present cases are located also near urban centers.

g. On page 1.6-9, fourth paragraph, an alternative for retrievable surface storage of high-level wastes has been considered. For many persons retrievability is very important. One may question the cost factors too. The cost ought to be secondary to radiological safety.

h. In general on the matter of handling radioactive wastes, many aspects need to be brought up to the same high degree of technology being used on the LMFBR itself.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. T. O. Jones
Deputy Assistant Director
National and International Programs
National Science Foundation
Washington, D. C. 20550

Dear Mr. Jones:

Thank you for your letter of April 9 on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Energy Research and Development Administration (ERDA) has reviewed all written comments received on the PFES as well as the testimony received during the Public Hearing held on May 27-28, 1975, and has taken these views into account in the preparation of the Final Environmental Statement on the LMFBR Program. We hope you will find satisfactory responses to your comments in the enclosures to this letter.

Thank you for your comments and for your interest in the LMFBR program. A copy of the Final Environmental Statement is enclosed for your information.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Responses to Specific Comments by the National Science Foundation

Comment (p. 1):

> "The Environmental Impact Statement must be accepted as a sincere and competent effort to address the environmental consequences of the LMFBR in the total context of our society. Because of the scope of this endeavor there is a lag between when the report is written and when it is reviewed. .... This is particularly true in regard to future demand projections and the potential impacts of energy conservation programs."

ERDA Response:

The time lag between any effort and the subsequent publication and review of that effort is indeed unfortunate. However, in the context of the PFES which deals with long range planning through the Year 2020 such time lags do not severely impact the forecasts and conclusions. With respect to future energy demand there is little reason to think the current recessionary drop in energy demand will change the long range energy growth any more than similar points in history. The potential impacts of energy conservation were adequately treated by sensitivity studies based on large, hypothesized variations in the energy demand. It is also important to note that conservation of scarce energy resources, particularly oil and natural gas, may actually lead to increased use of electrical energy.

Comment (p. 1):

> "The cost-benefit analysis of the LMFBR in the EIS is based upon a development cost on the order of $5 billion and an introduction date of 1987. The Wall Street Journal (1-27-75) reports that the current estimates are for a development cost of $10 billion and an introduction date in the 1990's. Reportedly, the GAO has studied the total costs of the program. These results should be updated in the EIS."

ERDA Response:

The PFES examined the costs and benefits of several LMFBR introduction dates. As shown on page 11.2-33, the total breeder R & D costs for a 1987 introduction of the LMFBR is estimated to be $10.2 billion. However, $2.1 billion is allocated to other breeders and non-breeders so the actual LMFBR R & D cost estimate is $8.1 billion. Normal cost-benefit procedure utilizes discounted costs and benefits, therefore the text of the cost-benefit analysis generally discusses the discounted LMFBR R & D costs of about $5 billion.

Comment (p. 1):

2. "The ERDA legislation includes a mandate from Congress that net energy be considered in energy research and development. The primary conceptual flaw in the document is the neglect of the question of potential net energy production by the LMFBR relative to alternative power systems."

ERDA Response:

A net energy study is informative but fails to account for the economic penalties associated with the use of finite energy resources. However, the PFES did examine the energy requirements of alternative fuel cycles and the results are shown in Table 9.1-2. At the suggestion of Dr. D. Speer, NSF, the preliminary calculations of Dr. Chester Kylstra, University of Florida, and Dr. P. F. Chapman, United Kingdom, were reviewed. Dr. Kylstra indicates that he has computed a 3:1 net energy ratio for a LWR, but has not yet computed a ratio for the LMFBR. Dr. Chapman reported a ratio of 8 to 19:1 for a PWR in the December 1974 issue of New Scientist. A recent article by C. T. Rombaugh and B. V. Koen in the May 1975 issue of Nuclear Technology shows that on a total system energy cost basis PWR plants are comparable to coal plants. In the context of the Rombaugh-Koen article an LMFBR with essentially negligible fuel cycle energy inputs would require about 2% of its total plant output for construction energy input. This compares to the total, construction plus fuel cycle, energy input requirements of about 7% for LWR's and coal-fired plants. In the parlance of the net energy ratio, the LMFBR (as defined above) would have a ratio of 50:1. Also, the LMFBR by breeding plutonium reduces the net uranium ore and separative work requirements for LWRs which increases the net energy ratio for LWRs and thus vastly improves the net energy ratio for the total power generation system.

Comment (p. 2):

"The crucial question on the benefit side is what happens to the economy if we postpone committing ourselves to producing a significant portion of our energy from the LMFBR?"

ERDA Response:

The basis of the economic, cost-benefit analysis in Section 11.2 is a simple comparison of total national power costs with and without the LMFBR. Within this context postponement of the LMFBR results in irretrievable losses of our uranium resources with commensurate economic penalties. The price elasticity of energy demand does indicate decreasing demand for energy as prices rise. However, two mitigating effects

should be noted. First, the price elasticity during the period of rising prices (post-1971) shows decreasing sensitivity relative to the period of falling prices. Second, the cost of electric energy generated by nuclear power plants will be much lower than other systems. With the LMFBR the cost of electricity in constant dollars should actually fall as shown in Figure 11.2-17 in the PFES.

Comment (p. 2):

> "There are some unsupported statements in this report, such as: 'A conclusion of the cost-benefit analysis is that about 1.7 trillion dollars (undiscounted) will be available through the year 2020 to the citizens of the U. S. for [goods and services] if the LMFBR is developed for electric energy generation instead of relying on other generation systems.' (What generation systems? Is LMFBR superior to coal powered plants? How much certainty can we attach to these estimates of capital requirements?)"

ERDA Response:

The conclusion that 1.7 trillion dollars (undiscounted) will be available through the year 2020 if the LMFBR is developed is supported by the analyses presented in Section 11.2 of the PFES. A similar study[1] conducted by General Electric and Commonwealth Edison reaches a similar conclusion.

Economic benefits calculated in the PFES are based only on competition between nuclear alternatives within a limited portion (less than 60% of installed capacity) of the electric power plant market. Sensitivity studies show that LMFBR benefits increase if fossil-nuclear competition is allowed.

The relative costs for capital and fuel cycle expenses are based on sound engineering experience and estimates of future conditions.

Comment (p. 3):

> "Page 3.5-6 needs to be amended to cover changes which have taken place in the Project Management Corporation since the subject report was prepared."

---

[1] "An Assessment of Economic Incentives for the Liquid Metal Fast Breeder Reactor," T. R. Stauffer, H. L. Wyckoff, R. S. Palmer, presented to: Breeder Reactor Corporation, Chicago, Illinois, March 7, 1975.

ERDA Response:

Recently approved changes to the CRBR Project Management arrangements are in the process of being implemented. These changes include ERDA assuming the responsibility of managing the total project through the establishment of a single integrated management organization comprised of both industry and government personnel under ERDA direction. These modifications recognize that the continuation of the Federal Government's financial commitment to the CRBR Project, with a fixed financial commitment from the electric utilities, required alignment of direct management authority with the much larger financial responsibilities of the government, and integration and streamlining of the management mechanism for executing the Project under single direction. PMC, while no longer responsible for the direct management of the Project, will administer the utilities' interests in the Project. An updated revision of the CRBR Project Management arrangements is presented in Section III A, 3.5.2S.

Comment (p. 3):

> "Pages 3.5-8 through 3.5-11 covers specific economic and doubling time considerations. The recent advances made by other countries in the LMFBR effort ought to receive due attention in resolving the U. S. position. The matter of reactor safety ought to be one of the highest priorities here."

ERDA Response:

The advances made by other countries are described in Section 2.2.2 of the PFES. Considerable attention is of course being focused on reactor safety as described in Section 4.2.7 of the PFES and in Section III B of the Final Environmental Statement.

Comment (p. 3):

> "Section 3.6, LMFBR Supporting Studies, deals in part with the environmental considerations. It appears that these considerations have lagged behind the thorough effort given to the technical research, development, and engineering of the LMFBR itself."

ERDA Response:

Environmental aspects of nuclear power plants have and will continue to receive attention. Much work done in the past on LWRs is directly

applicable to LMFBRs. Environmental concerns specific to the LMFBR are being examined. At this time there appear to be solutions to all problems, however at this stage of the LMFBR program several issues (mainly in the areas of waste management, safeguards, reactor safety and health effects) are not yet sufficiently resolved to permit a decision to be made on the widespread commercial use of LMFBRs. The research, development and demonstration program will continue to definitively resolve these issues before a final commitment to the commercial deployment of LMFBRs is made.

Comment (p. 3):

> "On page 1.1-6, second paragraph, it is disturbing to read, 'In the past few years, exploratory drilling has not added greatly to uranium reserves, and no new producing areas in the U. S. have been discovered in the past 17 years.' This raises the question: How can we have a nuclear power program without information on new sources of uranium?"

ERDA Response:

Of course information on uranium reserves is essential to long range nuclear power program planning. Section 11.2.3.7 of the PFES describes the status and forecast for uranium supply. The National Uranium Resource Evaluation program is designed to answer the questions about future uranium sources. However, recent data indicates the current uranium resource estimates may be too optimistic. It is this uncertainty in the extent of our uranium resources that is one of the most compelling arguments for developing the breeder. The breeder will increase the utilization of our uranium resources more than sixty times that possible with LWRs and can utilize existing stockpiles of partially depleted uranium so that the need for additional uranium mining will not be needed for centuries. Further information on uranium resources is provided in Section III E of the Final Environmental Statement.

Comment (p. 3):

> "On pages 1.3-3 and 1.3-4, reference is made to the technology to be used on radioactive wastes from the LMFBR fuel cycle and to new technology under development. One may conclude that the waste management for both LWR's and the LMFBR needs to be advanced and implemented before further commitment of funds on the LMFBR."

ERDA Response:

It is agreed that additional research, development and demonstration of waste management technology is required before a decision to proceed with widespread commercial deployment of LMFBRs is made. We cannot agree that this work needs to be advanced and implemented before further commitment of funds on the LMFBR can be made. We see no problems in developing radioactive waste management technology for the LMFBR while continuing to pursue the LMFBR Program, provided this technology is available when the LMFBR is ready for commercial use. (See Sections 4.2 and 4.6 of Volume II of the Proposed Final Environmental Statement on the LMFBR Program for additional information regarding present radioactive waste technology and Section 7.3 of Volume IV of the PFES for information on future radioactive waste technology. Additional information on the waste management program can be found in Section III D of the Final Environmental Statement.)

Comment (pp. 3-4):

> "At the top of page 1.4-3 reference is made to this statement. 'Proper design and operation of blowdown discharge systems easily provide for the dilution of discharged chemicals to acceptable concentrations in the environment.' This is not a satisfactory means of disposal in 1975. Adequate treatment would provide for removal of undesirable constituents."

ERDA Response:

We agree that dilution is not always a satisfactory solution to blowdown treatment. Undesirable constituents could be removed by ion exchange, filtration, or even recovery, as discussed on page 4.3-51 of the LMFBR Program Proposed Final Environmental Statement."

Comment (p. 4):

> "Section 1.4-2.1, page 1.4-3, deals with an estimate of added annual population radiation dose due to specific operations. It raises the question: Who has the right to do this?"

ERDA Response:

We are required by NEPA to make such estimates. Of course the decision to permit construction of any particular facility with the attendant

advantages and disadvantages depends upon the reviewing agency's approval of each individual environmental statement.

Comment (p. 4):

> "The matter of transportation of radioactive materials is considered on pages 1.4-4, 1.4-5, 1.4-7, and 11.4-8. More consideration should be given to centralizing facilities to reduce the risks of transportation."

ERDA Response:

A discussion of nuclear energy centers is provided on page 4.5-76 of the LMFBR Program Proposed Final Environmental Statement.

Comment (p.4):

> "In the last paragraph, on page 1.5-1 there is an indication that '... nuclear plants are usually built in rural locations.' Some other wording, such as low population areas, may be more appropriate here because these rural areas in many present cases are located also near urban centers."

ERDA Response:

This is correct, as shown in Section 4.2.2.2.7 (pages 4.2-7 to 4.2-10) of the PFES.

Comments (p. 4):

> "On page 1.6-9, fourth paragraph, an alternative for retrievable surface storage of high-level wastes has been considered. For many persons retrievability is very important. One may question the cost factors too. The cost ought to be secondary to radiological safety."
>
> "In general on the matter of handling radioactive wastes, many aspects need to be brought up to the same high degree of technology being used on the LMFBR itself."

ERDA Response:

We agree. See the discussions in Sections 4.6 and 7.3.5 of the PFES.

V.65-1

ENVIRONMENTAL POLICY CENTER

324 C Street, S.E., Washington, D.C. 20003
(202) 547-6500

April 9, 1975

Mr. W. H. Pennington
Division of Biomedical and
Environmental Research
Energy and Research Development
Administration
E201
Washington, D. C. 20545

Dear Mr. Pennington:

In reviewing the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor, we have focused our attention on:

1) A review of the electrical energy forecast assumptions;

and

2) A review of the electrical energy data base and the potential substitution of solar-thermal energy for electric energy in residential space heating, air conditioning and water heating;

and we are herewith enclosing duplicate copies of this Review as our comments on the Proposed Final Environmental Statement.

Sincerely,

Marc Messing, Director
Energy Facility Siting Analysis

MM:jeh

Encl.: Review of the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program (in two parts).

ENVIRONMENTAL POLICY CENTER

324 C Street, S.E., Washington, D.C. 20003
(202) 547-6500

April 10, 1975

Mr. W. H. Pennington
Division of Biomedical and
Environmental Research
Energy and Research Development
Administration
E201
Washington, D. C. 20545

Dear Mr. Pennington:

Enclosed please find duplicate copies of an Errata Sheet for our submission of comment on the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program dated April 9, 1975. Additionally, we have enclosed duplicate copies of the corrected paper.

Sincerely,

Marc Messing
Director
Energy Facility
Siting Analysis

MM:jeh

Encl.: Errata Sheet and corrected Review of the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program (in two parts).

Review of Proposed Final Environmental Statement on the Liquid Metal Fast Breeder

ERRATA SHEET

Part 1/9	TABLE 1 should read: TABLE 5
1/12	TABLE 6 should read (TKWh); not (QBTU)
---	the last sentance should read: However, these electric energy projections are deduced from total energy demands on the basis of historical economic trends, rather on any assessment of projected market needs, and bear no direct relation to projections of
1/15	footnote 17, the year 1972 should read: 1973
1/20	Figure 11.2-23 should read: Figure 3
1/22	no casual relation should read: no causal relation
Part 2/4	footnote 4/should read: 2/
2/9	there should be an asterisk following the year 2000 on the Table, reading: * ADL projected rate of growth is for the year 1990 and is not carried out to the year 2000
2/14	the word odes should read; does
2/16	the source for Table 19 is: M. Messing/EPC
2/17	the source for Table 21 is: M. Messing/EPC
2/20	footnote 47 should read: Vol. 3, p. 6S-5, emphasis added
2/21	the final passage of the text should read: "... with projected levels of nuclear energy production in the same year.

V.65-4

ENVIRONMENTAL POLICY CENTER
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REVIEW OF THE PROPOSED FINAL ENVIRONMENTAL STATEMENT ON THE LIQUID METAL FAST BREEDER REACTOR PROGRAM

U.S. ATOMIC ENERGY COMMISSION / WASH 1535 DECEMBER 1974

PART I:

A REVIEW OF THE ELECTRICAL ENERGY FORECAST ASSUMPTIONS

PART II:

A REVIEW OF THE ELECTRICAL ENERGY DATA BASE AND THE POTENTIAL SUBSTITUTION OF SOLAR THERMAL ENERGY FOR ELECTRIC ENERGY IN RESIDENTIAL SPACE HEATING, AIR CONDITIONING AND WATER HEATING

MARC MESSING

April 10, 1975

This Report was Prepared as an
Energy Research Project of the Environmental Policy Institute.

Part 1/i

Review of the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program

U.S. Atomic Energy Commission / Wash 1535 December 1974

PART 1: A REVIEW OF THE ELECTRICAL ENERGY FORECAST ASSUMPTIONS

Summary and Conclusions

Total Energy Forecasts

Electrical Energy Forecasts

Nuclear Energy Forecasts

Appendix (Tables)

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SUMMARY AND CONCLUSIONS

The Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor (Wash 1535), concludes, in part, that

> "The electrical energy needs of the Nation are so large and are likely to grow to such an extent, that existing methods of energy production will be insufficient to meet the requirements. Additional electrical energy technology options will need to be developed if the Nation is to be assured a secure energy supply,"[1]

and, (consequently), that

> " ... the advantages of developing the LMFBR* as an alternative energy option for the Nation's use far outweigh the attendant disadvantages."[2]

The conclusions concerning levels of total energy consumption, electrical energy production, and nuclear energy production are derived from an econometric model which correlates historical relationships between GNP and energy use, and projects the trends to the year 2000.

---

* Liquid Metal Fast Breeder Reactor

1 Vol. 1, p. 1.10-1

2 Vol. 1, p. 1.10-2

PART 1/2

This approach leads to two fundamental errors in the conclusions: 1) Projections of total energy consumption are based on economic trends from 1947 to 1972 which are incompatible with changes in economic conditions during the past two years, and 2) electrical energy projections and nuclear energy projections are derived from the same model as the total energy projections, and therefore incorporate the same economic fallacies.

The result is an economic tautology which projects energy growth rates on the basis of historic economic trends, and justifies those growth rates on the basis of a presumed continuity of underlying economic factors. On the basis of recent changes in traditional resource pricing and of availability of materials, as well as dramatic changes in the projected availability of capital and associated rises in capital interest rates, these assumptions no longer appear valid. Furthermore, in the absence of independent market analysis of projected energy demands by end-use consumption sectors, projected rates of electric energy growth appear highly inflated.

TOTAL ENERGY FORECASTING

Wash 1535 considers several projections of total energy consumption and inputs to electrical energy generation through the years 2000 and 2020.* Assuming a base line figure of 69 QBTU total energy

* For the purpose of this analysis, all base line data is based on 1971 figures unless otherwise noted, and all projections have been made to the year 2000. Tables reproduced in the text show only these years.

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consumption in 1971, and a total electrical energy production** of 6 QBTU in the same year; Wash 1535 projects * total energy consumption of 192 QBTU to 203 QBTU in the year 2000, and electrical energy production of approximately 38 QBTU.

In projecting energy growth rates through the year 2000 the AEC utilizes two basic parameters: 1) variations in population growth, and 2) variations in per capita energy consumption as a function of per capita GNP. Projections of electric energy consumption, and of nuclear power production are derived in the same manner from extrapolations in the historical model.

Although a range of per capita energy consumption rates are projected in terms of the potential energy conservation (and based upon a fixed population of 271 million in the year 2000) Table 6c.6-4, the energy requirements projected on the basis of the econometric model assume a fixed population (271 million) and derive a fixed per capita energy consumption level, as indicated in Tables 11.2-7, and 2.1-13.** Table 6c.6-4 indicates a projected range of total energy consumption from 135 QBTU to 200 QBTU, and a range of installed generating capacity from 5.81 kW/capita to 9.22 kW/capita.

---

* Projections in Wash 1535 generally refer to electric energy consumption - referring to the energy input to electric utilities. The production figure used here refers to electric energy output (in kWh), and is converted to BTU's at the rate of 3.412 BTU/kWh.

** Note the projected population level of 279.7 million in Table 2.1-13.

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TABLE 1[1/]

FORECASTS OF ENERGY CONSUMPTION IN GENERATING CAPACITY

IN THE UNITED STATES IN THE YEAR 2000

	Case A	B	C	D
Energy Consumed MBTU per capita	499	719	737	642
Total Energy Consumption QBTU	135	195	200	174
Fraction of Energy Used for Electric Generation	0.51	0.50	0.54	0.50
Total Electric Generating Capacity per capita, kW	5.81	8.19	9.22	7.45
Total Electric Generating Capacity Thousands of MW	1575	2200	2500	2020

Vol. 3, p. 6c.6-17

However, the data on which the econometric projections are based assume a population level of 271 million, and project a total energy consumption level of 195 QBTU on the basis of historic trends in the relation bewtween per capita GNP and BTU expenditures.[3]

---

[3] Vol. 4., p. 11.2-53

[1/] Source, Wash 1535, Table 6C.6-4.

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TABLE 2[1]/

NATIONAL ECONOMIC ENERGY FORECAST
- Excerpts from Table 11.2-7

	1971	2000
Population (millions)	205	271
GNP (billions)	724	2300
Total Energy Demand (Btu x 10^{15})	67	195

Explicitly, Wash 1535 states that

> "Projections of total energy consumption ... (were) made on the basis of their historical relationship to the real Gross National Product (GNP ...)[4]

and;

> "The total energy projection was obtained by assuming that total energy demand will continue to grow in relation to GNP much the same way it has in the past twenty-five years. This assumption implies that the economy will become more efficient in the utilization of energy, continuing the long term trend."[4]

---

[4] Vol. 4, p. 11.2-53

[1]/ Source, Wash 1535, Table 11.2-7

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The projection of this trend is represented in Table 11.2-7 (on the previous page). However, the assumption that the relation between energy and GNP is constant and will continue in "much the same way it has in the past twenty-five years," is open to serious challenge.

In fact, 1971 data indicates that the relation between energy and GNP followed a steady trend from 1947 through 1966, but then reversed sharply for the five year period through 1971 (see Figure 1).

An additional assumption which is made in the projection of total energy growth rates is that greater energy efficiencies will be achieved. In its explanation of the cost-benefit analysis (Section 11), the AEC states (in regard to the assumed relation between energy and GNP) that

> "The assumption implies that the economy will become more efficient in the utilization of energy, continuing the long term trend. Technological changes and shifts to more efficient production processes and energy utilizing devices are an explanation of this phenomenon."[5]

It is unclear from the evidence presented that the dominant trend in the long-term utilization of energy represents increasing efficiencies.

---

[5] Vol. 4, p. 11.2-53

THE ENERGY/GNP RATIO
1947-1970

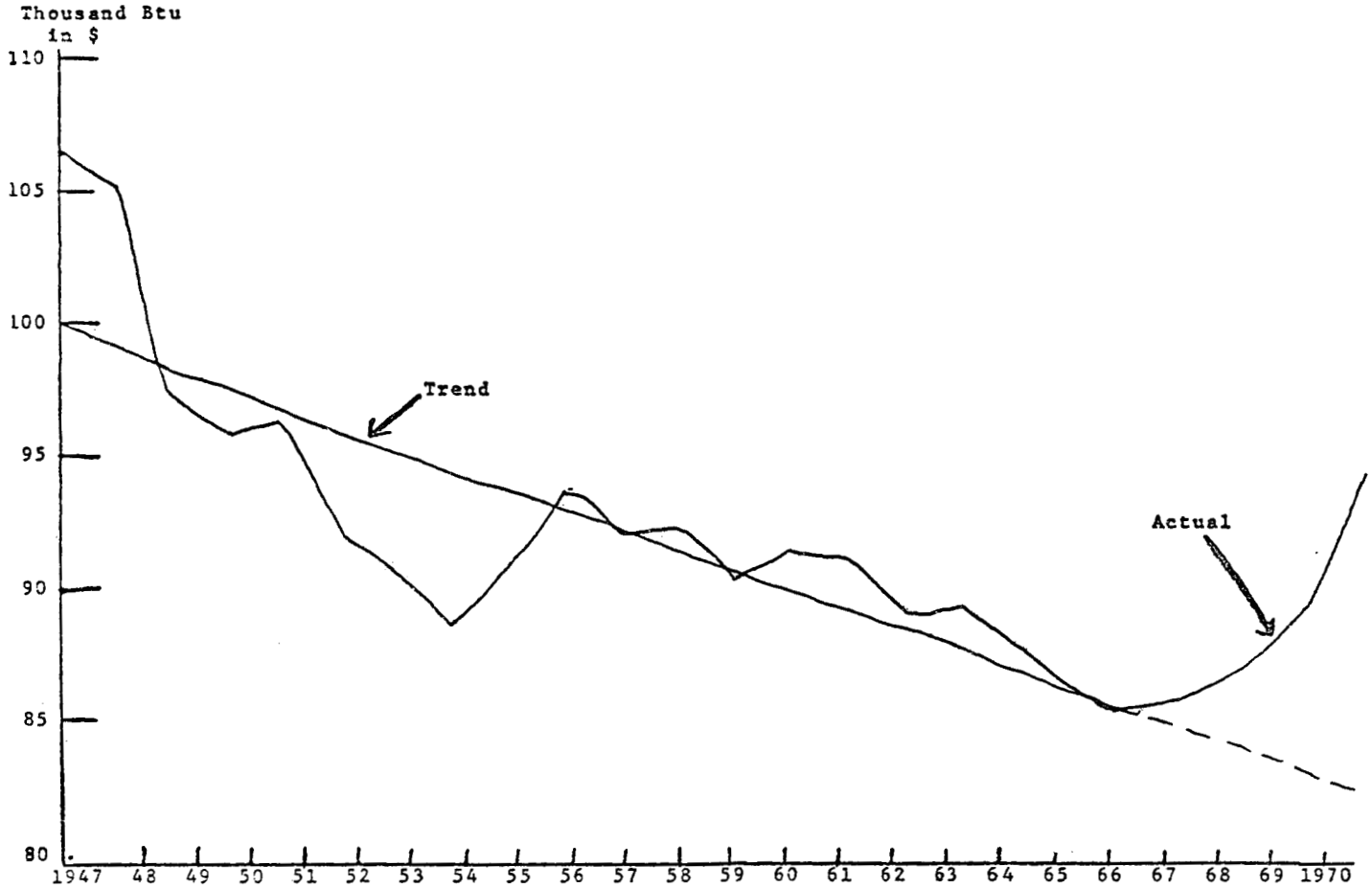


FIGURE 1

SOURCE: National Economic Research Associates, "Energy Consumption and Gross National Product In the United States" March, 1971. Also Earl Cook, "The Flow of Energy in an Industrial Society," Scientific American, September, 1971, p.140.

PART 1/8

To a certain extent, the range of conservation alternatives presented in Section 6 represent the inefficiencies which have been incorporated in our dominant modes of transportation, housing, and industrial processes. Hirst and Moyers (1973) conclude that "greater efficiency is feasible (for) transportation, space heating, and air conditioning."[6] The AEC itself presents the range of conservation possibilities forseen in Table 6C.7-1:

TABLE 3[1/]

APPROXIMATE COMPARISON OF ENERGY SAVINGS RESULTING FROM IMPLEMENTATION OF PROPOSED CONSERVATION MEASURES

Office of Emergency Preparedness	23-25% by 1990
Ford Foundation - Energy Policy Project	36% by 2000 (technical fix scenario)
Council on Environmental Quality	35% by 2000
Environmental Protection Agency	30% by 1990
Federal Energy Administration	30% by 2000[a]
Nation's Energy Future	at least 20% by 2000
AEC, Office of Planning and Analysis	10-30% by 2000

[a] Based on extrapolation of annual 2% growth rate.

Finally, it should be noted that as the percentage of electric energy within the total national energy budget increases, the net energy

6 "Efficiency of Energy Use in the United States, SCIENCE, 30 March 1973.

1/ Source, Wash 1535, Table 6C.7-1.

PART 1/9

efficiency decreases. This can be seen clearly by reorganizing the data presented in Table 2.1-12.

TABLE 4[1/]

GROSS ENERGY INPUTS TO ELECTRICITY

	(Actual) 1971	2000
Total Gross Energy Resources Inputs Trillion BTU	69,969	202,637
Total Generation (Billions of Kilowatts)	1,720	11,143
Trillion BTU (Thermal Value of Resource Inputs)	17,048	100,287
Percent of Gross Energy Inputs to Electricity)	25	49

M. Messing/EPC

By converting the total generation of electricity from kilowatts to BTU's (at the rate of 3,412 BTU/Kilowatt), the total thermal value of the electricity produced can be compared with the total thermal value of resource inputs to electricity. By comparing the difference between the thermal value inputs to electricity and the thermal value outputs, the efficiency of the total energy budget can be approximated by calculating the percentage of energy resources lost in the generation of electricity. This can be seen in TABLE 5:

1/Source, Wash 1535, Table 2.1-12

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TABLE 5

PROJECTION OF TOTAL ENERGY LOST THROUGH GENERATION OF ELECTRICITY FROM 1971 THROUGH 2000 (QBTU)

	1971	2000
Total Gross Energy Resource Input	68.969	202.637
Total Generation of Electricity (TBTU)	1.720	11.143
Total Thermal Value of Electricity Generated (QBTU)	5.869	38.016
Total Thermal Value of Resource Input to Electricity (QBTU)	17.048	100.287
Thermal Energy Lost in the Generation of Electricity (QBTU)	11.179	62.271
Percentages of Total Thermal Resources Lost in the Generation of Electricity	16.2	30.7

M. Messing/EPC

Electrical Energy Forecasting

Similar problems arise in methods of forecasting electrical energy production levels. These forecasts are derived from two assumptions based on the econometric forecasts of total energy consumption:

1) "that electrical energy input requirements ... (will) continue to grow in relation to GNP in much the same way that it has in the past,"[7]

[7] Vol. 4, p. 11.2-55

PART 1/11

and

2) "that electricity would continue to substitute for other forms of energy in areas of current energy use and that new cases would be found for it in the future ..."[8]

Additionally, these forecasts also assume that:

1) "electric utilities (will) continue to add more efficient generation units and, therefore, that the average energy inputs needed to produce a kilowatt hour (will) gradually decline for the total U.S. system."

and

2) "dramatic increases in conversion efficiency have been achieved by the electric power industry since its inception. The more efficient electric plants today achieve a thermal efficiency of about 40% -- a major improvement over the 5 to 10% of the earliest plants ... "[9]

---

[8] Vol. 4, p. 11.2-55

[9] Vol. 1, p. 1-11

PART 1/12

The inherent problems outlined in relation to the projection of total energy levels, are compounded in the computation of projected electric energy levels.

In reviewing the range of projections which have been made for electrical generating capacity in the year 2000, the AEC cites an updated estimate of 6.1 to 12.3 trillion kWh by the Federal Power Commission, and lists a number of other estimates, which are summarized below:

TABLE 6

CCOMPARISON OF ESTIMATED POTENTIAL OF ENERGY CONSERVATION THROUGH THE YEAR 2000 (TKWH)

	LOW	LIKELY	HIGH
AEC	7.1	10.6	11.7
Cochran/Searly	5.5	6.5	
Chapman et al	1.9		4.6
FPC	6.1	11.1	12.3
Interior		9.0	
Others	4.5		10.8

M. Messing/EPC

As indicated in this table, the AEC's base case assumption for the purpose of the cost benefit was 10.6 TkWh (36.17 QBTU).

However, these electric energy projections are deduced from total energy demands on the basis of historical economic trends, rather than on any assessment of projected market needs, and bear no direct relation to projections of

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market demand based on sector analysis.

There is no corroboration of either the assumption or the conclusion. The absence of corroborating analysis is particularly important in relation to the evaluation of alternative technological options. The only alternative technological options which are considered are those which are foreseen as options for "generating and conserving electrical energy"[10]: no alternatives are examined which conflict with the AEC "belief that electricity (will) continue to substitute for other forms of energy in areas of current energy use and that new cases (will) be found for it in the future ..."[11] Wash 1535 states that

> "Solar energy systems for residential and commercial buildings that combine water heating, space heating, and air conditioning are considered to have the most promise because solar collectors and energy storage units, the major cost centers, are common to all three functions ..."[12]

but it considers only the possibliity of solar-to-electric conversion in the cost-benefit analysis.

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[10] Vol. 3, p. 6p-1
[11] Vol. 4, p. 11.2-58
[12] Vol. 4, p. 6A.5-4

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In fact, the AEC states in Wash 1535 that

> "Solar energy applications in this century are likely to be restricted to individual residential uses, since central-station power generation has numerous technological and economic hurdles to overcome ... "[13]

but it fails to consider the use of solar-thermal space heating as an alternative to increased uses of electricity for space heating, and dismisses solar energy from consideration in the cost-benefit analysis because of the problems and costs involved in solar-electric conversion.[14] In its belief that electric energy will continue to substitute for other forms, it fails to consider the possibility of substituting other forms of energy (such as solar thermal heating for residential buildings), as a viable alternative. In the absence of sectoral market analyses indicating current uses of electricity for space heating, and projected demands for residential space heating, it is impossible to evaluate this alternative, despite the apparent technological feasibility.

The assumption that society will continue to increase the efficiency of its energy utilization, and the implication that the electric power industry will continue to achieve greater efficiency in the generation of

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[13] Vol. 4, p. 11.2-62

[14] Vol. 4, p. 11.1-18, 19

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electricity, have also been seriously challenged.

Hirst and Moyers (1973)[15] indicate that the overall efficiency of delivered electricity, allowing for losses in generation, transmission, and distribution, may be about 30% (rather than the 40% figure which the AEC mentions)*[16]; and Odum (1972)[17] has questioned the net energy efficiencies of many current and proposed converison systems. As systems become more dependent upon high-technology (energy intensive) methods, Odum argues, both the net energy efficiency tends to diminish, and the BTU recovered per dollar invested, tends to diminish as well. Questions of net energy efficiencies have tended to focus especially on the nuclear power cycle as the AEC recognizes, and several calculations have suggested that the net energy benefits of nuclear power production will ultimately depend upon load factors and the duration of plant operations.[18]

Finally, it should be noted that the increased efficiencies in electric power generation which the utility industry has achieved over the years, have come in fossil fueled gnnerating plants, (37.5%-39%),[19] and through increasing load factors. Conventional nuclear reactors, however, are intrinsically less efficient than the most efficient fossil

* Although Wash 1535 considers the potential for increased efficiency of transmission through increased voltage capacity (Table 6C.5-2) it computes these savings on the basis of a continued electrical energy growth rate of 7% per annum through the year 1980; additionally it should be noted that serious social objections have been raised to the installation of extra-high-voltage transmission lines considered.

15 "Efficiency of Energy Use in the United States", SCIENCE, 30 March 1973.

16 Vol. 1, p. 1-11

17 "Energy, Ecology, and Economics", Dr. Howard Odum, 1973.

18 Clark, Messing, Comments on Draft EIS LMFBR, May, 1974.

19 Vol. 3, p. 6B1-1

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fueled plants.[20] Insofar as the AEC projects the nuclear component of the electric generating sector to increase from approximately 2% in 1971[21] to 60% in the year 2000[22], allowance should be made for a proportionate decrease in the overall generating efficiency of the electric utility industry.

Nuclear Energy Forecasts

Forecasts of nuclear energy production levels are based on the same assumption of total energy forecasts and electrical energy forecasts, and utilize approximately the same methods. The forecasts of most likely, high, and low cases is reproduced below:

TABLE 7[1/]

FORECAST OF NUCLEAR ELECTRICAL CAPACITY IN MEGAWATTS

	Year			
	1980	1985	1990	2000
Most Likely	131,600	280,000	508,000	1,200,000
High	144,000	332,000	602,000	1,500,000
Low	127,000	256,000	412,000	825,000

"This forecast is based on an extrapolation of historic trends in energy consumption and generating

20 Vol. 3, p. 6C.4-4
21 Vol. 1, Table 2.1-12
22 Vol. 2.1-12
1/ Wash 1535, Table 2.1-14

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> capacity additions. The forecast is built up of from two components. The first is the nuclear plants which are in operation, are under construction, or have been ordered. These plants are considered to be the total additions to nuclear generating capacity until about 1979. Some of these "known" plants contribute to the growth in the forecast until 1982. The other component is an extrapolation of the trend in these additions to the end of the century. It should be noted that the 1980 projection is proving to be optimistic and that the January 1974 utility projection for 1980 is approximately 122,000 MWe." (emphasis added).[23]

The discrepancy which is noted between the low case (127,000 MWe) forecast and more recent utility revisions of these estimates (122,000 MWe) underscores the shortcomings of the economic forecasting method which is employed in the Wash 1535 analysis. It is curious to note, however, that Census Bureau Series D data was used for the projection of nuclear energy production base case.[23] "The E-series population projection of the Bureau of the Census was used" as the basis for the

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[23] Vol. 1, p. 2.1-22

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GNP estimates.[24] Presumably this would have the effect of increasing the proportion of nuclear energy calculated within the total budget in a comparison of the nuclear energy forecasts. With a total installed capacity of about 29 million and with approximately another 174 million kW on order as of June 1974,[25] more than approximately 40 million kW of planned capacity had been cancelled or postponed by August,[26] and an additional 40 million kW had been postponed or cancelled by September.[27]

By January of 1975, 69% of planned nuclear capacity had been cancelled, postponed, or otherwise rescheduled. Of 190 planned units, only 59 were unaffected by planned changes, and only 50% of those plants rescheduled were delayed for financial reasons.[28] In other words, with 190 planned facilities, 18% of the total planned nuclear capacity was rescheduled only for reasons of adjusted load growth, and 33% was rescheduled for reasons unrelated to financial difficulties.

If one were to examine the trends in nuclear power development over the entire range of the ten year period since the first large wave of commercial nuclear power plant orders were placed in 1965, it would appear that the commitment to nuclear power production has peaked (during the period of low-cost fossil fuels), and there is no direct evidence to indicate that interest is likely to revive.

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24 Vol. 4, p. 11.2-53

25 Vol. 1, p. 2.1-20

26 NERA Survey, Herman Roseman, August 1974.

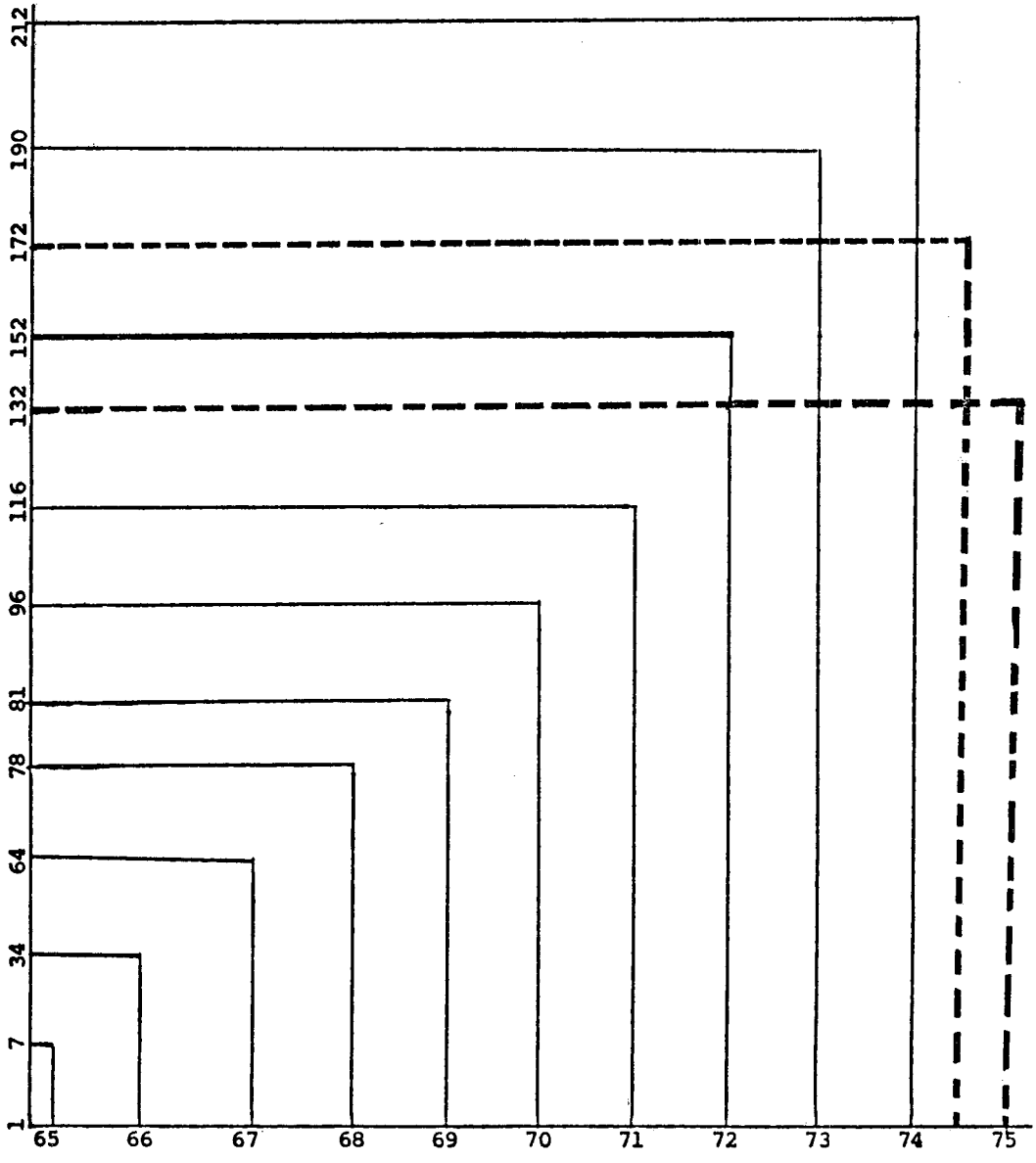
27 ELECTRICAL WORLD, September 15, 1974.

28 Analysis of Nuclear Power Plant Delays Announced in 1974, Richard H. Williamson, Federal Energy Administration, February, 1975.

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FIGURE 2

PLANNED NUCLEAR GENERATING CAPACITY (NORMALIZED TO 1000 MW, NUMBER OF UNITS ON ORDER)

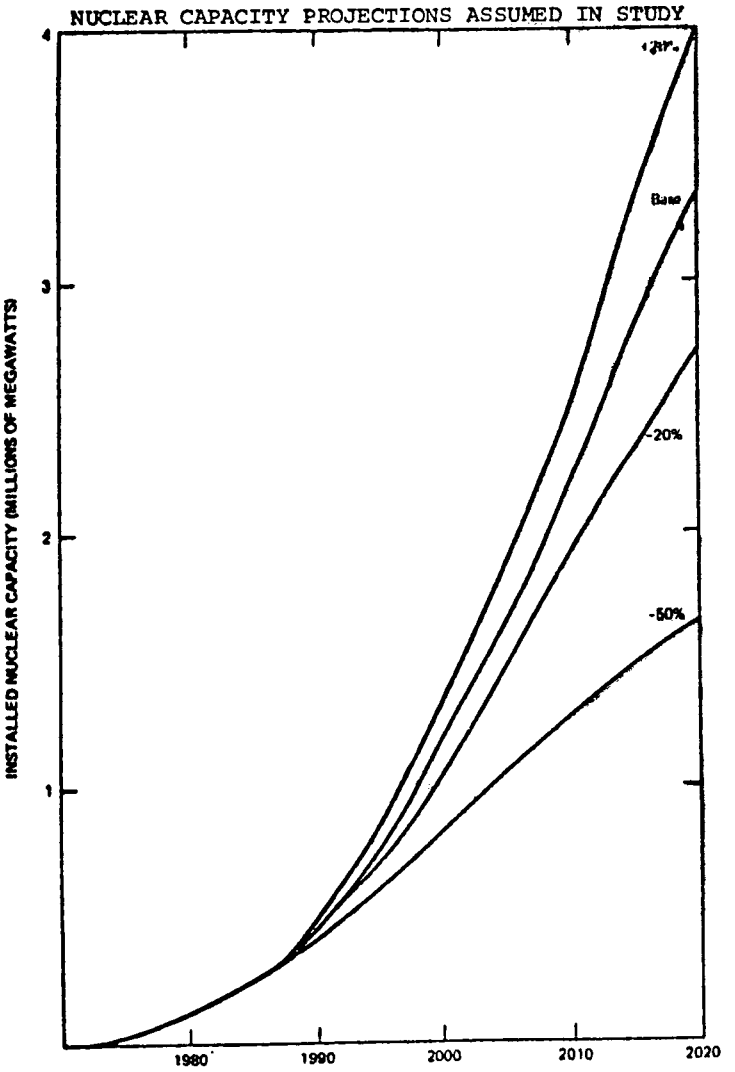


SOURCE: Vol. 1, 2.1-18; Williamson, Op. cit.

KEY: ——— Units on Order
– – – – Cancelled or Postponed Capacity

Figure 1 illustrates the discrepancy between the projection on which justification of the LMFBR program is based, as represented in Figure 3,* and the trends which have emerged subsequent to the oil embargo of October 1973. It suggests the fragility of the econometric model on which the AEC energy projections are based, and it draws attention to the projected levels of nuclear power production for the year 2000.

FIGURE 3



* Source, WASH 1535, Figure 11.2-23.

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As indicated in Table 2.1-13, not only is the level of gross energy consumption expected to rise three-fold (from 69 QBTU to 202 QBTU), but both total energy consumption and the installed generating capacity per capita are expected to increase 4-fold (4.12 and 3.78, respectively).

TABLE 8

UNITED STATES ELECTRIC UTILITY POWER STATISTICS[a]
(on a population, capacity, and consumption basis)

	1971	1975	1980	1985	2000
Generating Capacity (Millions of kW)	367.5	480	660	915	1,880
Population (Millions)	207.0	216.2	229.4	243.3	279.7
Kilowatt Capacity per Capita	1.78	2.22	2.88	3.76	6.72
Power Consumption (trillions of kWhr)	1.6	2.1	3.0	4.1	9.01
Annual per Capita Consumption (kWhr)	7,800	9,850	13.080	17,020	32,210
Nuclear Power Capacity (percent of total)	2.4	10.4	18.0	23.5	51.1

[a] Actual for 1971, and projected to the year 2000.

No analytical evidence is presented to indicate that these projected rates of per capita consumption are necessary to raise the standard of living (as, for example, in providing better home heating in low-income

housing), to provide greater national security, or for other socially desirable goals. Implicitly the only justification for these projected levels of increased per capita consumption, derive from presumed correlations between energy consumption and economic well-being. Unfortunately, no causal relation has been demonstrated. The historic period during which the correlation between increased energy consumption and increased GNP has been observed, has been a period characterized by numerous other economic factors, not the least of which has been low-cost fossil fuels. Since October 1973, that factor seems to have been irrevocably altered, and future economic conditions are likely to reflect the change. As Daly has observed in regard to energy and employment,

> "The observed positive correlation between non-human energy and employment means only that energy use and employment are both correlated to some third factors which have been increasing historically, namely total output and total population."[29]

Thus an economic tautology emerges in lieu of analytical data, in which energy projections are based not on sector or market analysis, but entirely upon econometric model which is characterized by historic, rather than current, economic conditions.

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[29] Op. cit., p. 10.

Review of the Proposed Final Environmental Statement

on the Liquid Metal Fast Breeder Reactor Program

U.S. Atomic Energy Commission / Wash 1535 December 1974

PART II: A REVIEW OF THE ELECTRICAL ENERGY DATA BASE AND THE POTENTIAL SUBSTITUTION OF SOLAR THERMAL ENERGY FOR ELECTRIC ENERGY IN RESIDENTIAL SPACE HEATING, AIR CONDITIONING AND WATER HEATING

Summary of Part 1

Summary and Conclusions

Projected Increases in Energy Consumption

Residential Space Heating, Air Conditioning and Water Heating

Residential Uses of Electric Space Heating, Air Conditioning, and Water Heating

The Potential for Solar-Thermal Energy Resources in Residential Buildings

PART 2/1

Summary of Part 1

Analysis of the electric energy projection model and forecast assumptions indicates that projection of electric energy growth and nuclear energy growth rates are both derived from an econometric correlation of GNP and energy consumption from 1947-1971. The model used does not account for changes in economic parameters since the dramatic changes in energy pricing which occurred in 1974; certain major assumptions no longer appear viable; and the projected levels of electric energy consumption appear seriously inflated. The limited consideration of alternative technological options only for the generation of electricity, has resulted in a failure to consider the application of non-electric alternatives for meeting projected energy needs.

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PART 2: SUMMARY AND CONCLUSIONS

An analysis of the electric energy data base used in WASH 1535 and demand projections of energy production modes and end-use markets, indicates:

1) that projections of residential space heating, air conditioning, and water heating based on end-use market analysis differ substantially from projections based on the WASH 1535 econometric model, and

2) that the substitution of solar-thermal energy for residential space heating, air conditioning, and water heating, appears to be a feasible alternative to electric energy sources for these end-uses.

By correlating energy production modes (such as fossil fueled electric energy, nuclear generated electric energy, and solar based thermal energy) with end-use markets (such as residential space heating, air conditioning, and water heating), it is apparent that solar energy provides a reasonable, and technologically feasible alternative to the generation of electric energy for these purposes.*

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* For the purposes of this review the emphasis is placed on the residential sector. However, all qualitative elements of the paper should be generally applicable to a significant portion of the commercial sector as well, and where figures for the commercial sector have been noted in several instances.

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Projected Increases in Energy Consumption

The energy projections on which the Liquid Metal Fast Breeder Reactor program is currently being justified, forecast per capita energy consumption through the year 2000 to increase two-fold; total energy consumption to increase three-fold; per capita electric energy consumption to increase four-fold; total electric generating capacity to increase five-fold; and total electric power production to increase almost six-fold. This baseline data and projected levels for the year 2000 as contained in Wash 1535, are tabularized in Table 9 along with computations of the annual rates of growth and factors of increases which they represent.

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TABLE 9

RATES OF GROWTH AND FACTORS OF INCREASE FOR PROJECTED ENERGY DEVELOPMENTS 1971 - 2000

		1971 (actual)	2000 (projected)	% Annual Rate of Growth	Factor of Increase
Population (millions)	1/	207	279	0.9	1.35
Total Per Capita Energy Consumption (MBTU)	2/	333	726	2.7	2.18
Total Energy Consumption (QBTU)	3/	68.969	202.637	3.8	2.93
Installed Per Capita Generating Capacity (thousands of kW)	1/	1.78	6.72	4.7	3.78
Total Per Capita Electric Energy Production (thousands of kWhr)	1/	7,800	32,210	5.0	4.12
Total Electric Generating Capacity (millions of kW)	1/	367.5	1,880	5.8	5.12
Total Electric Power Production (TkWhr)	1/	1.6	9.01	6.1	5.63
Total Nuclear Generating Capacity (millions of kW)	2/	8.82	960.69	14.1	108.9
Total Nuclear Power Production (billions of kWhr)	3/	38	6,880	31.3	181.05

M. Messing/EPC

1/ Table 2.1-13
2/ Computed from Table 2.1-13
3/ Table 2.1-12

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Using the same data, TABLE 10 indicates the total contribution of nuclear energy to the total U.S. energy budget (1971 and 2000), based on a thermal conversion rate of 3,412 BTU per kWhr.

TABLE 10

TOTAL U.S. ENERGY CONSUMPTION AND NUCLEAR POWER PRODUCTION

1971 - 2000

		1971	2000
Total Energy Budget (resource input in QBTU)	1/	68.969	202.637
Electric Energy Consumption (resource input to electric generation in QBTU)	1/	17.048	100.287
Electric Energy Production (resource output in QBTU)	2/	5.868	38.019
Percent of Gross Energy Inputs to Electric Generation	1/	25	49
Percent of Gross Energy Budget Output from Electric Generation	2/	8.5	18.7
Nuclear Electric Production (resource output in QBTU)	2/	0.130	23.4
Percent of Gross Energy Budget from Nuclear Generation	2/	0.2	11.5

M. Messing/EPC

1/ Table 2.1-12

2/ Computed from Table 2.1-12

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For the purpose of convenience, the information from these two tables can be further capsulized, as in Table 11.

TABLE 11

SUMMARY OF ELECTRIC ENERGY GENERATION 1971 - 2000

	1971	2000
Total Energy Consumption (QBTU)	69	203
Total Electric Energy Production (QBTU)	5.9	38.0
Total Nuclear Energy Production (QBTU)	0.13	23.4

M. Messing/EPC

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Residential Space Heating, Air Conditioning and Water Heating

Data regarding the total energy demands of residential and commercial heating are provided in Sections 2, and 6 of Wash 1535, but are not disaggregated either according to sector demand or source of energy. Thus, Table 2.1-1 of Wash 1535 indicates only that residential and commercial space heating consumed is 17.9 - 20 percent of the total energy budget in 1968.[30] Table 6C.6-1 provides some additional information but no information is given regarding either projections of

TABLE 12[1/]

ENERGY CONSUMPTION IN THE UNITED STATES BY END-USE

1960-1968

(QBTU AND % PER YEAR)

Sector	Consumption 1960	Consumption 1968	Annual Rate of Growth	% of National Total 1960	% of National Total 1968
Residential					
Space Heating	4.848	6.675	4.1	11.3	11.0
Water Heating	1.159	1.736	5.2	2.7	2.9
Air Conditioning	0.134	0.427	15.6	0.3	0.7
Commercial					
Space Heating	3.111	4.182	3.8	7.2	6.9
Water Heating	0.544	0.653	2.3	1.3	1.1
Air Conditioning	0.576	1.113	8.6	1.7	1.6

space heating, air conditioning, and water heating demands, or regarding the contribution of electrical energy sources to these sector demands.

1/ Abstracted from Table 6C.6-1

30 Vol. 1, p. 2.1-4

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Table 2.1-4 of Wash 1535 (reproduced below) indicates projected growth rates for several sectors, including electrical energy generation, but the data is not correlated to the data provided in Table 2.1-1.

TABLE 13[1/]

ENERGY GROWTH BY SECTOR (QBTU)

Sector	1971	1975	1980	1985	2000
Household-Commercial	14.3	15.9	17.5	19.0	21.9
Industrial	20.3	22.9	24.8	27.5	39.3
Transportation	17.0	19.1	22.8	27.1	42.6
Electrical Generation	17.4	22.4	30.0	40.4	80.4
Synthetic Gas	____	____	0.9	2.7	7.7
Total	69.0	80.3	96.0	116.7	191.9

As a result it is unclear how the residential commercial space heating loads considered in Table 2.1-1 relate to either the projected growth of the household-commercial or the electrical energy generation rubrics of Table 2.1-4.

More recent data regarding both residential and commercial space heating, air conditioning, and water heating has since been compiled by other sources, and the following Table is based on a preliminary report prepared by Arthur D. Little, Inc. (ADL).[31]

1/ Reproduction of Table 2.1-4, Wash 1535.

31 Residential and Commercial Energy Use Patterns, 1970-1990, Preliminary Report, July 1974, Not for Final Distribution.

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TABLE 14[1/]

RESIDENTIAL AND COMMERCIAL
SPACE HEATING, AIR CONDITIONING AND WATER HEATING:
RATES OF GROWTH PROJECTED FROM 1970 - 1990

Sector	1970 (QBTU)	Projected Rate of Annual Growth (%)	1990 (QBTU)	2000* (QBTU)
Residential				
Space Heating	8.146	1.3	10.547	12.0
Water Heating	1.769	1.4	2.336	2.684
Air Conditioning	0.163	8.4	0.818	1.832
Commercial				
Space Heating	2.206	2.7	3.758	4.905
Water Heating	0.484	5.8	1.494	2.626
Air Conditioning	0.150	4.5	0.346	0.537

The differences between projected growth rates and figures for commercial demands as estimated here and in Table 12 should be noted.

1/ Source, ADL Preliminary Report, Figures 1.8, 1.9, Table 15.

* ADL Projected rate of growth is for the year 1990 and is not carried out to the year 2000.

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As stated in the text of the ADL Report, the estimates are made

> "on the basis of macro-economic projections of income, and GNP ... (indicating) that the housing inventory will grow modestly (1.7% per year), between 1970 and 1990, whereas commercial space will grow at a much higher rate (4.1% per year). On the basis of these growth expectations, the change in the inventory mix and the different energy use of these two sectors, we forecast growth in residential energy demand at 1.6% per year and commercial energy demand at 4.1% per year, compounded to 1990 ... (assuming) low cost fuel ($4 per barrel oil) and unconstrained supply."[32]

Thus these figures, though preliminary, differ substantially from the estimated, and projected growth rates of residential space heating loads inferred from WASH 1535. As indicated in Part 1,* WASH 1535 estimates of projected energy growth rates and electric energy growth rates were based upon an econometric model and assumed increasing electric energy substitution in sectors such as residential space heating. If we can assume that the data presented in WASH 1535 regarding residential and commercial energy demand growth rates (as indicated above) are consistant with the data used in the projection models, and if we can assume

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* For a detailed discussion of the forecast model and assumptions in WASH 1535, see Review of Proposed Final Environmental Impact Statement on the Liquid Metal Fast Breeder Reactor; Part 1: A Review of the Electric Energy Forecast Assumptions.

[32]ADL, ibid, p. 5.

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that residential and commercial space heating, air conditioning, and water heating represent sectors which have been projected to undergo increasing substitution of electric energy sources, then the projections calculated in Table 14 represent substantial differences between the estimated energy demands of these sectors in the year 2000.

Residential Uses of Electric Space Heating, Air Conditioning, and Water Heating

The Report of the Office of Science and Technology, from which the WASH 1535 data in Table 2.1-1 is derived,[33] contains more complete information regarding the uses of electric energy for residential space heating, air conditioning, and water heating, from 1960-1968. Using a conversion rate of 3,413 BTU per kWh, the report includes the following estimates (abstracted).[34]

TABLE 16

RESIDENTIAL CONSUMPTION OF ELECTRICITY BY END USE, 1960-1968

Sector (in QBTU's)	1960	1968
Space Heating	0.029	0.164
Air Conditioning	0.048	0.154
Water Heating	0.155	0.250

[33] Patterns of Energy Consumption in the United States, Office of Science and Technology, January, 1972. Table 17, p. 41.

[34] Ibid, p. 42.

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The percentage of total residential energy consumption for each of these sectors is derived from comparison with the data in Table 12 (above). In terms of unit saturation, comparable figures have been compiled by Makhijani and Lichtenberg.[35]

TABLE 17

GROWTH IN PER CAPITA ELECTRICITY FOR SELECTED HOUSEHOLD USES

	1960 Saturation	ANNUAL Per Capita Consumption (KWHr)	1970 Saturation	ANNUAL Per Capita Consumption (KWHr)
Electrical Resistance Heating	1.5%	41	6.1%	190
Electric Water Heating	18.6%	232	29.6%	416
Air Conditioning	14.8%	59	42.6%	191

As indicated above (page p.10), the WASH 1535 projection of electric energy consumption growth rates assumes an increasing consumption of electricity for residential uses, such as space heating. Implicitly the assumption is stated:

> "that electricity would continue to substitute for other forms of energy in areas of current energy use

[35] A.B. Makhijani, and A.J. Lichtenberg, "An Assessment of Residential Energy Utilization in the U.S.A.," Berkeley, California, (1972), Table 111; as referred to by Wilson Clark, ENERGY FOR SURVIVAL, Doubleday, 1974, pp. 187, 188.

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and that new cases would be found for it in the future ..."[36]

and explicitly WASH 1535 refers to the projections of the 1970 National Power Survey:

"The 1970 FPC National Power Survey forecast of growth in electrical generating capacity reflected to some extent consideration of power needs for environmental protection, but the acceleration of concern with the environment that has occurred since the survey was made will result in the need for more capacity than was projected. Among the factors that will contribute to the increase are the following:

(1) Control of air and water pollution from electric generating plants, power to operate control equipment and reduced plant efficiency.

(2) Electrical energy demands for widespread sewage disposal improvement.

(3) Electrical energy demands for meeting water pollution control standards in industrial processes.

(4) Where apartment buildings, commercial establishments, and factories are now using direct combustion of fossil fuels for space heating and processes heating, a significant number may convert to electricity because of restriction on the emission of particulates and oxides of sulfur and nitrogen." [37]

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[36] Vol. 4, p. 11.2-55

[37] Vol. 3, p. 6C.4-2, emphasis added.

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The National Power Survey, in turn, is much more sanguine about the trend towards electric space heating in residential homes and the general trend towards all-electric homes, but does not estimate component growth rates. Instead, it estimates only total residential energy consumption (1,467 million megawatt hours), unit consumption (33,000 kWh per customer) and numbers of all-electric homes (24 million) for 1990.

> "Electric energy used by residential consumers, including farm residential, is projected to increase from 270 million megawatt hours in 1965 to 1,467 million megawatt hours in 1990. A significant factor in this projected increase is the growing number of residential customers who live in all-electric homes, where the average customer in the contiguous United States, according to 1968 reports, consumed three times as much electric energy as the average residential customer. In 1970, the average all-electric home customer used about 20,000 kilowatt hours of electric energy. By 1990, the corresponding average annual use is expected to be 33,000 kilowatt hours, slightly more than twice the average annual use of all residential customers ...
>
> "The estimated growth in all-electric dwelling is shown in Table 3.1. Approximately one-third of the new dwellings constructed in 1970 used electricity for heating and cooling. The projections are based on the assumptions that 40 percent of new dwellings constructed in the 1970-1980

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decade will be all-electric, 50 percent constructed in the following decade will be all-electric, and that there will be about half as many conversions as there are new installations ..."[38]

TABLE 18[39/]

ELECTRICAL HEATING DWELLINGS IN THE UNITED STATES

1964 - 1990

YEAR	Millions of Dwellings
1964	2.2
1966	2.7
1968	3.4
1970	4.2
1980	12.5
1990	24.0

These figures represent projected growth rates of 9.1% annually for units of all-electric homes (1970-1990) and 2.4% for annual consumption of all-electric units. Projected to the year 2000, this would indicate approximately 57.3 million all-electric homes, consuming an average of 42,000 kWh per year, for an aggregate electric energy consumption of 2406.6 x 10^9 kWhr per year.

[38] FPC THE 1970 NATIONAL POWER SURVEY, p. 1-3-8.
[39] Ibid., Table 3.1.

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TABLE 19

ELECTRIC ENERGY DEMAND OF ALL-ELECTRIC HOMES

	1970	1990	2000
Number of Dwellings (Millions)	4.2	24	57.3
Average Annual Electric Consumption (kWh)	20,000	33,000	42,000
Aggregate Electric Energy Consumption ($\times 10^9$ kWh)	84	742	2406.6

M. Messing/EPC

As evidenced by the following table compiled by the National Association of Home Builders, these estimates by the FPC have been very accurate to date:

TABLE 20[40/]

(abstracted from)

1973 BUILDING PRACTICES IN TYPICAL SINGLE FAMILY HOMES BY TYPE OF HOUSE

(Percent of Housing Units)

	Single Family Detached	Townhouse	Duplex Quaduplex, Etc.	All Types
Heating Electric	39.4	54.1	35.3	41.9
Cooling Electric	68.6	80.1	46.6	69.0
Hot Water Electric	50.9	55.0	29.9	50.0

40/ Source, National Association of Home Builders.

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As can also be seen, the use of electric energy sources for air conditioning and hot water heating extends considerably beyond thoes units utilizing electric space heating.•

Taking the percentage of residential energy demands by component, as represented in Table 21,[41]

TABLE 21

RESIDENTIAL ENERGY DEMANDS, COMPONENT PERCENTAGE (1968)

Space Heating	6,358	69%
Air Conditioning	66	1%
Water Heating	1,348	15%
All Uses	9,188	85%

M. Messing/EPC

and assuming, for the purpose of projection estimates only, that the percentage demands of residential space heating or space heating and air

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• Interestingly, in an analysis of Residential Energy Consumption prepared for the Department of Housing and Urban Development in 1972, it was found that the use of electric heating in new construction tended to be inversely related to the thermal efficiency of teh housing unit; i.e., 25% in low rise buildings (with lowest thermal efficiencies), 16% in single units, and 14% in high-rises. The trend was even more pronounced in recent apartment projects, with 42% installation in low-rises and 0% recorded in high-rises. [RESIDENTIAL ENERGY CONSUMPTION, Multi-Family Housing Data Acquisition, Oct. 1972, Department of Housing and Urban Development].

41 Abstracted from OST REPORT, Jan. 1972, Table 4, p. 17.

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conditioning * remain approximately constant, the following table can be constructed:

TABLE 22

RESIDENTIAL DEMAND FOR SPACE HEATING, AIR CONDITIONING AND WATER HEATING IN ALL-ELECTRIC HOMES; ESTIMATED FOR THE YEAR 2000

	1970	2000
Total Energy Demand in All-Electric Homes ($\times 10^9$ kWh)	84	2407
Total Energy Demand in All-Electric Homes (QBTU)	0.286	8.212
Percentage Used for		
Space Heat	0.197	5.666
Air Conditioning	0.002	0.082
Water Heating	0.043	1.231
Total	0.242	6.979

M. Messing/EPC

The Potential for Solar-Thermal Energy Resources in Residential Buildings

The trend towards increasing utilization of electric energy for space heating, air conditioning and hot water heating, and the assumption in the projection model of WASH 1535 that this trend will continue, is especially interesting in the context of the potential for the application

* This second assumption allows for a decreasing ratio of space heating/total energy, and an increasing ratio of air conditioning/total energy.

of solar thermal technologies to these end-uses. In Section 6, Wash 1535 states:

> "Most contemporary uses of solar energy are to provide thermal energy for building. Solar water heaters are manufactured and used in several countries, including the United States; they were once common in Florida, but their use has diminished because of the availability of natural gas. Space heating by use of solar energy has been demonstrated in about 20 experimental buildings... Solar energy systems for residential and commercial buildings that combine water heating, space heating, and air conditioning are condiered to have the most promise because solar collectors and energy storage units, the major cost centers, are common to all three functions."[42]

and in Section 11, it indicates that:

> "Solar energy applications in this century are likely to be restricted to individual residential uses, since central-station power generation has numerous technological and economic hurdles to overcome."[43]

Furthermore, it notes that:

1) "The projections of the portion of building thermal energy supplied by solar range from 10% (NSF-NASA) to 30% (Subpanel 1X),"[44]

2) "That all proposed solar energy systems, with the exception of thermal collection for buildings, have poor prospects for economically competing with either coal or nuclear systems for at least several decades."[45]

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42 Vol. 3, p. 6A.5-4
43 Vol. 4, p. 11.2-62
44 Vol. 3, p. 6A.5-17
45 Vol. 4, p. 11.1-19

Part 2/20

However, there is no estimate given in Wash 1535 of the potential for the substitution of solar-thermal resources for energy in residential buildings, except for the observation that,

> "If solar is assumed to displace all building thermal energy sources (oil, gas, electricity) equally, then the above projections are equivalent to reducing electrical energy production by 2% to 6% in the year 2,000..."[46]

and the preliminary conclusion that:

> "Solar energy utilization has great appeal because it is the most direct, plentiful and renewable form of energy known... Unfortunately, the poor efficiencies of the available systems for collecting and transforming solar energy into useful forms, the wide fluctuations over the period of a day in the energy received (requiring energy storage systems), and the dilute nature of the energy (requiring large collection areas), militate against large-scale use of this energy form for central station power application..."[47]

Other analysts have estimated that up to 92% of the energy used in U.S. residences could be met with decentralized solar energy collection units[48], and that "the economics of solar space and water heating are already competitive with fossil fuel and electrical systems,"[49] in such areas as Oregon.

Unfortunately, in considering only those alternative technology options available for "generating or conserving electrical energy"[50], with the "belief that electricity (will) continue to substitute for other forms of energy..."[51], the potential for substituting solar-thermal energy for electric in selective

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46 Vol. 3, p. 6A.5-17
47 Vol. 3, p. 6S-5, emphasis added.
48 Wilson Clark, Energy For Survival, Doubleday, 1974, p. 469
49 Transition: A Report to the Oregon Energy Council; The Office of Energy Research and Planning, Office of the Governor, Jan., 1975, pp. 148,149
50 Vol. 3, p. 6P-1

Part 2/21

residential component sectors, has been completely overlooked. Instead, Wash 1535 states:

> "One of the most attractive alternatives, in principle, is solar energy. However, the high costs and large land areas associated with its use as a central station power source and the high costs, social acceptability, and the inertia associated with local, distributed use militate against this form of electrical energy production making a substantial contribution in this century."[52]

The "beliefs" and the conclusions of Wash 1535 notwithstanding, it is clear that the utilization of solar-thermal energy for residential space heating, air conditioning, and waterheating is technically feasible, and its substitution for projected electrical energy demands in these areas should be closely examined. Table 23 compares the projected demands of residential space heating, air conditioning, and water heating in all electric homes for the year 2,000, with projected levels of nuclear energy production in the same year.

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51 Vol. 4, p. 11.2-58

52 Vol. 3, p. 6S-8

Part 2/22

TABLE 23

COMPARISON OF NUCLEAR ENERGY PRODUCTION AND THE POTENTIAL FOR SUBSTITUTION OF SOLAR-THERMAL RESOURCES FOR ELECTRIC SPACE HEATING, AIR CONDITIONING, AND WATER HEATING IN THE YEAR 2000

	2,000	
Projected Nuclear Energy Production	23.4	QBTU
Projected Energy Demand for Space Heating Air Conditioning, and Water Heating in All Electric Homes	6.979	QBTU
Ratio of Residential Electric Demand/ Nuclear Energy	29.8%	

M. Messing/EPC

On this basis, it is apparent that the potential for solar-thermal resource utilization in residential homes represents a potential contribution equal to approximately 30% of projected nuclear energy production in the year 2,000. It should also be noted, that these figures do not consider either the potential for energy conservation in residential buildings*, or the potential application of solar-thermal resources in the commercial sector.

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* The potential savings in residential and commercial buildings estimated in the ADL study, and utilizing only strategies based on available and practical means, estimates a potential savings of 8QBTU by 1990; and independent estimates in the HUD Residential Energy Consumption Report on Single Family Housing (March 1973) reported that energy consumption in good quality single family houses could be reduced up to 40 without affecting the lifestyle of the occupants.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Marc Messing
Director
Energy Facility Siting Analysis
Environmental Policy Center
324 C Street, S. E.
Washington, D. C. 20003

Dear Mr. Messing:

Thank you for your letters of April 9 and April 10, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Energy Research and Development Administration (ERDA) has reviewed all written comments received on the PFES as well as the testimony received during the Public Hearing held on May 27-28, 1975 and has taken these views into account in the preparation of the Final Environmental Statement for the LMFBR Program. We hope you will find satisfactory responses to your concerns in the enclosures to this letter.

Thank you for your comments and for your interest in the LMFBR program. A copy of the Final Environmental Statement is enclosed for your information.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Response to Comments by the Environmental Policy Center

Comment (p. 1/2):

> ".... 1) Projections of total energy consumption are based on economic trends from 1947 to 1972 which are incompatible with changes in economic conditions during the past two years, and 2) electrical energy projections and nuclear energy projections are derived from the same model as the total energy projections, and therefore incorporate the same economic fallacies."

ERDA Response:

All forecasts are based upon historical relationships. The forecasts in the PFES are based on the belief that the basic structure of the relationships between population, GNP, total energy, and electric energy will remain intact. Continuation of relationships does not of course mean no change, but rather change in the direction of historic trends rather than dependence on short term trends. The use of short term trends is not compatible with the goals of prudent long term planning. The current divergence from the long term electric energy growth rate is due in large part to the current economic recession. The long term growth rate is a smoothed, time-average of the actual continuous growth rate which has in the past had short term periods of negative growth as well as accelerated positive growth. Obviously then, it is hazardous to base long range plans on short term swings in the electric energy growth in lieu of the more stable, time-averaged long term growth rates.

Although the forecasts of electric energy demand in the PFES are based on historic trends, they are not a simple extrapolation of the historic growth rate. For example, the influence of decreasing population growth and increasing energy efficiency results in a steady decline from the 7-8% growth of the early 1970's to a growth rate of less than 4% per year in Year 2020.

Comment (p. 1/6):

> "It is unclear from the evidence presented that the dominant trend in the long-term utilization of energy represents increasing efficiencies."

ERDA Response:

The separate effects of increased energy use and increased efficiency of energy applications are of course combined in the data you present. Since energy demand growth is greater than the energy savings from improved efficiency, the trend of increased energy consumption is the more apparent trend in the data.

Comment (pp. 1/8-1/10):

"Finally, it should be noted that as the percentage of electric energy within the total national energy budget increases, the net energy efficiency decreases."

ERDA Response:

Your conclusion is not warranted from the data you presented in Tables 4 and 5. You have assumed that non-electric energy applications are 100% efficient which of course is not true. In fact there are good reasons to expect that some current and future applications of electricity are more efficient than alternatives. For example, home heating with an electric heat pump requires fewer Btu of input to the electric generating plant than the number of Btu required at the natural gas processing plant to eventually heat a home.

Comment (p. 1/14):

The PFES

"... fails to consider the use of solar-thermal space heating as an alternative to increased uses of electricity for space heating, and dismisses solar energy from consideration in the cost-benefit analysis because of the problems and costs involved in solar-electric conversion."

ERDA Response:

Solar space heating and cooling are technologically feasible but are not currently economically feasible for mass application throughout the nation. For many parts of the country solar applications will either require large, expensive storage systems or backup systems. This requirement may result in little change in required backup capacity although it should provide fuel savings. Note also the cost-benefit analysis allowed nuclear plants to compete only within an envelope of 60% of the electric generating capacity. Thus 40% of the electric capacity and all of the non-electric energy demand must be supplied by non-nuclear alternatives.

Comment (pp. 1/14, 15):

"The assumption that society will continue to increase the efficiency of its energy utilization, and the implication that the electric power industry will continue to achieve

greater efficiency in the generation of electricity, have also been seriously challenged."

"As systems become more dependent upon high-technology (energy intensive) methods, Odum argues, both the net energy efficiency tends to diminish, and the BTU recovered per dollar invested, tends to diminish as well."

ERDA Response:

The assumption that society will increase the efficiency of energy utilization is based on historic trends of improvement in the efficiencies of energy generation, transportation and application. Electric energy generation efficiency has increased in the past and the deployment of LMFBR can continue this trend relative to current nuclear reactors and fossil plants.

An implication that high-technology methods diminish energy and economic efficiency is of course a generality and certainly is not always true. For example, application of heat pumps for space heating may be more efficient than both electric resistance heating and direct combustion of fossil fuels. Also, nuclear reactors produce electricity at lower cost than fossil plants in many areas of the country right now. The advent of the LMFBR can further increase the economic advantage of nuclear power.

Net energy efficiency is a useful measure of performance although one must remember that optimum economic use of energy does not always coincide with maximum energy output-to-input ratios. Present day nuclear plants have been found to be comparable to fossil fueled electric generating plants in terms of net energy efficiency. Rombough and Koen[1] indicate LWRs and coal fired plants require about 7% of their lifetime output to pay their construction and fuel cycle energy debt. The LMFBR will have negligible fuel cycle energy costs and will reduce LWR fuel cycle energy costs. Therefore the LMFBR will increase the total power system net energy efficiency.

Comment (p. 1/17):

".... Census Bureau Series D data was used for the projection of nuclear energy production base case. The E-series population projection of the Bureau of Census was used' as the basis for

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[1] "Total Energy Investment In Nuclear Power Plants," C. T. Rombough and B. V. Koen, Nuclear Technology, Vol. 26 (May, 1975).

the GNP estimates. Presumably this would have the effect of increasing the proportion of nuclear energy calculated within the total budget in a comparison of the nuclear energy forecasts."

ERDA Response:

In the long term, a mismatch in the population projections would lead to a mismatch in the capacity and demand projections. However, in the short term, like the 1980 projections you quote, there is very little difference in capacity projections stemming from population projections. The plants that will be on line in 1980 are committed now. As was noted on p. 2.1-22, the PFES was modified to include the updated WASH-1139 (74) capacity projections which have decreased near term plant build schedules to reflect current plant commitments.

Comment (p. 1/18):

"If one were to examine the trends in nuclear power development over the entire range of the ten year period since the first large wave of commercial nuclear power plant orders were placed in 1965, it would appear that the commitment to nuclear power production has peaked (during the period of low-cost fossil fuels), and there is no direct evidence to indicate that interest is likely to revive."

ERDA Response:

On the contrary there is substantial evidence to indicate future reliance on nuclear power. Current declines in nuclear plant construction are caused by a combination of licensing delays, capital shortages and recessionary impacts on electricity demand. The current ability of LWRs to generate electricity from domestically available fuels at lower cost than fossil fired plants provides strong incentives to build additional nuclear power plants. Federal government support in terms of Project Independence goals and capital investment tax incentives clearly demonstrate a desire to break the nuclear plant construction bottleneck.

Comment (p. 1/21):

"No analytical evidence is presented to indicate that these projected rates of per capita consumption are necessary to raise the standard of living (as, for example, in providing better home heating in low-income housing), to provide greater national security, or for other socially desirable goals. Implicitly the only justification for these projected levels of increased per

capita consumption, derive from presumed correlations between energy consumption and economic well-being. Unfortunately, no causal relation has been demonstrated."

ERDA Response:

In the free market system the only possible objective measure of the worth of a good, such as energy, to a consumer is his willingness to purchase the good. Therefore, based on this causal relationship and the desire of the public to improve their standard of living (particularly the large minority now living at a sub-standard economic level), increases in per capita energy consumption are socially desirable goals. Historically, increases in per capita consumption and increases in the gross national product have been closely related (see Section III F.2) and have indicated the close relationship between energy consumption and the standard of living.

Comment (p. 2/9):

"The differences between projected growth rates and figures for commercial demands as estimated here and in Table 12 should be noted."

ERDA Response:

Table 12 represents historical data and Table 14 represents forecasted demand, the data cannot be directly compared.

Comment (p. 2/10):

Figures from an ADL Preliminary Report differ substantially from the estimated, and projected growth rates of residential space heating loads inferred from WASH-1535.

ERDA Response:

The cost-benefit analysis in the PFES utilized energy demand projections obtained from an econometric model. Since the econometric analysis does not provide a breakdown of demand by sector it is difficult to understand the basis for your conclusion that the ADL data "represent substantial differences" from the PFES data.

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Comment (p. 2/20):

> "Unfortunately, in considering only those alternative technology options available for 'generating or conserving electric energy', with the 'belief that electricity (will) continue to substitute for other forms of energy...', the potential for substituting solar-thermal energy for electric in selective residential component sectors, has been completely overlooked."

ERDA Response:

The LMFBR Environmental Statement necessarily must focus on alternatives to the LMFBR. The LMFBR generates electricity. The assumption that electricity will substitute for traditional uses of fossil fuels and that new uses of electricity will be found is a generalized statement based on historic and current trends. A trend to electrify residential and commercial space and water heating is only a part of the more global trend. Certainly solar energy has a potential to satisfy residential and commercial heating requirements. The cost-benefit analysis of the LMFBR neither explicitly evaluates nor ignores the potential of solar energy.

Instead the cost-benefit analysis determines the benefits of the LMFBR to penetrate a limited portion of the electric generating capacity market. The contributions of solar and other alternatives can and probably will contribute to the remaining 40% of the electric generating capacity and the non-electric energy supply market. In addition the cost-benefit analysis contains many cases which analyze the incentives for the LMFBR under conditions of reduced energy demand. Thus the data is available for you to formulate your own conclusions.

SCIENTISTS' INSTITUTE FOR PUBLIC INFORMATION

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April 8, 1975

Mr. W. H. Pennington
Assessment and Coordination Officer
Division of Biomedical and Environmental Research
U.S. Energy Research and Development Administration
Washington, D. C. 20545

Dear Mr. Pennington:

Enclosed please find comments of the Scientists' Institute for Public Information on the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor (LMFBR) Program as solicited in the Federal Register volume 40 #17 January 24, 1975, pages 3804 - 3806.

Sincerely,

Alan McGowan
President

Comments of the

Scientists' Institute for Public Information

in regard to the

Atomic Energy Commission's

Proposed Final Environmental Statement

on the

Liquid Metal Fast Breeder Reactor Program

Submitted to the

Energy Research and Development Administration

April 8, 1975

Prepared by the following SIPI Task Force Members:

Barry Commoner	Chairman, SIPI
William Groth	Research Assistant, SIPI
Leonard Maniace	Research Assistant, SIPI
Alan McGowan	President, SIPI
Sheldon Novick	Editor, Environment Magazine, SIPI
Diane Yale Sauter	Research Associate, SIPI

April 9, 1975

STATEMENT OF THE EXECUTIVE COMMITTEE OF THE
SCIENTISTS' INSTITUTE FOR PUBLIC INFORMATION

In its comments on the Draft Environmental Statement of the Atomic Energy Commission's Liquid Metal Fast Breeder Reactor Program, and in a statement by the SIPI Executive Committee accompanying those comments, the Scientists' Institute stated that it found the AEC's draft statement "so grossly inadequate as to prevent rather than enhance public discussion". It went on to say that the AEC should "withdraw (the draft statement) and produce a new draft that seriously confronts the complex issue of how best to produce and use the energy that is essential to the nation's future".

Accordingly, the Scientists' Institute looked with great interest on the new environmental statement which SIPI and others had called for. A Proposed Final Environmental Statement was prepared by the AEC as one of its last acts before having its activities absorbed into the newly established Energy Research and Development Administration and the Nuclear Regulatory Commission.

However, changes of great magnitude have occurred in the twelve months since the preparation of the original draft statement, both within the agency responsible for the Liquid Metal Fast Breeder Reactor Program, and within the American nation. These changes have not been seriously considered in the Proposed Final Environmental Statement, yet they are crucial to the program under consideration. The Scientists' Institute for Public Information concludes, therefore, that the Statement must be withdrawn by ERDA, and the breeder program must be completely reassessed, before presentation of a relevant environmental impact statement.

The Statement was prepared by the Atomic Energy Commission (AEC) which was created by the Atomic Energy Act of 1946, amended in 1954, with the paramount objective of assuring and maximizing military defense and security through the development and control of atomic energy. The AEC was abolished by act of Congress in 1974, and its nuclear research and development activities were inherited by the Energy Research and Development Administration (ERDA), which is now the agency responsible for issuing a final environmental statement on the breeder program.

However, ERDA's mandate is quite different: to increase the efficiency and reliability of the use of all energy sources to meet the needs of present and future generations, while advancing the goals of restoring, protecting and enhancing environmental quality, and assuring public health and safety. The various methods of utilizing solar energy, whose contributions are minimized in the Statement, are specifically named by Congress as warranting priority by ERDA.

ERDA has been assigned responsibilities under the Energy Reorganization Act of 1974, the Federal Nonnuclear Energy Research and Development Act of 1974, the Solar Heating and Cooling Act of 1974, the Solar Research, Development and Demonstration Act of 1974, and the Geothermal Energy Development and Demonstration Act of 1974. While the Proposed Final Environmental Statement was mailed to commentators by the AEC on December 31, 1974, ERDA did not officially begin operation until January 19, 1975, although Dr. Robert C. Seamans, Jr. took office as Administrator on December 30, 1974.

In addition to ERDA's Assistant Administrators in charge of nuclear energy and national security, there are also Assistant Administrators in charge of fossil energy; environment and safety; solar, geothermal and advanced energy systems; and conservation. While ERDA received a large transfer of personnel from the AEC, there are also 1165 new employees transferred from the Department of the Interior, the National Science Foundation, and the Environmental Protection Agency. It is apparent that their areas of competence are not reflected in the Statement.

ERDA is required by June 30, 1975 to present to Congress the nation's first comprehensive plan for energy research, development and demonstration, to achieve short-term (to the early 1980's), middle-term (early 1980's to 2000), and long-term (beyond 2000) solutions. This plan is to be accompanied by a comprehensive program to implement ERDA's nonnuclear functions, and will include an evaluation of costs as well as of economic, environmental, technological and social merits. The plan will have the benefit of review within sixty days by the congressional Office of Technology Assessment.

The National Environmental Policy Act (NEPA) specifies that the lead agency in a proposed action must prepare an original environmental impact statement and may not accept one carte blanche from another agency (Greene County vs. Federal Power Commission and Kalur vs. Resor). Through no fault of its own, ERDA has been placed in the position of having to answer to the public for a statement

which it did not prepare, and which fails to satisfy its own mandate as well as several requirements of NEPA, including full disclosure to the affected community.

Fortunately, before the end of this fiscal year, ERDA should have a better idea of what place it considers the breeder program should have in a comprehensive national energy plan, and be able to begin preparation of a new statement with a more current data base.

The data base

Although 1974 and 1975 have been designated "shrink years" that have caused the Edison Electric Institute, Electrical World, and the Federal Power Commission, as well as various electrical utility and manufacturing corporations to revise their former predictions of future electrical growth rates, the Statement explicitly rejects this course, considering it "most prudent" to center its own demand projections on extrapolations from earlier high growth rates. This is in contradiction to its own admission that "Any projection model used to estimate electrical energy growth depends directly on the continued relevance of the parameters selected".

Parameters used in the Statement to predict future electrical demand are population growth, size of work force, rates of labor productivity, gross national product, and total energy demand. These are inflated in the Statement in every case, either because the data used were several years old, or because of an unwillingness to accept the

relevance of changed circumstances. No serious evaluation was made of the future impact of the drastic declines which have occurred more recently or of the possible impacts of proposed Federal programs such as Project Independence.

The Statement's cost-benefit analysis does not incorporate any new information, continuing to assume the historic increase in electrical demand of 7.8% per year till 1980, whereas in 1974 demand actually decreased .56% below the 1973 level, and the first two months of 1975 showed only a 4% increase. The Statement claims that recent variability is accounted for by its inclusion of cases down to 50% of their base case projection, but their -50% case is above the projection made in December 1974 by the Technical Advisory Committee on Finance of the Federal Power Commission for historic growth up to the year 1990.

It is at -50% of the base projection for demand that the Statement presents the first benefit-cost ratio below 1.0, yet it is from this point that ERDA may have to begin to prepare new input to the econometric model, providing current information on the delayed breeder introduction date, increased capital costs, lower energy demand compounded by all the parameters cited, more optimistic uranium supply, and increased research and development costs.

With capital formation among the most serious problems facing the nation, continued investment in this program would inevitably

foreclose the development of other energy options which ERDA, in its comprehensive plan, and with its expanded authority, may choose to emphasize.

Conclusion

WASH-1535, the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor Program, is the obsolete vision of a now defunct agency. It would be tragic indeed if uncounted future generations of humans were committed to the irreversible effects and irretrievable losses imposed by breeder development, simply because proper evaluation of the program was impeded during an administrative transition.

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CHAPTER I

INTRODUCTION

One year ago the Atomic Energy Commission (AEC) released a Draft Environmental Statement on the Liquid Metal Fast Breeder Reactor Program. The Scientists' Institute for Public Information (SIPI) found this document grossly inadequate, and called for a new draft that seriously confronted "the complex issue of how best to produce and use the energy that is essential to the nation's future".

As one of its last acts, the AEC released a Proposed Final Environmental Statement on the breeder program, giving its successor, the Energy Research and Development Administration (ERDA), the option to adopt the Statement after review. While this revision made a cosmetic attempt to improve some of the blemishes exposed by commentors, it remains outdated, incomplete, inaccurate and misleading. This Statement continues to be an inadequate document upon which to base a decision that will influence the structure of society for decades to come.

Particularly, it fails to confront the impacts of changes of great magnitude that have occurred in the past six months, both within the agency responsible for issuing the Statement, and in the American nation itself. As a result, SIPI concludes that the Statement must be withdrawn by ERDA, and the breeder program must be completely reassessed, incorporating new comments made by the public, before presentation of a relevant environmental impact statement.

The Lead Agency

This Statement was prepared by the AEC, which was created by the Atomic Energy Act of 1946, amended in 1954, with the paramount objective of assuring and maximizing military defense and security

through the development and control of atomic energy. The AEC was abolished by act of Congress in 1974, and its nuclear research and development activities were inherited by ERDA.

ERDA has been assigned additional responsibilities under the Energy Reorganization Act of 1974, the Federal Nonnuclear Energy Research and Development Act of 1974, the Solar Heating and Cooling Act of 1974, the Solar Research, Development and Demonstration Act of 1974, and the Geothermal Energy, Development and Demonstration Act of 1974. While the Proposed Final Environmental Statement was mailed to commentors by the AEC, over the signature of James L. Liverman, on December 31, 1974, ERDA did not officially begin operation until January 19, 1975, although Dr. Robert C. Seamans, Jr. took office as Administrator on December 30, 1974.

ERDA's mandate is quite different from the AEC's: to increase the efficiency and reliability of the use of all energy sources to meet the needs of present and future generations, while advancing the goals of restoring, protecting and enhancing environmental quality, and assuring public health and safety. The various methods of utilitizing solar energy, whose contributions are minimized and difficulties exaggerated in the Statement, are specifically named as warranting priority by ERDA. Maximum conservation measures, simimarly minimized in the Statement, are also specified as an ERDA goal.

In addition to ERDA's Assistant Administrators in charge of nuclear energy and national security, there are also Assistant Administrators in charge of fossil energy; environment and safety; solar, geothermal and advanced energy systems; and conservation. While ERDA received a large transfer of personnel from the AEC,

there are also 1165 employees transferred from the Department of the Interior, the National Science Foundation, and the Environmental Protection Agency. It is apparent that their areas of competence are not reflected in the Statement.

A comparison is appended at the end of this introductory chapter, which details the many areas in which the responsibilities of ERDA differ from those of the AEC, including the dissemination of information to the public.

ERDA is required by June 30, 1975 to present to Congress the nation's first comprehensive plan for energy research, development and demonstration, to achieve short-term (to the early 1980's), middle-term (early 1980's to 2000), and long-term (beyond 2000) solutions. This plan is to be accompanied by a comprehensive program to implement ERDA's nonnuclear functions, and will include an evaluation of costs as well as economic, environmental, technological and social merits. This plan is currently in preparation, with the assistance of the Mitre Corporation, and TRW, Incorporated. It will have the benefit of review within sixty days by the congressional Office of Technology Assessment.

The National Environmental Policy Act (NEPA) specifies that the lead agency in a proposed action must prepare an original environmental impact statement and may not accept one "carte blanche" from another agency (Greene County vs. Federal Power Commission and Kalur vs. Resor). Through no fault of its own, ERDA has been placed in the position of having to answer to the public for a statement which it did not prepare, and which fails to satisfy its own mandate as well as several requirements of NEPA, including full disclosure to the affected community.

Fortunately, before the end of this fiscal year, ERDA should have a better idea of what place it considers the breeder program should have in a comprehensive national energy plan, and be able to begin preparation of a new statement with a more current data base.

An Example of the Statement's Definition of "Current"

In basic ways, the Proposed Final Environmental Statement (PFES) remains unchanged from the Draft Environmental Statement (DES). An example follows, taken from one small section of the Summary volume.

Volume I, Section 2.1 of the PFES, "Relationship of the LMFBR Program to the U.S. Energy Economy", is twenty-five pages long, and contains a total of seventeen figures and tables. Sixteen of these are identical with those that appear in the same section of the DES, and were generally produced in 1972 or earlier. The one addition to the PFES is a figure comparing 1968 per capita income and energy consumption.

The PFES Section 2.1.3.3., dealing with the "Current Situation" in the generation of electricity, presents Table 2.1-11, identical to the DES Table 2.1-11, giving U.S. electrical utility industry statistics for 1972. Similar statistics are published for 1973 and beyond in monthly issues of the Federal Energy Administration's Monthly Energy Review published in 1974, and so were certainly available to the AEC at the time the PFES was being prepared.

Several identical Tables (2.1-12, 2.1-13, 2.1-14) which were produced in 1972 contain projections of population, energy consumption, and/or generating capacity. (The PFES bases its projections for electrical demand on 1972 Bureau of the Census projections,

though these are revised several times a year.)*

Compared word for word, the PFES Section 2.1.3.4 dealing with "Projections of Future Electrical Demand" is substantively identical with the same section of the DES, with the substitution of "there is wide agreement" in one instance where "there is universal agreement" had appeared, and the addition of "but now we must add the expectation that electrical energy will be substituted for applications that had been served directly by dwindling oil and gas supplies".

To support its own projections of electrical demand, the Statement cites projections that were made by the Federal Power Commission (FPC) from 1969 through 1973 (pp 2.1-14,15). Yet projections released by the FPC in 1974 are substantially lower than these. A projection considered by the AEC to be 50% below their base case of historical growth of 7.8% per year till 1980 (p. 11.2-9) was above the FPC projection for an all-electric case accelerated beyond historical growth in that period. Similarly, the AEC -50% case was still above the FPC projection for historical growth till 1990.**

The Cost-Benefit Analysis

The Statement claims that "the range of variables explored in the cost-benefit analysis...(e.g. cases which assume a 50% reduction in the base case projection of electrical demand in the

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* Publications Order Form: Current Population Reports, U.S. Dept. of Commerce, Bureau of the Census, Form BC-2340, October, 1973.

** A Report to the Federal Power Commission by the Technical Advisory Committee - Finance, The Financial Outlook for the U.S. Electric Power Industry, December 1974 (Preliminary Release), pp. 72, 76, 139, 140.

year 2020) appears to provide adequate insight into the possible effects of major uncertainties in the assumptions used". It further claims that benefits are reduced below costs only when a number of assumptions are simultaneously weighted in a manner which is considered unlikely to occur (p. 11S-1).

We observe that these "unlikely" circumstances only begin to touch upon current and realistic interactions of the chosen parameters. It is from this point that ERDA may have to begin to prepare new input to the econometric model, providing current information on the delayed breeder introduction date, increased capital costs, lower energy demand compounded by all the parameters cited, more optimistic uranium supply, and increased research and development costs. A discussion of each of these parameters follows.

LMFBR Introduction Date

Of fifty-six cases run in this "updated" cost-benefit analysis which considered introduction of the LMFBR, only four possible dates were evaluated (Appendix IV.D):

Year of introduction	No. of cases considered/year
1985	6
1987	40
1988	4
1991	6

Yet the most recent pronouncement of the date of introduction* hoped for the generation of electricity by the breeder "in the early 1990s", if there was "extensive industrial and governmental

* Summary Sheet accompanying letter of transmittal, dated February 11, 1975, U.S. Atomic Energy Commission, along with Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program.

cooperation". This referred in part to the deferrment and cancellation by utilities of 170,000 out of 360,000 mw (47%) of generating capacity, in 1974, due to major financing difficulties.*

Therefore, at most, only 10.7% of cases run were possibly relevant. A meaningful Statement would have to consider several introduction dates beginning with 1991, reflecting a penalty for each year of delay. In the Statement, this penalty is described as follows: "Delaying the introduction date for the LMFBR reduces the benefits by $½ to 1½ billion per year of delay, with the exact value depending upon the uranium supply and the energy demand" (p. 11.2-15).

Capital Costs

The assumption is made in the Statement that a decrease will occur in the capital cost of the LMFBR, due to the learning process associated with the introduction of a new plant type, from $520/kwe in 1985 declining to $360/kwe in 2000, in 1974 dollars (p. 11.2-12).

Comparing this to the experience with light water nuclear reactors, we find an original estimate of $135/kwe raised to $240/kwe, then $350/kwe, and later to $400-$510/kwe. in an eight year period. In real costs, during the two years 1971 to 1973, this amounted to a $90 million capital cost increase for a 1000 mwe LWR.**

Research and Development Costs

While the maximum undiscounted research and development cost used in the Statement is $8.7 billion, or generally $4.7 billion at

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* "Utilities: Weak Point in the Energy Future", Business Week, January 20, 1975, p. 46.

**Power Plant Capital Costs, WASH-1345, U.S. Atomic Energy Commission, October 1974, pp. 6, 7, 8.

the accepted 10% discount rate (Appendix IV-D) the AEC estimated in January 1975 that it would require $10 billion of government funds plus substantial private funds to develop the breeder into a commercially viable energy option.*

Dr. Seamans himself has said, "The unstable financial situation has certainly contributed to problems in the development of the fast breeder...cost over-runs have far exceeded the rate of inflation."**

Electrical Demand

Although 1974 and 1975 have been designated "shrink years" that have caused the Edison Electric Institute, Electrical World, and the Federal Power Commission, as well as various electrical utility and manufacturing corporations to revise their former predictions of future electrical growth rates, the Statement explicitly rejects this course, considering it "most prudent" to center its own demand projections on historical experience (p. 11.2-55). This is in contradiction of its own admission that "Any projection model used to estimate electrical energy growth depends directly on the continued relevance of the parameters selected" (p. 11.2-57)

Parameters used in the Statement to predict future electrical demand are population growth, size of work force, rates of labor productivity, gross national product, and total energy demand (p. 11.2-53). These are inflated in the Statement in every case, either because the data used were several years old, or because of

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* Federal Register, Vo. 40, No. 17, January 24, 1975, p. 3806.

** "Speeches", Information from ERDA, February 26, 1975, p. 4.

an unwillingness to accept the relevance of changed circumstances. No serious evaluation was made of the future impact of the drastic declines which have occurred since September 1974, or of the possible impacts of proposed Federal programs such as Project Independence.

The cost-benefit analysis does not incorporate new information. It continues to assume the historic increase in electrical demand of 7.8% per year till 1980 (p. 11.2-9) whereas in 1974 demand actually decreased .56% below the 1973 level,*and the first two months of 1975 showed only a 4% increase. Instances are cited below where values of parameters used in the Statement deviate from those of other experts or from recent experience. These comments are offered not only for the percentage differences they suggest, but also as an evaluation of the Statement's methodology.

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*"1975 Annual Statistical Report", Electrical World, March 15, 1975, p. 66.

Population

Source of projection	Estimated fertility rate	Population by the year 2000 (millions)	Difference from Statement's projection
* Statement, based on 1972 Bureau of Census	2.1	271	
** 1972 Dept. of Interior	2.4	279.9	+3%
*** 1975 Bureau of Census	2.1	262	-3.4%
**** 1972 Planned Parenthood	2.1	271	
***** 1974 Planned Parenthood		"to be revised"	
****** 1974 Electrical World (extrapolated)		256	-6%
******* 1974 Council on Environmental Quality	1.8	250	-8%
*** 1975 Bureau of Census	1.7	245	-10%

Moreover, the National Center for Health Statistics reported an actual United States fertility rate of 1.9 in 1973, with the rate continuing to decline in 1974.********

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* p. 11.2-53.

**p. 2.1-16.

***News Release CB75-29, U.S. Dept. of Commerce, February 10, 1975.

****Population Boom or Bust?, Planned Parenthood World Population, N.Y., October 1972.

*****Lawrence A. Mayer, "It's a Bear Market for Babies, Too", Fortune Magazine, December 1974, p. 137.

******Leonard M. Olmsted, "25th Annual Electrical Industry Forecast", Electrical World, September 15, 1974, p. 44.

*******A National Energy Conservation Program: The Half and Half Plan, Council on Environmental Quality, March 1974, p. 6.

********Dana Little, "Marriages on the Decline", New York Times, March 1, 1975, p. 18.

Size of Work Force

Statement: The effects of changes in age composition of the population, which affect the size of the work force, will not be apparent until the late 1990s (p. 11.2-53).

McGraw Hill: The U.S. labor force, because of the changing age composition of our population, will grow less rapidly beginning with the late 1970s.*

Labor Productivity

Statement: 2.6% increase/employee/year till 2020 (p. 11.2-53).

McGraw-Hill: 2.3% increase/employee/year till 1988.**

Gross National Product

Source	Annual growth rate
*** Statement projection	Historical (3.7%)
**** 1973 Electrical World projection	3.7% to 1990
**** 1974 Electrical World projection	3.0% to 1995
***** Actual GNP, 1974	-2.1%
****** 1975 Electrical World projection for 1975	-2.3%

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*Economics Department, The American Economy: Prospects for Growth to 1988, McGraw-Hill, Inc., N.Y., 1975, p. 4.

**Ibid., pp. 5, 6.

***p. 11.2-53.

****Olmsted, op. cit.

*****"1975 Annual Statistical Report", p. 44.

******Ibid.

Price Elasticity

Seventy-eight utility companies requested price increases in 1974, tripling the amount per increase over 1970.* Although the cost-benefit analysis does not consider price elasticity, the average 24% increase in the price of electricity in 1974 should, using the Chapman, Tyrrell and Mount analysis,** eventually lead to a demand 36% less than it would otherwise have been. A drop of 18% would be apparent in 1981, with a drop of 3.6% by the end of 1975.

Conclusion

WASH-1535, the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor Program, is the obsolete vision of a now defunct agency. It would be tragic indeed if uncountable future generations of humans were committed to the irreversible effects and irretrievable losses imposed by breeder development, simply because proper evaluation of the program was impeded during an administrative transition.

With capital formation among the most serious problems facing the nation, continued investment in this program would inevitably foreclose the development of other energy options which ERDA, in its comprehensive plan, and with its expanded authority, may choose to emphasize.

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*"1975 Annual Statistical Report", p. 68.

**Duane Chapman, Timothy Tyrrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crises", Science, Vol. 178, November 17, 1972, pp. 703-8.

APPENDIX TO CHAPTER I

Comparison of the Mandates of the AEC Under the Atomic Energy Act of 1946 (and 1954, Amended) and ERDA Under the Energy Reorganization Act of 1974 and the Federal Nonnuclear Energy Research and Development Act of 1974

Paramount Objective

AEC

1946: To assure common defense, with development and utilization of atomic energy. So far as practicable, to improve the common welfare (Sec. 1(a)).

1954: To make minimum contribution to the common defense and security (Sec. 1(a)).

ERDA

ERA: To increase the efficiency and reliability of the use of all energy sources to meet the needs of present and future generations, while restoring, protecting and enhancing environmental quality and assuring public health and safety (Sec. 2(a)).

FNERDA:
To support the broadest range of energy policy options through conservation and use of domestic resources by socially and environmentally acceptable means (Sec. 3(a)).

Officers (in order of mention)

AEC

1954: General Manager,
Director of the Division of Military Application,
Director of the Division of Civilian Uses of Atomic Energy,
General Counsel,
Director of the Inspection Division (Sec. 25).

ERDA

ERA: Administrator,
Deputy Administrator,
6 Assistant Administrators of:
1) fossil energy
2) nuclear energy
3) environment and safety
4) conservation
5) solar, geothermal and advanced energy systems
6) national security

General Counsel,
Up to 8 additional officers,
Director of Military Application
(Sec. 102 (a) through (g)).

Primary Research and Development Responsibility

AEC

1954: R&D related to nuclear processes, atomic energy, utilization of nuclear and radioactive materials (Sec. 31 (a)).

ERDA

ERA: R&D, including demonstration of commercial feasibility and practical applications of the extraction, conversion, storage, transmission and utilization phases related to the development and use of energy from fossil, nuclear, solar, geothermal, and other energy sources (Sec. 103 (2)).
Priority might include but not be limited to various solar technologies (Sec. 2(e)).

Comprehensive Energy Policy Planning

AEC

Not included.

ERDA

ERA: Central responsibility for near-term and long-range policy planning, respecting all energy sources (Sec. 103(1)).

FNERDA:
To prepare an annual comprehensive plan for energy research, development and demonstration, in regard to short, middle, and long-term solutions, evaluating economic, environmental, technological and social merits, and including a program to implement nonnuclear aspects of the plan (Sec. 5(a)(2); 6(a) and (b), (1) through (3), (A) through (Q)).

Reports to Congress

AEC

1946: A report to Congress each January and July, concerning their activities, including recommendations for new legislation (Sec. 17).

1954: Same (Sec. 251).

ERDA

ERA: A report to the President and Congress at the end of each fiscal year concerning their activities, with a statement of short and long-range goals, priorities and plans, and assessment of progress (Sec. 307 (a)).
Note: The Nuclear Regulatory Commission has to submit a report with the same content as it relates to benefits, costs, and risks of commercial nuclear power, including design, abnormal occurrences and defects, safeguards, thefts, waste disposal, and protection against low-level radioactive emissions (Sec. 307 (c)).

FNERDA:
A report to Congress on or before each June 30 as in "Comprehensive Energy Policy Planning" above (Sec. 6).

Information to the Public

AEC

1954: Permits and encourages dissemination of scientific and technical information relating to atomic energy (Sec. 141(b)).

ERDA

ERA: Responsible for developing, collecting, distributing, and making available for distribution, scientific and technical information concerning the manufacture or development of energy and its efficient extraction, conversion, transmission, and utilization (Sec. 103(6)); for creating and encouraging general information to the public on all energy conservation technologies and energy sources, using mass communications where practicable (Sec. 103(7)); and for disseminating information from its policy planning efforts (Sec. 103(1)).

International Cooperation

AEC

1946: Maximum effect was to be given to policies contained in international treaties (Sec. 8).

1954: Same as above, but no cooperation was to be

undertaken in other instances until the President and Joint Committee approved the agreement (Sec. 121, 122, 123, 144).

ERDA

ERA: Encourages participation in international cooperation in energy and related environmental research and development (Sec. 103(9)).

Military Applications

AEC

1946: To conduct R&D into military applications of atomic energy, produce atomic weapons and deliver them to the armed forces (Sec. 6(a)).

1954: Same, to Department of Defense (Sec. 91).

ERDA

ERA: During first year of operation, to review desirability and feasibility of transferring all military applications to the Department of Defense or other Federal agency (Sec. 307(b)).

Health and Safety Research

AEC

1946: Relating to utilization of fissionable and radioactive materials for medical, biological, and health or military purposes (Sec. 3(a)(3)) and the protection of health during research and production activities (Sec. 3(a)(5)).

1954: Relating to utilization of special nuclear and radioactive material for medical, biological, agricultural, health or military purposes (Sec. 31 (a)(3)) and the protection of health and promotion of safety during research and production activities (Sec. 31(a)(5)).

ERDA

ERA: Engaging in and supporting environmental, biomedical, physical and safety research related to the development of energy sources and utilization technologies (Sec. 103(3)).

Conservation of Energy

AEC

Not included.

IA-5

ERDA

ERA: Encouraging and conducting R&D in energy conservation, toward goal of maximum reduction of total energy consumption and maximum improvement in efficiency of energy use (Sec. 103(8)).

CHAPTER II

THE POTENTIAL FOR A HYPOTHETICAL CORE DISRUPTIVE ACCIDENT

For more than thirty years the Atomic Energy Commission has tried to perfect a method of producing electricity from plutonium. The effort has not so far been marked by success. The first commercial LMFBR, the Enrico Fermi reactor near Detroit, suffered a disabling accident in 1966 before it could produce appreciable amounts of electricity, and is now being dismantled with great difficulty. Construction of a larger and hopefully more reliable succesor was to have begun in 1971. The ten-volume "Program Plan" for the LMFBR issued by the AEC in 1968 (WASH-1110) envisioned the third demonstration plant (not counting Fermi) under construction in 1975.

These hopes have not been realised. Plagued by technical difficulties, extraordinary escalations in cost and most of all by the AEC's inability to produce a satisfactory justification for the program, the LMFBR seems as far from realization as ever.

The LMFBR poses three very serious risks, which stem from its central reliance on plutonium. In principle, LMFBRs can explode. Plutonium can be stolen. Plutonium is the most toxic substance known. In a broad sense, therefore, the safety of LMFBRs is critical, and a proposed program must be accepted or rejected on the basis of the risks it will create. Hence, the Statement should identify these risks clearly so that a sensible decision can be made. Unfortunately, it does not provide an adequate assessment of risks, but instead takes refuge in uncertainty and the hope that doubts will be resolved

in favor of the program.

Safety hazards in the LMFBR program are in theory very great. Without regard to practical likelihood or the actual design of a plant, we can say it is possible for the fuel of an LMFBR to undergo a nuclear explosion. This follows from the use of two tons of plutonium in a form which, without further alteration, can be made to explode. The critical mass of LMFBR fuel is estimated variously as between 30 and 60 kilograms (p.V.20-7) - roughly one hundred pounds - or a very small fraction of the tons of fuel available in a power plant. From this it follows as well that a small part of a plant's fuel may be stolen and made into a nuclear weapon.

On this point there has never been any dispute, although the AEC has assiduously avoided the term "explosion". The acceptable locution is "hypothetical core disruptive accident" (HCDA) or "core disassembly". In our comments on the draft statement, SIPI pointed out that "disassembly" is a euphemism for an explosion, which the Statement somewhat pettishly concedes:

> The disassembly process has often been referred to as an "explosion". Technically, the term explosion could be used in that one of the forces contributing to the disassembly can be fuel vapor. However, in virtually every instance, other earlier acting forces are available... (p.4.2-146).

One might wonder why the term "explosion" should be limited to the case in which vaporized fuel expands rapidly enough to do the damage with which we are concerned. Would "disassembly" by rapidly expanding sodium vapor not be an "explosion"? The American Heritage Dictionary defines the

word as "A sudden rapid violent release of mechanical, chemical or nuclear energy from a confined region", which seems to cover the ground pretty well. But perhaps the AEC's concern is more clearly expressed in the final sentence of the paragraph just quoted:

> It is absolutely impossible for any nuclear incident to lead to explosions of the magnitude associated with nuclear weapons, that is, many thousands of tons of explosive equivalent.

This indicates fairly clearly the concern about this word - the AEC would not like LMFBRs linked in the imagination with nuclear weapons. The concern, in short, is not for technical accuracy but for public relations.

Nor is this a minor point. The safety of nuclear power is a decisive issue, and the safety of LMFBRs depends decisively on their potential for explosion - if the plants are found to be likely to suffer explosions that release radiation it seems very unlikely they will ever be built in a populated country. The importance of this point is clear once we begin to talk about the possibility of explosions in the fuel of an LMFBR. An explosion severe enough to rupture the protective enclosures and disperse a large quantity of plutonium and radioactive wastes into the air is precisely the event we are concerned about. A mere disruption of the core, or fuel, while it might cost some power company and its customers the billion dollars or so invested in the plant, would be a matter of less concern.

Because it is precisely the explosive potential of

accidents that is of concern, it used to be routine to describe theseoccurrences in terms of equivalent weights of TNT. In the first detailed program plan for the LMFBR, for instance, published in 1968 when public attention was perhaps less acutely focused on these matters, "explosion" is the word of choice:

> Nuclear Bursts: For both EBR-II and Fermi, explosive energy releases from nuclear bursts as well as sodium-air reactions were considered as design basis accidents.... The meltdown-reassembly...accidents were calculated to produce energy releases roughly equivalent to the detonation of 300 to 500 lb. TNT. This was used as the design basis for the blast and missile shielding.*

At another point in the discussion this early report points out that the translation of accidents into equivalent weights of TNT explosion is merely shorthand, and that references should always be included to describe the actual release of energy more precisely. But the usage is retained, and for good reason, since it is the possibility of an explosion which concerns us.

An explosion is conceded, therefore, as a possibility. Is an explosion a practical as well as a theoretical possibility - and how large would or could such an explosion be?

This question is ordinarily put in a different form. The theoretical possibility of an explosion being conceded, the issue is whether we can put some practical upper limit on the explosion, and build a power plant structure strong enough to contain it. As the AEC pointed out, a nuclear weapon with the

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* WASH-1110, p. 10-2.2

force of thousands of tons of TNT which no structure conceivable could withstand, seems to be out of the question. Purposeful design is needed to produce explosions of this size. That is not a very comfortable upper bound - but, as the Statement implicitly concedes, it is the only one which can be drawn with certainty.

A hundred pounds or less of plutonium is capable of undergoing a nuclear explosion. There are circumstances in which a plant's fuel may melt - a portion of the Fermi's fuel melted in the accident which shut it down. In an accident more severe than one which has yet occurred in a commercial power plant, all or much of the fuel may melt. How can we know that a small fraction of this fuel will not collect or be compressed until it explodes? The euphemism for such an occurrence is "autocatalytic recriticality". There are several conceivable ways in which a power plant's fuel, following an accident, might be collected into an explosive configuration, and several are briefly discussed in the Statement. Here is the entire discussion of one possibility:

> An example of this ("autocatalytic recriticality") would be a situation where a disassembly excursion ejects molten material out against the surrounding structure where it temporarily collects and goes critical. This mode of recriticality is at least conceptually possible in large reactors (reference); planning has begun to evaluate the effects of this mode of recriticality.

"Planning" apparently had begun somewhat earlier for other such possibilities, but in every case one is faced with the formidable problem of predicting in detail what will happen to the tons of plutonium and other material in a reactor's core under circumstances which have already led to the melting and

gross dispersal of the fuel within its vessel. It is not surprising that efforts to make such predictions are constantly being defeated by the appearance of new complexities. In commenting on the earlier Draft Statement, NRDC had said of this research:

> These results further demonstrate the tremendous uncertainties with respect to estimating the explosive potential of these reactors. (p.4.2-149).

To which the Statement replies:

> It is true that significant uncertainties exist in the analysis of recriticality situations. In large measure, these uncertainties stem from the as yet incomplete research and development program; analytical methods do not permit detailed assessment of all the contributing factors that would affect the outcome of such situations, if indeed such situations are possible at all (ibid.).

The report then goes on to argue that the situations about which there is so much uncertainty are unlikely to arise, because a large explosion seems to require a large mass of fuel being compacted quickly, and this would be "possible in only a limited range of circumstances". Whatever the actual explosive potential of such an accident would be, and we admittedly cannot say at this point, it is apparently an accident of "low probability".

Neither the AEC nor, apparently, anyone else is therefore in a position to draw an upper bound on the force of explosions possible in LMFBRs short of the force of a nuclear weapon. A common-sense view would be that no such upper bound can ever be drawn. Implicitly conceding this point, the AEC declined to take into account all accidents which are physically possible. Instead, the AEC chose to rely on its research program to

demonstrate that such accidents are either so unlikely that they need not be taken into account, or that once identified and understood properly, adequate measures can be taken to prevent them.

Uncertainties are not limited to this class of accidents, by any means. "Autocatalytic" accidents are events which follow the occurrence of an initial accident that damages the reactor's fuel - a "hypothetical core disruptive accident" that itself is or can be an explosion. The great concern with the second step, the autocatalytic accident, stems from the realization that the initial accident is neither impossible nor improbable:

> With the greater sophistication of analytical tools used to aid the understanding of the disassembly process, the possibilities of an initially mild prompt critical burst have increased, at least for some HCDA events arising from loss of flow and failure to scram. Secondary criticalities correspondingly have been given increasing emphasis in the research and development program. (p.4.2-148).

Which is to say, a mild first explosion may set off a more severe second explosion, and the AEC has found the chances of the first explosion's occurring to be larger than it thought at first.

As this passage suggests, the first explosion, or disruption, might occur from a stoppage of the flow of molten sodium which cools the fuel. Unlike present water-cooled reactors, which cannot function without the flow of water through the fuel, LMFBRs suffer an increased rate of nuclear reaction if their coolant is lost. If the reactor is not shut down, the nuclear reactions will continue to increase until the fuel is "disrupted" by the energy release.

In a commercial-size (1000 megawatt) plant, such a release of energy is calculated to reach no more than about 15,000 megawatt-seconds (p.4.2-152) before the fuel is dispersed, halting the release (unless, of course, there is a second compaction of fuel somewhere in the reactor setting off a second explosion). A megawatt-second is a quantity of energy roughly equal to that released by the explosion of a half-pound of TNT, so this release is comparable in terms of energy to the explosion of perhaps three tons of TNT.

There is a difference, however, between the energy released in the nuclear reactions and the energy which would contribute to an explosion. The question is, how much of the nuclear release can be converted into a form capable of doing damage to the physical structure of the reactor - of doing "work" in the physicist's sense. The Statement says that a theoretical limit has been calculated, of about 10%. The actual explosion, therefore, simply cannot be greater than about 600 pounds of TNT.

This is not as reassuring as it might be, since at another point the Statement says the LMFBR is built to withstand only "several hundred megawatt-seconds of work energy," or perhaps three hundred pounds of TNT at the most.

Another disturbing point should be mentioned here. In its 1968 program statement, in a passage quoted above, the AEC cited what it then thought was the most conservative analysis, the "Bethe-Tait" analysis, which produced estimates that an explosion in a 1000-megawatt plant could be no more than the equivalent of 300-500 pounds of TNT, which reactors were then

designed to withstand. The Bethe-Tait analysis is about twenty years old now, and apparently the progress of research has shown that the earlier "conservative" analysis was too optimistic, and that better understanding has revealed the possibility of worse accidents.

To reassure us, the AEC notes that laboratory-scale experiments have not shown any appreciable conversion of nuclear energy to useful work, and that the observed conversion in these laboratory experiments is less than 0.2 percent. This is not as reassuring as perhaps it is intended to be. The wide disparity between calculation and experiment seems to indicate either that the experiments do not purport to test the worst events in an accident, or that the calculations are wrong. Perhaps both are true.

All that seems certain is that we do not know how big an explosion is possible or likely in an LMFBR, and that calculations are inadequate to predict them. Perhaps full-scale experiments in which fast reactors are built and then melted down will provide the needed information, but these are not planned so far as the public has been told.

Once again, we are faced with the need to rely on future research. As already noted, however, the advance of knowledge does not necessarily show the risks of LMFBRs to be smaller than ignorance or prudence would have thought them.

In the second large category of risks posed by the LMFBR, the hazards of theft of plutonium, even less apparently can now be said with certainty. The Statement acknowledges that its present security systems will not be adequate to protect

an expanded plutonium-based electric power industry, but just what measures will be needed, and how we are to know whether they will be effective, cannot now be decided. The decision awaits the outcome of future study - although a wide range of possibilities can be listed. Very much greater experience with the realities of a plutonium economy will be required before any of these techniques can be realistically evaluated. Until then, of course, the risks are unknown but may be very great indeed.

We are reduced, once again, to hoping that research will vindicate the LMFBR. And perhaps it will. But the point of doing research is to find out what we did not know at the outset, and what we do not know now is whether LMFBRs are safe enough to build. The research involved is the construction and operation of a large number of commercial LMFBRs. The laboratory is the United States, and if the experiments turn out poorly we will have lost $10 billion and a great deal of time and opportunity. We may also find that the outcome of the experiment is the worst disaster of peace-time history. It may, indeed, result in a nuclear explosion spreading radioactivity, either through terrorism or accident, over a populated area.

Trusting to the outcome of research, in this proposed program, is to proceed with the construction of LMFBRs, trusting that no disaster will occur. Such risks require a far more impressive justification than is given by the AEC's Statement.

CHAPTER III

PROJECTIONS OF FUTURE ELECTRICAL DEMAND

SIPI's comments called for a detailed and careful discussion of the assumptions made in forecasting the growth of electric power demand over the next fifty years (SIPI, pp.IV-4,5).

The Statement's projection of electrical demand is as follows (pp.11.2-8, 58):

By the year:	Base case:	Possible range, -50% to +20% of base case: (in trillion kwhr)
2000	10.6	7.1 to 11.7
2020	27.6	13.8 to 33.0

This corresponds with a projected nine-fold increase in the per capita installed electric capacity between 1972 and 2020, from 1.92 kw per capita (population 208.2 million) to 17.5 kw per capita (assumed population 306.8 million)(pp.1.1-5, 6).

While the Statement acknowledges that "any projection model used to estimate electrical energy growth depends directly on the continued relevance of the parameters selected" (p.11.2-57), it has centered its base case on historical projection, which is defined as the "most prudent" course in the analysis of cost vs. benefit of the LMFBR program (p.11.2-55). The parameters selected were population growth, size of work force, rates of labor productivity, gross national product, and total energy demand (p.11.2-53).

Assumptions about each parameter formed the basis for assumptions about the next, until an estimate of electrical demand was finally derived from the last.

To support its position, the Statement uses projections of demand that were made by the Federal Power Commission from 1969 through 1973 (pp.2.1-14, 15). However, projections released by the FPC in December 1974 (the date of the Statement) are "substantially lower" than these, "partly explainable in terms of the passage of time and the occurrance of significant events".*

Table I follows, comparing the FPC 1974 seven-scenario projections of electrical output till 1990 with similar projections from Electrical World's 1974 forecast, input to the FPC's 1970 National Power Survey, and an FPC 1973 projection. All FPC projections quoted in the Statement are higher than the FPC 1974 scenarios, with the exception of the "all electric" Case IV, which represents an acceleration of historic growth.**

Figure I follows, showing the FPC seven-scenarios for output till 1990. We have interpolated the Statement's output projections for this period by adding 10% to the projected demand shown in Figure 11.2-5 on page 11.2-9. This was judged "honest" by Paul Wagner, manager of press relations, of the Edison Electric Institute, based on the historical relationship between sales, which have been equivalent to demand, and output.*** The

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* A Report to the Federal Power Commission by the Technical Advisory Committee-Finance, The Financial Outlook for the U.S. Electric Power Industry, December 1974 (Preliminary Release), p.72.

** Ibid., p.140.

*** Telephone interview, March 26, 1975.

Table I

U.S. Electric Power Industry [21]
Electrical Output, 1970-1990

Electrical Output (Trillions of kwh)	Cases I & IA Moderate Growth	Case II Historic Growth	Case III Low Growth	Case IV All-Electric	Case V Zero Growth	Case VI Topping Out	Case VII Modified Topping Out	For Comparison: Electrical World's 25th [22] Forecast	For Comparison: TAC-Power Supply Projections "Most Probable Case" [23]	For Comparison: FPC 1973 Projections in Statement [24] Table 2.1-12
1970 (actual)	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54		
1975	1.83	1.92	1.76	2.00	1.72	1.86	1.84	2.06		2.30
1980	2.63	2.81	2.41	2.99	1.86	2.58	2.32	2.77	3.20	3.29
1985	3.55	3.91	2.95	4.83	1.96	3.01	2.71	3.59	4.40	4.60
1990	4.64	5.38	3.42	7.40	2.09	3.16	2.99	4.64	5.80	6.54

Source:
Report to the Federal Power Commission by the Technical Advisory Committee-Finance, The Financial Outlook for the U.S. Electric Power Industry, December, 1974, p.73.

21 Source of 1970 actual data is "Statistical Year Book of the Electric Utility Industry", Edison Electric Institute, New York, New York. Excludes non-utility private power plant generation.

22 Electrical World, September 15, 1974.

23 Report to the Federal Power Commission by the Technical Advisory Committee on Power Supply, advisory to the FPC in connection with the National Power Survey.

24 1973 Federal Power Commission projection, reproduced in Table 2.1-12 of Proposed Final Environmental Statement, LMFBR Program, December 1974, Vol. I, p.2.1-15.

III-4

U.S. ELECTRIC POWER INDUSTRY
ELECTRICAL OUTPUT
1965-1990

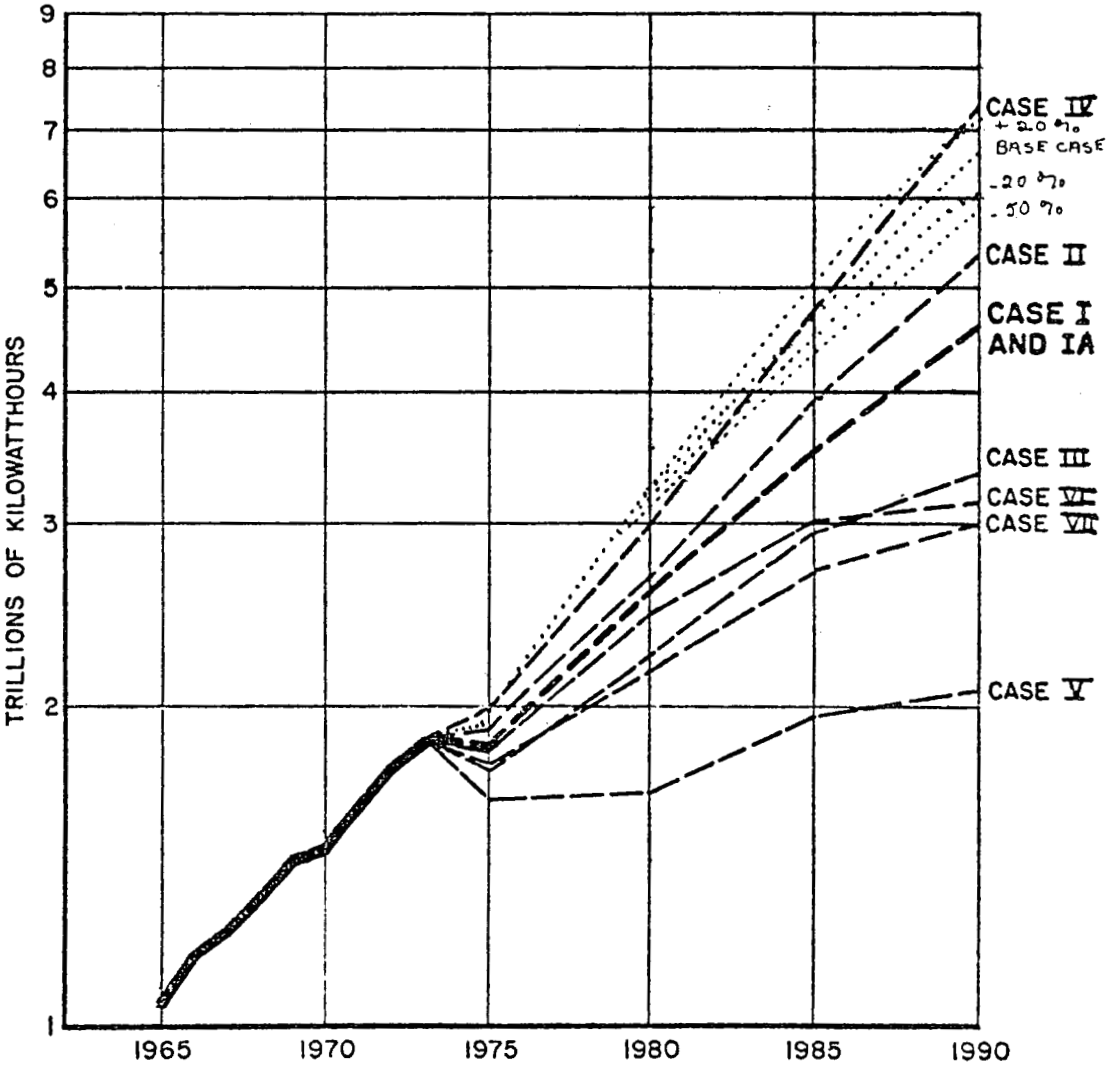


FIGURE I

Sources:

A) Cases I through VII:
Report to the Federal Power Commission by the Technical Advisory Committee-Finance, The Financial Outlook for the U.S. Electric Power Industry, December 1974, p.76.

B) +20%, Base Case, -20%, -50%
Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program, WASH-1535, Vol. II, December 1974, p.11.2-9.

10% is lost in transmission and in use by the utilities. Chapman et al add 9% for transmission losses to demand in order to derive generating requirements (output).*

The Statement claims that its model assumes historic growth of 7.8% per year till 1980, with a gradual reduction by the year 2020 to 4.2% in the +20% case, 3.7% in the base case, 3.0% in the -20% case, and 2.8% in the -50% case (p.11.2-9). Yet a comparison of the December 1974 projections by both the FPC and Statement shows that for the year 1980, all of the Statement's projections, including that for -50% of the base case, exceed the FPC projections for all cases including their highest growth, all electric Case IV.

By 1990, all of the Statement's projections, including that for -50% of the base case, are still above the FPC Case II, which represents historic growth, defined as a resumption of past trends after a moderate 1974 slow-down, with some moderation in the 1980's.** By 1990, the Statement's base case is 30% above the FPC's moderate growth Cases I and IA, which represent a moderation of past growth trends, after a sharp 1974 slow-down.*** The Statement's -50% case is 20% above Cases I and IA.

Other experts on electrical demand have recognized the need to revise their projections downward in the recent past. For

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* Duane Chapman, Timothy Tyrrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crisis", Science, Vol.178, November 17, 1972, p.707.

** Report to the Federal Power Commission, p.139.

*** Ibid., p.139.

example, the "24th Annual Electrical Industry Forecast" in the September 15, 1973 issue of Electrical World projected a total electrical sales in the year 1990 of 5.07 trillion kwhr, under the subheading "Utilities plan expansion to meet record demands".* By the time the "25th Annual Electrical Industry Forecast" was published in the September 15, 1974 issue, the sales projection for 1990 had declined over 17%, to 4.19 trillion kwhr, and the subheading read "Slower growth in sales and peaks sparks sharp cut in expansion plans..."**

Additionally, since September 1974, changes of great magnitude have occurred that have completely invalidated projections made before that time, and the situation remains uneven to this date.

Electrical World's consulting editor, Leonard M. Olmsted, author of the 1974 forecast, said in February 1975 that as late as September 1974 the projected growth of electrical sales in 1975 was for a historical 7% increase, but the rate is currently 4%. The projected growth rate for 1974 was 2%, but instead the rate declined by .5%, so that projection was off by 2.5%. Among factors that had not been anticipated were major industry shutdowns, as in auto manufacturing.***

In February 1975, Irving Levine, assistant director for public information for Con Edison in New York, said that projections

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* "24th Annual Electrical Industry Forecast", Electrical World, September 15, 1973, p.50.

** Leonard M. Olmsted, "25th Annual Electrical Industry Forecast", Electrical World, September 15, 1974, p.54.

*** Telephone interview, February 26, 1975.

six months old were obsolete - "There's a new energy ethic... it's a whole new ball game."* In March 1975, John R. Dyer, director of public relations of the Edison Electric Institute, said there are no projections of electric power demand that are meaningful at this time, and none can be generated until a condition of stability is reached again. He said the electrical industry now had to make short-term decisions (five to ten years) based on regional differences.**

In a chapter entitled "Current Situation" (p.2.1-12), a sentence is inserted which indicates there was some attempt to make the Statement seem current: "Over the past year, however, growth in the use of electric energy in the U.S. decreased to about 0.6% as compared with the 7+% growth rate of prior years" (p.2.1-13). However, the Statement denigrates the efforts of other experts to incorporate this new information in their future planning: "(R)elatively abrupt revisions in growth projections seem likely to be more a reaction to current uncertainties than to hard assessments of future demands" (p.1.1-7).

Accordingly, the cost-benefit analysis does not take into account these new circumstances. As stated, it assumes a historical increase in demand of 7.8% per year until 1980 (p.11.2-138), with growth in demand then falling in the base case to an average of 3.7% by 2020 (pp.11.2-8, 9).

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* Telephone interview, February 19, 1975.

** Telephone interview, March 17, 1975.

Beginning from 1980 only, and through 2020, cases were run in the Statement's model down to -50% of the base case projection, at which point the benefit-cost ratio was generally shown to approach or fall below 1.0, whatever the other variables, at the 10% discount rate (p.IV.D-3, 4). The Statement claims, however, that benefits are reduced below costs only when a number of assumptions are simultaneously weighted in a manner which is considered unlikely to occur (p.11S-1).

The table on page 11.2-140 indicates that -50% of base case demand would occur at an annual rate of increase of 3.6% in 2000, 2.8% in 2020, or an average of 4.6% between 1974 and 2020. It shows an annual rate of increase of 7.8% projected for 1974. The fact that the rate of increase has already fallen below the rate of 7.8% which was presumed till 1980 makes the attainment of a benefit reduced below cost far more likely than the Statement assumes. When Electrical World published the fact that total sales in 1974 dropped .56% below the 1973 level, it forecast, "1975 will turn out to be the second shrink year in a row, and significantly worse than we had expected only a few months ago."*

Discussion follows which describes the fallacy of particular assumptions upon which the Statement's demand parameters were based.

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* "1975 Annual Statistical Report", Electrical World, March 15, 1975, pp.66, 44.

III-9

Population

The Statement's forecast of future electrical requirements utilizes the 1972 E-series population projections of the Bureau of the Census, which, the Statement claims, "takes into account the recent sharp decline in fertility". It predicts the following population, in millions (p.11.2-53):

1980	1985	2000	2020
228	240	271	307

Population Estimates and Projections, from which these figures were derived (p.11.2-59), are issued by the Bureau of the Census approximately twenty times per year,* and we find it is curious that a Statement dated December 1974 would rely for its most basic parameter on estimates issued early in 1972. We are advised that even by December 1972, the E-series projection for the year 2000 had fallen 2.6%, to 264 million.**

More recent projections, released by the Bureau of the Census in February 1975,***indicate a population in the year 2000 of 262 million, assuming the E-series fertility rate of 2.1 births. (The fertility rate is the average number of births per woman upon completion of child-bearing). They also offer a lower population estimate for an assumed fertility rate of 1.7, which would yield a population in 2000 of 245 million. These two new 1975 estimates would alone yield between 3.4 and 10% less electrical demand than

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*Publications Order Form: Current Population Reports, U.S. Dept. of Commerce, Bureau of the Census, Form BC-2340, October 1973.

**Telephone advice from U.S. Dept. of Commerce Library, N.Y. District Office, February 11, 1975.

***News Release CB75-29, U.S. Dept. of Commerce, February 10, 1975.

the one used in the Statement.

While the Statement refers for support to the Department of the Interior's 1972 population projection of 279.9 million by 2000 (p.2.1-16), which assumed a fertility rate of about 2.4, it does not refer to the Council on Environmental Quality's projection of 250 million by 2000. This assumed a fertility rate of 1.8, which CEQ called "equivalent to a continuation of the present annual growth rate of 0.7%."*

There is reason to believe that the lower estimates may be sustained. The National Center for Health Statistics has released data showing that the 1973 fertility rate dropped below the replacement level of 2.1, reaching 1.9 children per family. In 1974, rates continued to decline, though not so steeply as between 1970 and 1973. Though the number of women in the child-bearing years increased 2% in 1974 over 1973, the number of births rose only 1%. At the same time, there was a decrease in marriage rates and an increase in divorce rates.**

A nationwide survey undertaken by the Roper Organization in the spring of 1974 concluded:

> Nearly half of American women and men think having two children is ideal - compared to only one in four who thought so in 1952 (p.64)...Attitudes of women today suggest a continuing down-trend in birth rates. Women in the prime child-bearing years - between 18 and 29 - are markedly less interested in having more than two children than women ten years older (p.68)...

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* A National Energy Conservation Program: The Half and Half Plan, Council on Environmental Quality, March 1974, p.6.

** Dana Little,"Marriages on the Decline", New York Times, March 1, 1975, p.18.

> Furthermore, only one in four women feels that having children is an impelling reason for marrying. And children are considered by only half of all women to be 'very important' to a good marriage (p.1). *

Planned Parenthood-World Population, which in 1972 used the same estimate of 271 million population by 2000** that was used in the Statement, said in December 1974 that "a new set of projections is due soon".***

In contrast to the Statement's projection of 271 million by 2000, the population projection found in the September 15, 1974 Electrical World, extrapolated to 2000****, would be 256 million, or 6% less. McGraw-Hill characterizes their forecast of 239 million by 1988 as "one-third slower than the gain in the 1958-73 years".***** In commenting on the slowing of the population growth rate, McGraw-Hill concludes, "there are no economic, social or environmental factors developing that suggest a reversal of this trend".******

Size of Work Force and Productivity Per Employee

In its projections of future electricity demand, the Statement estimates the size of the work force from the historical

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*The Virginia Slims American Women's Opinion Poll, Volume III, The Roper Organization, Inc., N.Y., 1974

**Population Boom or Bust?, Planned Parenthood-World Population, N.Y., October 1972.

***Lawrence A. Mayer, "It's a Bear Market for Babies, Too", Fortune Magazine, December 1974, p.137.

****Olmsted, p.44.

*****Economics Department, The American Economy: Prospects for Growth to 1988, McGraw-Hill, Inc., N.Y., 1975, p.4.

******Ibid., p.2.

population in the 18 to 64 age group (p.11.2-53). It states that the effects of changes in age composition of the population would not be apparent until the late 1990s (p.11.2-138). In contrast, the McGraw-Hill study predicts "...the U.S. labor force, because of the changing age composition of our population, will grow less rapidly beginning with the late 1970s than in earlier years".* The Statement does not consider changes in the unemployment rate,which is currently over 8%.

Similarly, the Statement assumes a continuation of the historical 2.6% increase in productivity per employee per annum (p.11.2-53). It does not consider changes in working hours, which the McGraw-Hill study predicts will be down 6% per employee by 1988,* or efforts at conservation of energy, which would reverse the increase in labor productivity. Although the McGraw-Hill study predicts a resumption of the 2.6% rate of increase after 1974, it estimates an over-all decline to 2.3% from 1973 to 1988 as a result of the decline in 1974 alone.**

While the McGraw-Hill forecast represents just one example of a difference in evaluation from that expressed in the Statement and does not extend to the full time period under consideration, this shows that variability of these parameters and the effect on electrical demand have not been adequately explored. The Bureau of Labor Statistics of the U.S. Department of Labor, for instance discusses trends in the Occupational Outlook Handbook which is revised annually. No information from the Bureau of Labor Statis-

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* Ibid., p.4.

** Ibid., pp.5, 6.

tics was found in the Statement.

Gross National Product

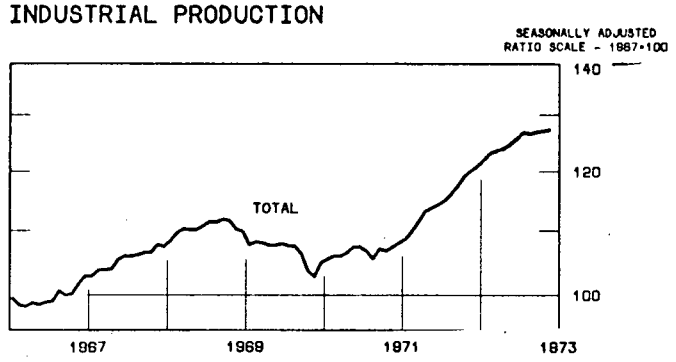
Late in 1973, following a period of business expansion that began in 1970, the Federal Reserve Board's index of industrial production was at a peak of 127.5* This is the culmination of historical experience upon which the Statement based its projection of gross national product. Figures II through IV illustrate the abrupt decline of 12.2% that occurred, however, between September 1974 and February 1975. In January 1975, the month when ERDA began operation, the index fell to 113.7. It was the sharpest monthly reduction in output since December 1937. Albert Rees, director of the Administration's Council on Wage and Price Stability, has predicted that the present economic slackness "will persist for some time in the great majority of industries".**

Real GNP had been growing at an annual rate of 3.7% since World War II, and as late as 1973, Electrical World continued to project this rate to 1990. On September 15, 1974, their projection was revised to 3% growth till 1995.*** In fact, real GNP declined 2.1% in 1974, with the fourth-quarter decline estimated at nearly 9.5%. A decline of 2.3% has now been forecast for 1975. This is the first time there have been two consecutive

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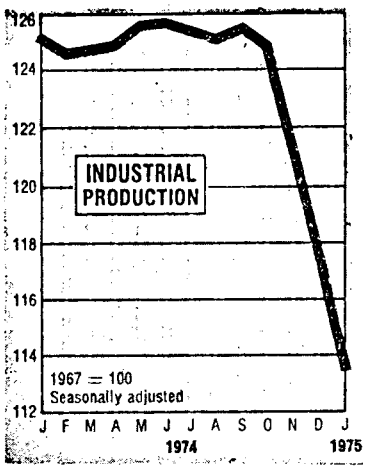
* Industrial Production News Releases, Federal Reserve Board, December 14, 1973 and March 14, 1975; and Vartanig G. Vartan, "Industrial Output is Down for Fifth Month in a Row", New York Times, March 15, 1975, pp.1, 37.

** "Economic Lag Seen Persisting", New York Times, February 28, 1975, p.46



Source: Federal Reserve Board, Statistical Release

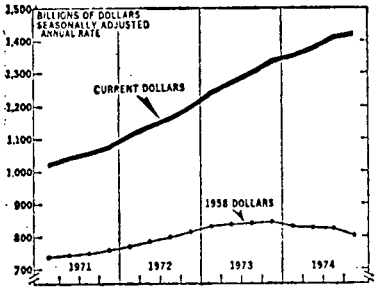
Figure II



Source: Newsweek 2/24/75 p.58

Figure III

Gross National Product



GROSS NATIONAL PRODUCT in the fourth quarter rose to a seasonally adjusted annual rate of $1,430.2 billion from $1,416.3 billion in the third quarter. Computed in 1958 dollars, the fourth quarter figure fell to $803.8 billion, from $823.1 billion in the third quarter.

Source: Wall Street Journal 3/13/75 p.1

Figure IV

shrink years since 1946-1947.*

Yet, comparing projections made in the September 15, 1974 issue of Electrical World** with projections of GNP made in the Statement (p.11.2-53), we find:

Year	Percentage by which Statement's projection of December 1974 is higher than Electrical World's projection of September 1974, in constant dollars	
1980	12.9%	
1985	16.0%	
2000	23.2%	(Electric World's projection extrapolated)

Similarly, the Statement's GNP projection for 1985 is 17.5% higher than McGraw-Hill's projection for GNP in 1988.***

It cannot be predicted with certainty what our future growth in GNP will be, or its relation to energy demand. But projections could more reasonably be made considering several scenarios and their energy-GNP rations. The U.S. Chamber of Commerce has said, "We may be entering an era in which the growth of productive capacity itself is subject to new and severe constraints."****

1. Accelerating energy prices and high unemployment may herald a return to an "intermediate technology" which is more

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* "1975 Annual Statistical Report", Electrical World , March 15, 1975, p.44.

** Olmsted, p.44.

*** The American Economy, McGraw-Hill, Inc., p.5.

**** A Report of the Council on Trends and Perspective, Economic Growth: New Views and Issues, Chamber of Commerce of the U.S. Washington, D.C., 1975, p.24.

labor-intensive, yielding a lower GNP.*

2. An increasing portion of the GNP will be claimed by activities which are less energy-intensive than the production of commodities: education, leisure, health care, government activities and other services. This has been evidenced by a decline in recent years of incremental kwhr/incremental constant dollars.**

3. Market saturation may be approaching in radios, television, refrigerators and other home appliances, illumination, automation of many industrial processes, air conditioning in the commercial sector.***

4. There may be less capital available from loans. In September 1974, Bank of America, the world's largest bank, reported a year to year loan growth of 31%. By December 1974, it had fallen to 26%, and the intention was reported in February 1975 to purposely lower it to 10%, a rate that was considered one they could "sustain on a long-term basis".****

5. The future of electricity-intensive industries such as aluminum, petro-chemicals and uranium enrichment is uncertain:

a. The production of primary aluminum absorbed nearly 12% of industrial electrical sales in 1973, or almost 5% of total

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* E.F. Schumacher, Small is Beautiful, Harper & Row, New York, 1973.

** (FPC) The Financial Outlook, pp.146-7.

*** Ibid., pp.135, 144-5.

**** "Why They're Slowing Growth at the World's Biggest Bank", Business Week, February 24, 1975, p.54.

electric sales.* However, recycling takes only 5% of the energy needed to create aluminum from virgin ore.**

b. Nations that produce oil and other key materials, such as copper, aluminum and tin, will be seeking a larger share of the economic pie, raising prices and shrinking American industrial production, which is currently 40.4% of electrical demand.*** Saudi Arabia, for example, has a new five-year economic plan which includes huge industrial projects that will make it a major supplier of petrochemical products.****

A conference of 104 developing countries has produced a program to raise their share of the world's economy from 7 to 25% by the end of the century, calling it a new international economic order. The plan includes the formation of more raw materials cartels, the right to nationalize foreign industries, and the transfer of basic industries from rich to poor countries.***** Even before release of this plan, U.S. energy consumption was projected by Shell to shrink from 32% of world consumption in 1970 to 22% by 2000.******

c. Uranium enrichment, accounted for 5% of industrial electrical sales in 1973, or 2% of total electrical sales, is dependant

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* Olmsted, p.49.

** Reynolds Aluminum ad: "We Don't Believe in Waste".

*** Olmsted, p.48.

**** Juan De Onis, "Saudi Arabia Plans More Huge Plants", New York Times, February 22, 1975, pp.33, 35.

***** "Developing Nations Finish Plan to Raise Share of Economy", New York Times, February 19, 1975, p.46.

****** "Energy Self-Sufficiency:1", Shell Reports, Shell Oil Company, Houston, July, 1974, p.1.

upon the future of the nuclear industry.*

Total Energy Demand

The Statement projects an historical energy growth rate of 4.0% till 1980, declining to 3.5% from 1980 to 2000 and 3.2% from 2000 to 2020 (p.11.2-54). Electrical energy generation is assumed to grow from 25% of current total energy consumption to 65% in 2020 (p.1.1-5).

Of five references given in the chapter on "Projections of Energy Growth" (p.2.1-6), four are from 1972 and one from 1973. It is stated, "Past forecasts of energy consumption frequently have proved to underestimate the demand that subsequently occurred". Aside from the Ford Foundation's Energy Project, all of the other reports with which the Statement superficially compares its forecast, were made from 1960 to 1971 (p.11.2-54).

The 3.4% per year growth rate assumed in the Ford Foundation's "historical" scenario is cited for its proximity to the Statement's model, but growth rates of the other two Ford Foundation scenarios are not cited, namely 1.7% for the "technical fix" and 1.4% for "zero energy growth" till 1985.**

Though SIPI's comments specifically asked for an evaluation

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* Olmsted, p.50.

** John C. Myers, "Energy Conservation and Economic Growth - Are They Incompatible?", The Conference Board Record, February 1975, p.27.

of the Council on Environmental Quality's "half and half" plan, which results in an annual energy growth rate of 1.8% by 2000,* this was not mentioned. Nor is the impact discussed of the effect on demand of the Federal Energy Office's plan (SIPI,p.IV-8). The FEO is now the Federal Energy Administration, which produced the Project Independence Report. This projects a range of growth rates from 3.2% down to 2.1% by 1985.**

In the chapter on the "Current Situation" (p.2.1-5), which is three brief paragraphs long, one paragraph and a table describe sources of energy during 1972. Another paragraph begins, "Over the past few years, the energy situation has changed dramatically", but the oil embargo of 1974 and sequela are not mentioned, or the dramatic energy programs currently under consideration by the executive and legislative branches of government to reduce total demand. The embargo is referred to in another context, however, to underline the need to develop and use energy sources besides oil or gas (p.1.1-5).

The Conference Board has expressed a concern which was not reflected in the Statement:

> Energy prices rose nearly 11% faster than the general price level (26.5% compared with 14.1%) from 1970 to 1973, and by the third quarter of 1974 had widened the margin by an additional 50% (over the 1973 average). Increases in relative energy prices of this magnitude should bring about substantial changes in energy use. ***

However, the Board concludes that energy use could grow at

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* Council on Environmental Quality, A National Energy Conservation: The Half and Half Plan, March 1974, p.10.

** Myers, p.27.

*** Ibid., p.30.

an annual rate of only 1.5% till 1985 without damage to the economy, assuming "adjustments in production and consumption that will permit less energy to be consumed per unit of product."*

Price Elasticity

SIPI's comments requested an evaluation of how recent price increases would affect future electrical demand (SIPI, p. IV-5 to 7). This was not found, though there was mention of the Chapman, Tyrrell and Mount study on price elasticity, which was said to project consumption of 1.9 to 4.6 trillion kwhr by 2000 (p.11.2-56). This study estimates that a 1% increase in price causes electrical demand eventually to be an average of 1.5% less than it would otherwise have been.** Price elasticity studies by Fisher and Kaysen, Anderson, and Wilson were not referred to *** nor was the study in the Project Independence Report.

While total kwhr sales dropped .56% in 1974 over the 1973 figures, U.S. utility revenues climbed 23.3%, due to rate increases and fuel-cost adjustments. The average price per kwhr was up to

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* Ibid., p.32.

** Chapman, Tyrrell, Mount, pp.703-8.

*** M.R. Seidel, S.E. Plotkin, & R.O. Reck, Energy Conservation Strategies, Implementation Research Division, Office of Research and Monitoring, U.S. Environmental Protection Agency, Washington, D.C., July 1973, pp.16-19.

$2.30, an increase of nearly 24% over the 1973 average. Table II follows, which shows not only the trend toward zero decreases and large numbers of increases in price, but over a tripling of amount per increase since 1970.*

Electric rate increases

	Granted		Pending at year end	
	No. companies	Dollars	Applications	Dollars
1964	4	27,500,000	1	270,000
1965	0	0	1	270,000
1966	4	33,432,000	0	0
1967	2	701,000	0	0
1968	8	20,657,000	19	194,827,000
1969	19	145,123,000	33	490,317,000
1970	45	430,578,000	40	629,798,000
1971	51	802,678,000	66	970,515,000
1972	94	827,090,000	69	906,676,000
1973	64	1,150,763,300	71	1,566,545,600
1974	**78**	**2,337,746,00**	**65**	**2,043,146,000**

Source: Ebasco Services, Inc.

Electric rate decreases

	No. companies	Dollars
1964	77	119,200,000
1965	83	113,400,000
1966	46	56,866,000
1967	26	37,703,000
1968	14	13,887,000
1969	7	5,833,000
1970	2	4,500,000
1971	1	1,000,000
1972	0	0
1973	0	0
1974	**0**	**0**

Table II

Using the Chapman, Tyrrell and Mount analysis, the 24% price increase in 1974 should eventually lead to a demand 36% less than it would otherwise have been, with a drop of 18% apparent in 1981. A drop of 3.6% should be apparent by the end of 1975. A drop of 3.6% from the historic growth of 7.8% projected in the Statement would be a growth of 4.2% over the 1.70 trillion kwhr sold in 1974, or 1.77 trillion. The growth rate reported in January and February 1975 was indeed 4%.** The price effect may be occurring sooner than Chapman et al predicted,

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* "1975 Statistical Report", pp.66-69.

** Telephone interview with Leonard M. Olmsted, consulting editor, Electrical World, February 26, 1975.

which was for the 1980's and thereafter.

In general, their conclusions may turn out to be conservative. Their lowest projections were based on the assumption of an average annual electricity price increase of 3.33% of 1970 values for thirty years, or a doubling of price by the year 2000. Their demand projection of 2.01 trillion kwhr in 2000 used that rate of price increase, coupled with a population growth of 1.4% per year, GNP of 4% and per capita personal income growth of 2.9% per year. The experience in 1974 makes this low demand seem more possible: a price increase of 24% over the 1973 level, population growth of 0.7%, GNP decline of 2.1%, and unemployment reaching 8% by early 1975.

CHAPTER IV

CONSERVATION

The potential for conservation measures to alleviate current fuel shortages or to become, individually or collectively, a viable alternative to the breeder, is summarized in the Statement as "mixed". Some measures are said to offer minor relief but involve economic and environmental penalties, while others are admitted to be "worth pursuing and should be implemented where practical" (p. 6C7-1).

Among the former are improvements in resource extraction and power plant conversion efficiencies, "whose total contributions might result in savings equivalent to approx. 5% of U.S. generating capacity in the year 2000"(p.6C.7-3). This is below the estimate of 9.7 to 15.9% discussed in SIPI's comments (SIPI, p. IV-17 and 18). There is no discussion of why the higher estimate is not accepted, or even of the implications of the 5% projected savings.

The Statement considers that end-use conservation is a measure that "can result in very substantial and worthwhile energy savings and could appreciably lower U.S. demand for both electricity and total energy usage in the years to come"(p.6C.7-3). The consensus is noted that a vigorous, successful conservation program could reduce total energy consumption by 30% by the year 2000(p.6C.7-6). However, the reduction of 20% of demand is then the only example of savings by conservation in a table entitled "Energy Sources for Electricity Production in the Year 2000 without the Breeder" (p. 11.1-24).

The Statement does not make clear that the conservation of 30% of demand projected for 2000 still represents a 50% greater per capita energy use than in 1970 (Table 11.2-7, p. 11.2-53) or over 3½ times greater per capita electrical use than in 1970 (p. 11.2-58).

The Statement states that the inconveniences to the public and changes in life style that would be caused by a savings of 30% of energy through conservation by 2000, would be "moderate to severe" (p. 6C.8-1). However, our review of the seven programs described on pages 6C.6-1 through 19, indicates that those allowing for 1.7% to 2.0% future energy growth rate as opposed to historical growth of about 3.5% imply no hinderance of national economic growth or change in life style, yielding up to a projected 36% projected total energy savings by 2000. The Subpanel XII program for 30% savings, for example, depends on increased efficiency of processes and products, and not on such measures as gas rationing, prohibitive taxation, or deliberately keeping houses less comfortable (p. 6C.6-16).

Moveover, the Statement's discussion of these programs is not sensitive to how their predictions relate to recent developments. In particular, the concurrent effect of savings through conservation coupled with lower demand is not considered. The conservation forecasts of the AEC Office of Planning and Analysis, for instance, are based on an assumed population of 271 million in the year 2000, which is the high projection accepted in the Statement. It is not clear what the assumed population is in the other studies.

Likewise, the Office of Emergency Preparedness program projects a total energy savings of 23% to 25% by 1990 if the electrical growth rate falls from 6% to 4.5% (p.6C.6-3). In 1974, this rate actually fell .56% under the 1973 level.*

The Statement's section on specific conservation actions does not give sufficient coverage to the merits of automated energy and electricity conservation systems, although it does note that computer control of fuel management in steel mills has yieled a 25% fuel savings (p. 6C.6-20). There is no discussion of the commercial application of automated systems, but only of less reliable personnel-directed conservation practices (p. 6C.6-23).

Both IBM and Honeywell have marketed computer controlled power management systems. These systems regulate the use of heating, lighting and air conditioning, and reduce peak loads while maintaining comfortable conditions. More than 100 companies have reported a savings of 10% to 20% in electricity consumption after installing the IBM System/7. The System has been installed in office buildings, airline facilities, distribution industries, manufacturing facilities, shopping centers, process-oriented industries, and universities. One user in Florida estimates the savings in his building at current electricity rates could reach $100,000 per year.**

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* "1975 Annual Statistical Report", Electrical World, March 15, 1975, p. 66.

**Letter from James E. Cain, Information Department, International Business Machines Corporation, Atlanta, February 14, 1975; IBM Advertisement, "How more than 100 companies have cut their electricity bills by 10%. At least."

At IBM's own installations, for a twelve month period beginning November 1973, fuel usage was reduced 31.3% and electricity usage by 22.3%. This was estimated to be enough oil to serve 18,000 homes in the Northeast for a year, and enough electricity to serve 45,000 homes for a year.*

Nevertheless, the Statement concludes that failure to develop the LMFBR "in the expectation that (it) may not be needed due to possibly lessened future energy requirements from a successful conservation program would be unwise" (p.6C.8-2). This is largely based on the fear that "there is no assurance at this time that future energy demand will be substantially reduced by conservation practices" (p.6C.8-1).

Rather than expand its own rationale of why abandonment of the breeder in favor of conservation programs might be unwise, the Statement relies for reinforcement on several brief quotes from people outside the lead agency, who express their opinions that "conservation is not the complete or final answer to the energy crisis" as follows:

1) J. W. Simpson, in an address to the American Nuclear Society, said that conservation alone cannot solve the long-term problem, and that a reduced standard of living for Americans would not solve the world energy problem (p. 6C.7-10, 11).

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* 1974 Annual Report, IBM Corp., p. 15.

The breeder alone, of course, does not solve the long-term problem either, its maximum projection being for the supply of 23% of need in the year 2000.

Waste at the point of consumption has been identified by the Federal Power Commision as an imbalance that exists in our national energy system.* Indeed, European analysts are reported to be worrying that energy savings in other nations will be squandered by America's profligate usage. Our minimal efforts at conservation have been called a "negative example (which) weakens the economizing zeal elsewhere". Between January and June 1974, for example, America trailed all European countries except Italy in curbing oil consumption:**

Country	Saving
Belgium	19.4%
Denmark	18.6%
Germany	14.3%
Netherlands	14.2%
Britain	9.5%
France	5.7%
United States	4.9%
Italy	3.7%

2) Jack Moore, Southern California Edison Company, wrote that conservation measures can go only so far and provide only temporary relief (p. 6C.7-11).

In contrast, the Project Independence Report suggests that "we may view conservation measures or the energy which is otherwise wasted, as a potential energy resource ". Among the benefits

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* The Report and Recommendations of the Task Force on Practices and Standards to the Technical Advisory Committee on Conservation of Energy, National Power Survey Practices and Standards Opportunities for Energy Conservation, Federal Power Commission December 1973, pp. 5,6.

**Richard F. Janssen, "The Outlook", Wall Street Journal, February 10, 1975, p. 1.

of conservation noted in the report are the elimination of pollutants associated with production and consumption of that energy, and phasing out of use the "smaller, dirtier power plants more rapidly", as well as reducing growth in new areas for energy production.*

3) Carl Bagge, National Coal Association, wrote that conservation is difficult to mandate, and that adoption of measures would represent a hardship to industry (p. 6C.7-11).

In this regard, the Statement failed to consider such experience as the response of Los Angeles to their shortage in generating fuels. In December 1973, the City mandated a reduction in the consumption of electricity, with penalties authorized for using more than was allowed. The effect was immediate, with consumption down 14% by the end of the first week, and eventual average reductions as follows:

Sector	Percent of Total Electrical Use	Average Percent Reduction in Electricity Consumption
Commercial	50	28
Residential	25-30	18
Industrial	20-25	10

Establishments surveyed **maintained uses that were considered vital, and most reported no economic hardship as a result of conservation measures. After suspension of the conservation ordinance, when oil supplies improved, consumption rates remained 14% below the previous year's level.

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* Federal Energy Administration, Project Independence Report, November 1974, p. 201.

** Judith Wheeler, Morlie Graubard, & Jan Paul Acton, How Business in Los Angeles Cut Energy Use by 20 percent, Federal Energy Administration, Washington, D.C., January 1975, pp 1-6.

4) Milton Levenson, Electric Power Research Institute, wrote that historical projections of population and per capita use of electricity indicate increased production will be a prime societal demand, rendering the net success of conservation unlikely (p. 6C.7-12).

Our chapter on "Projections of Future Electrical Demand" showed repeatedly that historical projections are no longer valid. For instance, Mr. Levenson said in April 1974 that "even with the most conservative projections of population growth during the next 30 years, we expect a 30% to 40% increase in the nation's total population". In contrast, the 1975 projections of the U.S. Bureau of the Census range between 13% and 26% increase over present population by the year 2000. Using the latest projections for the fertility rate assumed in the Statment, even the AEC would accept a population growth of 19% by 2000.*

The Statement's passive attitude toward promoting conservation measures is at variance with ERDA's new mandate "toward the goal of reducing total energy consumption to the maximum extent practicable, and toward maximum possible improvement in the efficiency of energy use. Development of new and improved conservation measures shall be conducted with the goal of the most expeditious possible application of these measures".**

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* News Release CB75-29, U.S. Department of Commerce, February 10, 1975, p. 1.

**Energy Reorganization Act of 1974, P. L. 93-438, Section 102(8), emphasis added.

This new goal was emphasized by Robert C. Seamans, Jr., Administration of ERDA, at the February 26, 1975, Regional Meeting of the Electric Power Research Institute in Washington, D.C., when he named energy conservation as the first major principal of energy development "that the Nation must follow if we are to maintain our way of life".* Fuel use efficiency was the second principal he named, and advanced energy technologies were third. Clearly there has been a reversal of priorities on the conservation issue since the time when the AEC directed energy policy. This is not reflected in the Statement.

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* Information from ERDA, Washington, D.C., March 5, 1975, p. 2.

CHAPTER V

EVALUATIONS REGARDING ALTERNATE TECHNOLOGIES

SIPI considered the greatest deficiency of the Draft Statement to be the lack of a comprehensive, balanced energy program, comparing the cost-benefit of the LMFBR program against conservation measures resulting in lower demand, coupled with rapid development of alternatives, such as direct and indirect solar, and geothermal technologies.

Although the Statement discusses conservation programs and alternate technologies to some extent, it generally treats them individually rather than as part of a prudent mix. In the chapter on "Alternative Strategies for Responding to Future Energy Requirements" (p.1.6-5), the strategies are identified as:

1. to plan for a future supply below predicted demand,
2. to meet predicted needs by relying on existing sources, the LMFBR, other fission breeders, or development of advanced nonfission alternatives.
3. a "mix" of various energy options.

A "mix" is selected in the Statement as the "more realistic strategy", and reference is made to Section 11.3., the "Conclusion" of the cost-benefit analysis. Yet here one finds enumeration of benefits of the LMFBR program only, and no mention of a mix of various energy options, except in regard to environmental impacts, where the alternatives are restricted to other types of nuclear fission and coal-fired plants only (11.3-1 to 3).

The consideration of alternatives in the Statement is generally in violation of the Council on Environmental Quality guidelines for an environmental impact statement, as summarized by Enk:*

> Alternative actions must be weighed objectively; there must be no slanting or slighting of information to discriminate for or against any project alternative. Alternative actions must be developed rigorously in the impact statement. Objective analysis of the costs and impacts of these alternatives must be included, so that less detrimental options are not prematurely eliminated because of slighting and slanting of information.

Discussion follows of the Statement's treatment of specific alternative techologies.

Minimization of the Contribution of Solar Energy: Misrepresentation of the NSF/NASA Report

Solar energy has been called the most benign of the inexhaustible energy sources. Yet the Statement has not only minimized the possible contribution from solar energy between 2000 and 2020, but has also failed to deal fairly with the potential contribution beyond the year 2020. Although the Statement mentions the projections of several studies it fails to report estimates that solar energy may ultimately supply 100% of our electrical demand. According to the Mitre report, three

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*Gordon A. Enk, Beyond NEPA: Criteria for Environmental Impact Review, The Institute on Man and Science, Rensselaerville, N.Y., May 1973, p. 19.

solar energy systems can each do so: solar thermal conversion, photovoltaic, and ocean thermal conversion.* Both Subpanel IX** and NSF/NASA*** project a possible 100% supply of electrical demand from ocean thermal conversion.

The Statement reports the total electric contribution of solar energy according to NSF/NASA to be less than 5% (p. 6A.5-18). Elsewhere it claims that it has adopted the NSF/NASA estimate of 1% as the potential contribution of solar to electric conversion by the year 2000 (p. 11.1-19). In fact, NSF/NASA estimates for electric power generation by various solar technologies are as follows:****

System	Estimated percent of market captured by the year 2000
Thermal conversion	1
Wind energy conversion	1
Ocean thermal difference	1
Photovoltaic	
Systems on buildings	5
Ground stations	1
Space stations	1

*Mitre Corporation, Systems Analysis of Solar Energy Programs, MTR 6513, December 1973, p. 120.

**Subpanel IX, Solar and other Energy Sources, October 1973, p. 120.

***NSF/NASA Solar Energy Panel, Solar Energy as a National Energy Resource, December 1972, p. 73.

****Ibid, p. 10

The NSF/NASA Panel states that these estimates are not necessarily additive, since not all systems will be carried to commercial readiness. Nevertheless, they consider their judgement to be less than the maximum possible. Nowhere do they select the potential of 1% or less than 5% as quoted in the Statement. The NSF/NASA estimates are much lower than those in other studies, notably the Mitre and Subpanel IX reports.

Reduced Costs for Transmission Lines in Solar Photovoltaic Systems

The Statement claims that SIPI's observation regarding savings from elimination of electric power distribution and transmission costs is "believed erroneous" (p. 6A.5-27), because according to the NSF/NASA Panel Report, Solar Energy as a National Energy Resource, ",....providing more than one day of storage would be uneconomical....." Thus, solar electric systems for buildings would require an external source of electricity during a series of cloudy days, and the required external capacity (generating plant, transmission systems, and distribution network) would not be reduced significantly. The Statement concludes, on these grounds, that "Solar electric systems for buildings would save fuel but would not materially affect the local utilities' investment in power facilities".

That this conclusion fails to contradict the original SIPI criticism can be seen from the following:

1. The statement cited from the NSF/NASA Panel refers to the contribution of the cost of a storage facility to the overall cost of electricity. What is at issue in this discussion, however, is the cost of storing sufficient energy to cover periods of inadequate solar input relative to the cost of an external auxiliary power source. Since transmission lines represent an appreciable fraction of the total capital costs for conventional central power systems (about 42% in 1970), there is considerable leeway to add to the expense of a building solar power system sufficient storage capacity to completely eliminate the auxiliary system.
2. If building solar power systems do require an outside stand by source, this requirement can be readily met without constructing a central power plant and distribution system. For example, this requirement could be met by installing a stand by fuel cell system and hydrogen storage capacity. Hydrogen could then be produced and stored at a central power plant (preferably solar) and distributed to buildings in tanks, for use when needed. Such a system would thereby achieve the

complete elimination of the distribution system envisioned in the original SIPI comment.

Solar Thermal Conversion

In discussing the costs of solar thermal conversion the Statement concludes:

> Assuming solar thermal conversion plants could produce supplemental power for 25 to 45 mills/kwhr (as estimated by Subpanel IX), the prices of fuel resources at which supplemental power from solar plants would be competitive are:
>
> | | |
> |---|---|
> | Oil: | $11 to $20 per barrel (Peaking units at 25% efficiency) |
> | Coal: | $70 to $127 per ton (Base and intermediate load units at 40% efficiency) |
> | Nuclear (LWR): | $390 to $725 per pound of U_3O_8 (Baseload unit at 32% efficiency) |
>
> Thus, there is little possibility that solar thermal conversion plants will displace either coal or nuclear generation since the supply of coal and uranium at prices significantly below those shown above would last well over a century (p. 6A.5-26).

The Statement also cites the findings of the Oak Ridge National Laboratory as:

> Estimates of prices that coal and uranium ore would have to reach before solar energy would be competitive were $40 per ton of coal and $250 per pound of U_3O_8, respectively. The study concluded that...sufficient coal is available in the United States at costs well below $40 per ton to last longer than the uranium (a century) even if an allowance is made for the cost of measures required to over come the effects of coal mining and processing on the environment (p.6A.5-25).

Recent data suggests that the prices on coal and oil have risen to the point where solar thermal conversion may become competitive well before the termination of the century. Using the Statement's range of competitive cost estimates, oil has already reached its competitive range. A barrel of oil cost $13.07 per barrel in February 1975,* well within the $11 to $20 per barrel range the Statement had quoted above.

Coal has risen in price from $7.08 per ton in 1970,** when many air polution standards were not yet enacted or enforced, to the point where some electric utilities are now paying over $40 per ton in 1975.*** This price escalation for coal has already reached the price quoted by the Oak Ridge National Laboratory and has in some areas risen in only 5 years from 10% to 60% of the price quoted by the Statement as competitive.

These figures indicate that the Statement's conclusion that solar thermal conversion will not be competitive for well over a century is invalid (p.6A.5-26). Solar thermal conversion may already be competitive in regions of the Southwest. Even if

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*New York Times, February 26, 1975, Part III, Sec. 3, p. 57. Saudi Arabia Light Crude in dollars/barrel: $11.25. 93% of this = $10.46/barrel plus $1.40 AFRA Freight, plus $1.21/barrel U.S. import duty, comes to $13.07/barrel.

**Electric Utilities Fuel Costs, Edison Electric Institute, N.Y.

***Public Service of New Jersey pays $43.78/ton of coal for electrical generation. Frank Hummler, Public Information Officer, attributes much of this cost to environmental considerations such as air quality and strip mining controls. Telephone interview, March 25, 1975.

solar thermal conversion is employed as a supplemental power source, the savings in fossil fuel costs and consumption are much too large to be ignored or lightly passed over. If solar thermal conversion with limited storage can supply only 1/2 or 1/3 of the daily generation demand, the implications of this conservation on the energy situation with respect to electrical generation is significant.

As to the percentage of electrical generation that can be met by solar thermal-conversion, the Statement shows in Table 6A.5-3 (p. 6A.5-17) the NSF/NASA market penetration of electrical energy by solar thermal conversion at 5%. The NSF/NASA report does show that they believe the realistic market penetration of solar thermal conversion plants will be approximately 5% of the nation's generation capacity in the year 2020.* However, they also state that a 20% generating capacity (market penetration) is possible in the year 2020.** This figure corresponds to the 30% and 29% figures given by Subpanel IX and MITRE reports.

In view of recent price escalations in the costs of fuel oil and coal, the Statement should re-evaluate its conclusion as to the time period in which solar thermal conversion may become cost competitive. Further, the Statement ought to more

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*NSF/NASA, p. 10.

**Ibid, p. 51

comprehensively cover the quantitative central station generation capacities of solar thermal conversion if promising storage technologies are developed in the time context of the year 2020.

Ocean Thermal Gradient Systems

After a restricted treatment of the capabilities of ocean thermal gradient plants, the Statement concludes that "Ocean thermal gradient plants are, at present, only in the conceptual stage. As such, there is very little basis on which to make a meaningful assessment (p.6A.6-5). However, a demonstration plant, such as Claude's in 1930 (p.6A.6-5), and the findings reported in the 1972 NSF/NASA, 1973 MITRE, and 1973 Subpanel IX reports all show significant basis on which to make a "meaningful assessment".

The Statement goes on to conclude that "After completion of the 5 year program recommended in 'The Nation's Energy Future', technical and economic feasibility may be more clearly established. At present, however, there is no reasonable basis for projecting a significant energy contribution from ocean thermal gradient plants in this century" (p.6A.6-8).

While technical feasibility has already been established, economic feasibility will need to be more thoroughly researched, as in all new technologies. Estimates of costs cited in the Statement range from $168 to $800 per kw for ocean thermal gradients (p.6A.6-6,7) and $368 per kwe to $520 per kwe for the

LMFBR (p.11.2-11). Other reports from the AEC itself claim the costs of nuclear power production to be closer to $700 per kwe.*

The range of cost estimates of the LMFBR program do not appear to be substantially stabilized or remarkably lower when compared to the ocean thermal gradient systems.

As previously noted in SIPI's comments, "When it comes to the breeder the AEC is able to see well into the 21st century" (SIPI, p.V-32). Yet the Statement restricts its assessment of ocean thermal gradient plants to "this century or to before the year 2000" (p.6A.6-8). This fails to consider the significant amounts of electrical demand that can be supplied by the year 2020, as stated in the 1972 NSF/NASA report and the 1973 report of the MITRE Corporation (SIPI, p. V-33).

The NSF/NASA report claims 1% of the electrical demand in the year 2000 and 10% in the year 2020 can be met by ocean thermal gradient plants. The MITRE report claims 1% to 5% by the year 2000 and 10% by the year 2020. The Statement cites but one projection for ocean thermal gradient plant electrical generation and that is the 1% electrical demand met by the year 2000 given by the NSF/NASA report (p.6A.6-8).

Apparently this one figure is what the Statement uses to reach its conclusion that there is "no reasonable basis for projecting a significant energy contribution from ocean thermal gradient plants in this century" (p.6A.6-8). This conclusion does not consider the greatly expanded electrical generation

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*Power Plant Costs: Current Trends and Economic Parameters, U.S. Atomic Energy Commission, Division of Reactor Research and Development, October 1974, p. 2.

capacity projected for ocean thermal gradient plants a mere 20 years later, in the year 2020.

Storage Technologies

SIPI's comments examined the relationship between solar energy and storage technologies (SIPI, p. V-19 to 22). Three methods of storage were suggested: 1. pumped storage combined with existing hydroelectric facilities, 2. development of economical storage batteries, and 3. the electrolysis of water into hydrogen fuel and oxygen.

The Statement, in its sections on "Solar Energy" (6A.5), "Hydroelectric Power Systems" (6A.3), "Hydrogen and other Synthetic Fuels" (6A.6.4) and "Batteries" (6B.7) makes limited remarks on the interdependence between solar energy and storage technologies. However, there is no single section examining all of the direct and indirect solar energy systems coupled with their possible storage subsystems. This omission deprecates the large role solar energy can play in electrical power production.

If even short-term storage facilities (3 to 6 hrs.) are economically developed using conventional generating s stems as a back up, the resulting savings in fuel might be suff cient to show that development of the breeder is unnecessary. This system is analogous to that used in solar space heating systems, which are backed up by conventional gas or oil systems, currently in use

in Florida. Development of long-term (3 to 4 + days) storage would greatly extend the reliability of solar plants as a source of local building and central station power.

In discussing the technology of pumped storage, (6A.3), the Statement makes no reference to the concept, mentioned by SIPI, of building solar stations "next to existing hydroelectric facilities, which could double as pumped storage facilities. This avoids two of the problems of conventional pumped storage: the cost is reduced because much of the equipment serves two purposes and no additional land is sacrificed to"create a reservoir" (SIPI, p. V-20). The Southwest, the area currently designated as holding the most promise for solar power, already has a number of large hydroelectric installations.

Water electrolysis and other methods of hydrogen production are mentioned in the Statement as favorable storage methods - as such synthetic fuels "are of interest because they may be derived from these abundant energy resources (nuclear power, solar power, or coal) and provide a convenient fuel form for transport, storage, and utilization. Thus they represent... a possible means for central station electric storage analogous to the pumped storage concept" (6A.6-9). The Statement cites one source* which "assumed that 20% of the electrical energy delivered in the year 2000 is produced from hydrogen" (6A.6-11).

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*Office of Science and Technology, Energy Advisory Panel, "Assessment of New Options in Energy Research and Development," Report AET-9, November 1973.

However, the Statement makes no calculations as to the possible load capacities that a solar energy hydrogen storage system could provide. These calculations on load capacities are not made for battery storage systems either. If a 20% hydrogen produced electrical generation capacity is possible by the year 2000 it would seem that a significant portion of this hydrogen could come from solar energy. Certainly this would be possible by the year 2020 when solar sources are projected to be more commerciably viable, if not by the year 2000. Yet the Statement concludes, "As implied previously, the development and widespread use of synthetic fuels (hydrogen) will not lessen the need to develop primary energy sources such as advanced nuclear systems" (emphasis added, p. 6A.6-11).

The Statement makes no specific mention of this type of storage technology in the section on solar energy (6A.5), nor of the effect such a technology would have on increasing the reliability of solar energy electrical power production in quantitative terms.

One concept the Statement also fails to comprehensively treat is the development of a national grid system. Such a system could help to even out the fluctuations of solar power in combination with storage facilities.

ERDA, which has a Division of Energy Storage, is currently involved with the Electric Power Research Institute in a one year study to assess advanced energy storage systems.* Their findings would be relevant for inclusion in a new Statement.

Fuel Cell Systems

Although the Statement's description of the operation of the fuel cell appears adequate, its conclusion that fuel cells "will not appreciably relieve the energy crisis" (6B.6-13) is misleading. In mentioning the November 1973 announcement by Pratt and Whitney of a $42 million cooperative program with nine electric utilities to develop a 26 mw fuel cell power plant able to serve the electrical needs of a community of 20,000 (6B.6-3), the Statement fails to state that Pratt and Whitney have received fifty six provisional orders for these plants.**

Fifty six such power plants would have the combined total generating capacity to serve the electrical needs of 1,120,000 people or approximately that needed to supply the entire city of Houston, Texas. Once these initial plants were constructed, full scale commercial production would realize an even greater

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*Remarks made by Dr. Robert C. Seamans, Jr. Administrator, ERDA at regional meeting of the Electric Power Research Institute, Washington, D.C., February 26, 1975

**Pratt and Whitney Aircraft News Kit, East Hartford, Conn., 1973

magnitude of combined generating capacity. Pratt and Whitney have informed us that they expect fuel cell power plants like their 26 mw unit to obtain 10% to 20% of the total generating capacity of such dispersed generating systems by the year 2000.*

In addition to their extremely small environmental effects, fuel cell generating plants such as Pratt and Whitney's 26 mw unit realize a fuel savings, in this case oil, of up to 15% for the same amount of electricity generated by a conventional fossil fuel plant.** Fuel cells are capable of delivering up to 30% more energy from a given amount of fuel than conventional systems.*** Neither of these figures were mentioned in the Statement. Such a savings in fuel can hardly be viewed as "non-appreciable," as concluded by the Statement:

> It should be pointed out that these developments (fuel cells), while promising more efficient use of fossil fuels for electrical generation, do not provide a system for utilizing new energy sources and, therefore, will not appreciably relieve the energy crisis (p.6B.6-13).

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*Letter from Ed Cowles, Assistant Manager of Public Relations, Pratt and Whitney Aircraft, Division of United Aircraft, East Hartford, Connecticut, March 18, 1975.

**Ibid., also statement of William H. Podolny, General Manager, Fuel Cell Operations, Power Utility Division, United Aircraft Corporation before the Subcommittee on Energy Research, Development and Demonstration Committee on Science and Technology, United States House of Representatives, February 27, 1975.

***Statement of William H. Podolny, op. cit.

This evaluation is especially inappropriate since both before and after the year 2000 our energy resources are still projected to be largely based on the use of fossil fuels. According to Table 2.1-12 (p.2.1-15) of the Statement, 64% of our energy will come from fossil fuel sources in the year 2000. Thirty-five percent will come from petroleum and natural gas alone, those fuels presently utilized in the Pratt and Whitney and TARGET fuel cell programs.

In this time context it seems irrelevent to say that the utilization of a technique for fossil fuel conservation will not appreciably affect the energy crisis. In effect such conservation techniques might be viewed as a new source of fossil fuel energy since they save a large sector of existing fuel supplies. Stretching the supply of our dwindling fossil fuels at this time will ensure their prolonged use should projected alternative technologies for energy utilization prove unfeasible or take longer to develop than anticipated.

Further, fuel cells can be used in conjunction with future energy sources to stabilize or provide specialized output loads. A good example would be solar electrical hydrogen production wherein the fuel cell would help to provide a stabilized system for utilizing an energy source which might have more favorable social and environmental impacts than the LMFBR program. Fuel cells may play a critical role in the storage technologies

needed to be developed before dispersed central station solar electrical generation can be relied upon. This important concept in the development of solar power is not fully discussed in the Statement.

Most important, ERDA is specifically directed to include in its comprehensive plan provisions "to commercially demonstrate the use of fuel cells for central station electric power generation."* This will undoubtably accelerate the emphasis to be placed on fuel cell development.

*The Federal Nonnuclear Research and Development Act of 1974, PL 93-577, Section 6 (a) (N).

CHAPTER VI

INTERNATIONAL COOPERATION

Section 102 (2) (E) of the National Environmental Policy Act of 1969 states that where consistent with foreign policy, the agency proposing an action should "maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment" (emphasis added).

This function was provided for in the Energy Reorganization Act of 1974, wherein it was stated that the Administrator of ERDA would be responsible for "encouraging and participating in international cooperation in energy and related environmental research and development" (Section 103(9)), and that he could delegate to an officer this special responsibility for international cooperation (Section 102(h)). The appointment of an Assistant Administrator for International Affairs was duly announced by ERDA on February 14, 1975.*

This provision for easy international cooperation reflects a growing realization that energy issues and not military issues are what connect one nation with another. It is in contrast to the provision for international agreement in the Atomic Energy Act of 1946, which defines "agreement" as a "treaty" (Section 8). It is also at variance with the constraints placed on international

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*"Weekly Summary", Information from ERDA, Washington, D.C. February 19, 1975, p.1.

activities in the amended Atomic Energy Act of 1954, which, while they permitted cooperation, included an elaborate system of approval by the President and Congress (Sections 121, 122, 123, 124, 141 and 144).

Unfortunately, the Statement was issued too soon to reflect this new policy or the efforts presumably initiated by the assistant administrator. While it briefly documents the history of developmental and operational breeders in the United Kingdom, France, the U.S.S.R., Germany and Japan, evidence of cooperation is contained in only one sentence, "Information is exchanged... within the context of technical exchange agreements in force" (p.2.2-10).

While the Statement considers and rejects the possibility of wholly imported breeder technology, it does not consider working together with other nations in the research and development of the technology. Its attitude is characterized by saying, "Placing reliance for meeting our future energy demands in foreign hands is not an attractive option" (p.1.6-8). The impression is conveyed that the AEC preferred to commit billions of dollars of taxpayers' money to duplicate experience that could be gained by international cooperation.

This is in contrast to the assessment made by our British allies, whose 250 mw prototype breeder became critical in Dounreay, Scotland in March 1974:

> ...our Fast Reactor strategy should be pursued within a framework of international co-operation...The benefits... come from an enlarged base; from sharing costs, facilities

> and experience through the R & D design, introduction and exploitation stages; from access to wider experience in problem solving; from rationalizing component production to secure economies of scale...There are strong arguments for adopting reactor systems which are in the main stream of reactor development to gain the benefits of joining the largest possible technical community...The commitment of resources for R & D in the nuclear field and the costs and problems of introducing and proving systems are too great for it to seem sensible for any country to bear them alone."*

In the same report, the Chief Inspector's advice was given as follows:

> There are some particularly difficult and new safety problems and a considerable programme of research, development and design work will be necessary before a firm view can be given on the acceptability of Fast Reactor for continuous commercial operation on sites suitable for the Electricity Boards' system requirements.**

This is considerably more tentative than the Statement's conclusion that an earlier, smaller British fast reactor had "added confidence that a fast reactor can be safely and reliably operated" (p. 2.2-10).

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*Nuclear Power Advisory Board, Choice of Thermal Reactor Systems, Presented to Parliament by the Secretary of State for Energy, London, September 1974, pp.10,18-19.

**Ibid., p.12.

In one case, it is not clear whether American industry has found a way to be thrifty, or will be paying an "isolation penalty". The American Experimental Breeder Reactor II, which became critical in 1963 (p.2.2-3), is essentially the same as the 250 mw French prototype breeder Phenix at Marcoule, which became critical in 1973. Now that the Phenix has been raised to full power, France is trying to sell the LMFBR on the world market, and both General Electric and Bechtel are talking openly to the French."*

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*Staff, "Nuclear Developments", Electrical World, March 1, 1975, p.37

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Alan McGowan
President
Scientists' Institute for Public Information
30 East Sixty-eighth Street
New York, New York 10021

Dear Mr. McGowan:

Thank you for your letter of April 8, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Responses by Energy Research and Development Administration (ERDA) staff to your specific comments are provided in the enclosure to this letter.

In your letter you have made several comments regarding the overall adequacy of the PFES. Specifically:

> ". . . SIPI concludes that the Statement must be withdrawn by ERDA, and the breeder program must be completely reassessed, incorporating new comments made by the public, before presentation of a relevant environmental impact statement." and
>
> "The National Environmental Policy Act (NEPA) specifies that the lead agency in a proposed action must prepare an original environmental impact statement and may not accept one carte blanche from another agency. . ."

In addition, you indicate that SIPI feels that the competence of the non-nuclear staffs of ERDA are not reflected in the PFES.

With regard to these comments, the Administrator recognized that ERDA has a broader mission in energy research and development than did the Atomic Energy Commission, and directed that the LMFBR Program be reevaluated by individuals not previously associated with the LMFBR Program. Accordingly, he appointed four senior ERDA officials who had no previous involvement with the LMFBR Program to act as an Internal Review Board to review the Statement and to advise him on whether the issues relevant to a decision on the LMFBR Program had been adequately treated. They were the ERDA Deputy Administrator, and the ERDA Assistant Administrators for Solar, Geothermal and Advanced Energy Systems, for Conservation and for Fossil Energy. As

part of its review this Internal Review Board held a Public Hearing on May 27-28, 1975. The Board presented its Report to the Administrator on June 20, 1975 (see Section IV B of the Final Environmental Statement (FES)). In addition to the Internal Review Board, the Administrator enlisted the assistance of several eminent scientists and managers outside ERDA to furnish him with their views on the PFES (see Section IV C).

Quite apart from the reviews requested as a result of the transition of responsibility for the LMFBR Program from the AEC to ERDA, each successive version of the Statement has benefited from the contributions and reviews of groups and individuals outside the AEC and ERDA. In preparation of the Draft Statement, contributions were solicited and received from other Federal and State agencies, from private industry, from environmental groups, and from the academic community. Development of the PFES was further guided by comments received on the Draft Statement.

The reviews and comments received on the Draft and Proposed Final Statements as well as the testimony presented at the two Public Hearings of April 25-26, 1974 and May 27-28, 1975 have been considered by Dr. Seamans in preparation of the "Administrator's Findings (June 30, 1975) on the Liquid Metal Fast Breeder Reactor Program Proposed Final Environmental Statement, WASH-1535 (December 1974)" (see Section IV A of the FES). In his Findings, Dr. Seamans adopted the Internal Review Board's Report and concluded that the Proposed Final Environmental Statement provides a comprehensive environmental review of a major technology development program and the alternative technology options, and that the PFES amply demonstrates the need to continue research, development and demonstration of the LMFBR concept. Accordingly, the PFES has been incorporated as an integral part of the FES prepared by ERDA to complete the NEPA process. However, several issues were identified during the review process which require resolution before a commitment to widespread commercial deployment of the LMFBR can be made. The research and development effort in these areas is continuing and supplemental information on the program has been included in the Final Environmental Statement (See Section III of the FES). The FES also includes copies of all solicited comment letters received on the PFES with detailed responses to each letter.

In view of the actions detailed above it is ERDA's belief that the Final Environmental Statement cannot be considered as being "accepted carte blanche from another agency." It is also ERDA's belief that the breeder program has been completely reassessed by independent reviewers and that new comments made by the public have been incorporated into the record of the FES.

As requested in the May 30, 1975 letter from D. Y. Sauter to W. H. Pennington, the attachments to that letter have been published in the FES (see Section V). We found the comments in that letter to be similar in content to comments made in your April 8, 1975 letter. As noted above your comments have been treated in the enclosed ERDA staff responses and in Section III of the FES.

Thank you for your detailed comments and your continuing interest in the Energy Research and Development Administration's programs. A copy of the Final Environmental Statement has been enclosed for your information.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Responses to Specific Comments by the Scientists' Institute for Public Information

Statement of the Executive Committee of SIPI and Chapter I - Introduction

Comment (pp. 4,5, I-5, I-9):

SIPI feels that the data used in the PFES cost-benefit study is outdated and that PFES electric growth projections are inconsistent with the projections of others.

"The Statement claims that recent variability is accounted for by its inclusion of cases down to 50% of their base case projection, but their - 50% case is above the projection made in December 1974 by the Technical Advisory Committee on Finance of the Federal Power Commission for historic growth up to the year 1990."

ERDA Response:

The data used in preparation of the PFES was the latest and most reliable available at the time of preparation. Recent trends indicate that the declines in energy and economic growth during 1974 were temporary, and that projections giving those events too much weight may be seriously in error.

Several interim projections made in 1974 indicated massive decreases in future power demand as compared to earlier projections, based mainly on the drop in demand observed in 1974. More recently, however, the power situation in 1974 is becoming widely recognized as an anomaly, caused more be depressed economic conditions than by any basic change which would strongly affect future demands.

The Federal Power Commission, in its comments on the PFES[1] indicates that it concurs substantially with the projections in the PFES. For further discussion see the first two responses to comments from Chapter 3 of the SIPI letter.

Comment (pp. 5, I-5, I-6):

"The Statement claims that 'the range of variables explored in the cost-benefit analysis...(e.g., cases which assume a 50% reduction in the base case projection of electrical demand in the year 2020) appears to provide adequate insight into the possible effects of major uncertainties in the assumptions used.' It further claims that benefits are reduced below

[1] Federal Power Commission, comment letter No. 60 on PFES.

costs only when a number of assumptions are simultaneously weighted in a manner which is considered unlikely to occur (p. 11S-1)."

"We observe that these 'unlikely' circumstances only begin to touch upon current and realistic interactions of the chosen parameters. It is from this point that ERDA may have to begin to prepare new input to the econometric model, providing current information on the delayed breeder introduction date, increased capital costs, lower energy demand compounded by all the parameters cited, more optimistic uranium supply, and increased research and development costs."

ERDA Response:

As described in the PFES, ERDA believes the combination of adverse assumptions mentioned above are unlikely. However, several commentors requested that a wider range of conditions be considered, and therefore a number of new cost-benefit cases have been evaluated. These results are discussed in Section III F, 11.2S of the Final Environmental Statement (FES). These new cases evaluate 1993 and year 2000 introduction dates, a new capital cost estimate, lower energy demand, and new uranium and separative work costs.

A more optimistic assumption for uranium supply was not considered necessary because the most recent ERDA projections, which reflect early results in the NURE program, indicate that the PFES base projection is realistic and may, in fact, be somewhat optimistic. Updated LMFBR program R&D costs were included in the PFES. The program is now at a stage where costs can be expected to be predictable, and therefore new estimates are not considered necessary.

Comment (pp. 5,6, I-12):

"With capital formation among the most serious problems facing the nation, continued investment in this program would inevitably foreclose the development of other energy options which ERDA, in its comprehensive plan, and with its expanded authority, may choose to emphasize."

ERDA Response:

ERDA does not agree that continuation of the LMFBR program would foreclose other options. Active R&D is currently being carried out on a wide range of nuclear and non-nuclear power options with markedly increased budget allocations. The only "foreclosure" which might

occur would result if the developed LMFBR proved economically more viable than other options.

In the long range, the LMFBR holds the promise of significant savings in capital requirements. As shown in Section 11.2.1.3 of the PFES, a modest increase in capital costs for power plants in a system containing LMFBR's produces savings of more than $160 billion by reducing the capital requirements for the mining of uranium ores, recovery of concentrates, and uranium isotopic enrichment.

Data reported by the NASA-NSF Solar Energy Panel, the Subpanel IX report for "The Nation's Future," and the Project Independence Blueprint all project higher capital costs for solar and geothermal power systems than are projected for the LMFBR.

Comment (p. I-4):

> "Volume I, Section 2.1 of the PFES, 'Relationship of the LMFBR Program to the U.S. Energy Economy,' is twenty-five pages long, and contains a total of seventeen figures and tables. Sixteen of these are identical with those that appear in the same section of the DES, and were generally produced in 1972 or earlier. The one addition to the PFES is a figure comparing 1968 per capita income and energy consumption."
>
> "The PFES Section 2.1.3.3., dealing with the 'Current Situation' in the generation of electricity, presents Table 2.1-11, identical to the DES Table 2.1-11, giving U.S. electrical utility industry statistics for 1972. Similar statistics are published for 1973 and beyond in monthly issues of the Federal Energy Administration's Monthly Energy Review published in 1974, and so were certainly available to the AEC at the time the PFES was being prepared."

ERDA Response:

The collection of massive amounts of data required to present statistics on U.S. energy production and consumption, and in particular, on the U.S. electrical industry, is a difficult and time-consuming task. There is, therefore, considerable time lag in the availability of collected data for the entire country.

For both the FPC and the Edison Electric Institute, time lags of about 6 months are involved in the collection of preliminary, unverified monthly data; preparation of collected annual data typically involves lags of one year to 18 months.

The tables referred to in the comment were not "produced in 1972 or earlier." The tables for the Draft Statement were prepared in late 1973 and early 1974. At that time the latest data on U.S. power generation was for 1972; some data (e.g., on total energy consumption) were available only for 1971 and earlier.

Material for the PFES was prepared during the summer of 1974, only a few months after data for the Draft Statement were collected. At that time only partial data were available for years later than those shown in the Draft Statement; consequently, updating of the affected tables was not warranted. Subsequent inspection of 1973 data shows that its inclusion, had it been available, would not have changed the impact of the tables.

In the case of the one figure mentioned using 1968 data, this is a bar chart comparing the relationship of national per capita income and energy consumption for the U.S. and for several other countries. This information, from a 1972 publication of the U.S. Department of Interior, was included to illustrate the general, world-wide relationships of income and energy consumption.

Comment (pp. I-6, I-7):

> "A meaningful Statement would have to consider several introduction dates beginning with 1991, reflecting a penalty for each year of delay."

ERDA Response:

Additional cost-benefit cases assuming LMFBR introduction dates of 1993 and the year 2000 have been included in Section III F, 11.2S of the FES.

Comment (p. I-7):

> "The assumption is made in the Statement that a decrease will occur in the capital cost of the LMFBR, due to the learning process associated with the introduction of a new plant type, from $520/kwe in 1985 declining to $360/kwe in 2000, in 1974 dollars (p. 11.2-12).
>
> Comparing this to the experience with light water nuclear reactors, we find an original estimate of $135/kwe raised to $250/kwe, then $350/kwe, and later to $400-$510/kwe in an eight year period. In real costs, during the two years 1971

to 1973, this amounted to a $90 million capital cost increase for a 1000 MWe LWR."

ERDA Response:

LMFBR capital costs were assumed to decrease from $520/kwe at introduction (1987) to $368/kwe (not $360/kwe) in 2000. Of the assumed decrease, $100/kwe was ascribed to learning effects, and $52/kwe to size-scaling of unit capacity from 1300 MWe to 2000 MWe.

The progression of LWR costs which were quoted from WASH-1345 cannot be directly compared among themselves or with the PFES capital costs. The quoted costs are based on differing "constant dollars" ranging from 1967 to mid-1974 dollars; hence, the effects of 7-1/2 years inflation are implicitly included. The assumed length of the licensing and construction periods varies from 5 to 9.5 years; this directly affects the amount of interest paid on capital during the construction period. Finally, the WASH-1345 figures are for a 1000 MWe plant, rather than the 1300 MWe plants used as pre-1990 models in the PFES.

Apart from escalation, cost increases were ascribed by WASH-1345 to effluent controls (cooling towers, SO_2 limits, lower radionuclide release limits); regulations relating to safety and quality control; increased conservatism in regulations; and increased time required for licensing and construction of nuclear plants. Each of these factors led to across-the-board cost increases for all types of nuclear plants; some affected fossil plant costs strongly as well.

As was discussed in the PFES, the array of capital costs used in the cost-benefit study was intended to reflect expected relative differences in capital costs among various plant types. Absolute capital costs may either increase or decrease, but changes are assumed to affect all types of plants, preserving the relative cost positions as given.

Comment (pp. I-7, I-8):

"While the maximum undiscounted research and development cost used in the Statement is $8.7 billion, or generally $4.7 billion at the accepted 10% discount rate (Appendix IV-D), the AEC estimated in January 1975 that it would require $10 billion of government funds plus substantial private funds to develop the breeder into a commercially viable energy option."

ERDA Response:

The future research and development cost requirements of $8.4 billion (1987 introduction) or $8.7 billion (1991 introduction) used in the

PFES are in agreement with the $10 billion referenced in the comment; the $10 billion figure includes expenditures already made in the program.

Comment (pp. I-9, I-10):

> Recent population projections are lower than the one used in the PFES.

ERDA Response:

All population projections listed in the comment fall within the envelope of energy projections used in the cost-benefit study. In particular, the 1975 Bureau of Census report, referenced by SIPI, appears to differ only slightly from the 1972 E-series projection used in the PFES.

Comment (p. I-11):

> SIPI includes the following for purposes of comparison:
>
> "Statement: The effects of changes in age composition of the population, which affect the size of the work force, will not be apparent until the late 1990s (p. 11.2-53)."
>
> "McGraw-Hill: The U.S. labor force, because of the changing age composition of our population, will grow less rapidly beginning with the late 1970s.*"

ERDA Response:

The above statement does not appear in the PFES, but it is consistent with the Series-E population projection used for the cost-benefit study. The following statement is made on page 11.2-138 of the PFES: "The trend toward lower birth rates, if accelerated, could lessen future energy demand, through changes in population and age-group distributions, although the effect of these changes would not be apparent until the late 1990's." Alternate projections, of course, could result in different assumptions as to work force. However, the two statements listed in the comment are not necessarily contradictory. Without more data on the McGraw-Hill data base, it is difficult to analyze the quoted statement.

*Economics Department, The American Economy: Prospects for Growth to 1988, McGraw-Hill, Inc., N.Y., 1975, p. 4.

Comment (p. I-11):

SIPI notes that the PFES assumes employee productivity will increase at an annual, long-term rate of 2.6% whereas a McGraw-Hill reference uses a rate of 2.3% until 1988.**

ERDA Response:

The differences are minor, and the 2.3% rate is for a relatively short term when compared to the 45 years covered by the PFES cost-benefit analysis. Further, the McGraw-Hill reference, published in 1975, may have ascribed undue significance to the events of 1974.

**Ibid., pp. 5,6.

Comment (p. I-11):

SIPI provides the following GNP figures for comparison:

Gross National Product Source	Annual growth rate
Statement projection	Historical (3.7%)
1973 Electrical World projection	3.7% to 1990
1974 Electrical World projection	3.0% to 1995
Actual GNP, 1974	-2.1%
1975 Electrical World projection for 1975	-2.3%

ERDA Response:

The additional GNP figures reflect the recent depressed state of the national economy. In fact some investigators are predicting higher growth rates (see response to comment on page III-15 of the SIPI letter). As stated previously, the use of short term transients for long range planning is inappropriate.

Comment (p. I-12):

"Seventy-eight utility companies requested price increases in 1974, tripling the amount per increase over 1970. Although the cost-benefit analysis does not consider price elasticity, the average 24% increase in the price of electricity in 1974 should, using the Chapman, Tyrrell and Mount analysis,** eventually lead to a demand 36% less than it would otherwise

**Duane Chapman, Timothy Tyrrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crises," Science, Vol. 178, November 17, 1972, pp. 703-8.

have been. A drop of 18% would be apparent in 1981, with a drop of 3.6% by the end of 1975."

ERDA Response:

The Chapman, Tyrrell and Mount analysis predicts elasticity effects appreciably greater than other studies using more recent data. As noted, this analysis would predict a drop in demand (relative to historic projections) by the end of 1975. To the contrary, the FPC foresees a return to historic rates of increase in demand for electricity. In balance, the increase in cost of electricity must be weighed against the rapid rise in cost of alternative energy forms and the resulting general price increases throughout the economy. Please also see the ERDA response to the comments on page III-20 of the SIPI letter.

Chapter II

THE POTENTIAL FOR A HYPOTHETICAL CORE DISRUPTIVE ACCIDENT

General Response:

This chapter contains a large number of comments on LMFBR "explosions" and core disruptive accidents, many of which appear to overlap or to be based on similar premises. In such cases the ERDA response to a given comment may not include all of the relevant background information contained in responses to previous comments on pages II-1 through II-10. For this reason some of the responses should be considered in the context of the responses to other comments in this section. Considerable additional information on these and related topics is included in Section III B of the Final Environmental Statement (FES).

Comment (p. II-2):

> "Safety hazards in the LMFBR program are in theory very great.... it is possible for the fuel of an LMFBR to undergo a nuclear explosion. This follows from the use of two tons of plutonium in a form which, without further alteration, can be made to explode. The critical mass of LMFBR fuel is estimated variously as between 30 and 60 kilograms (p. v.20-7) -roughly one hundred pounds-or a very small fraction of the tons of fuel available in a power plant. From this it follows as well that a small part of a plant's fuel may be stolen and made into a nuclear weapon."

ERDA Response:

This comment appears to bear upon two issues: the potential for a nuclear explosion within the reactor and the potential for theft of a portion of the plutonium fuel and the fabrication of a nuclear weapon. The question of an explosion within an LMFBR is discussed in responses to the comments that follow. With regard to the fabrication of a nuclear weapon as a result of the theft of a small part of a plant's fuel, this is generally regarded as infeasible though theoretically possible. Dr. Theodore Taylor in testimony at the public hearing on the PFES* after discussing the practicality of fabricating a weapon from LMFBR fuel at some length concluded, "Just to state an opinion - and that's really all it is - I would say that with fast breeder fuel without separating the plutonium, one would have an object so big and so heavy, my guess is it would weigh a number of tons, that I think one should look at the alternative, namely, what is required to separate the uranium from the plutonium."

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*Volume 1, Public Hearing Record for the Public Hearing held May 27-28, 1975 on the Proposed Final Environmental Statement, WASH-1535 December 1974 for the Liquid Metal Fast Breeder Reactor Program, pp. 321-323.

Comment (p. II-3):

> "The safety of nuclear power is a decisive issue, and the safety of LMFBRs depends decisively on their potential for explosion - if the plants are found to be likely to suffer explosions that release radiation it seems very unlikely they will ever be built in a populated country."

ERDA Response:

It is agreed that if there were a potential for explosion, this would be a decisive LMFBR safety question and that they would not be built in populated areas. The question of the effects of an energetic disruptive accident (rupturing the protective enclosures) has been discussed in the response to the comments on pp. II-6 and II-7. However, it is expected that R&D efforts will in the near future provide a basis for the conclusion that core disruptive accidents resulting in the generation of significant amounts of mechanical energy are physically unrealizable. The safety and licensability of LMFBRs do not have to await this R&D result since it is possible to contain significant amounts of mechanical energy from a disruptive accident (e.g., the FFTF design). Once the anticipated R&D confirmation is obtained, design features of subsequent plants may change significantly.

Comment (p. II-5):

> "A hundred pounds or less of plutonium is capable of undergoing a nuclear explosion. There are circumstances in which a plant's fuel may melt - a portion of the Fermi's fuel melted in the accident which shut it down. In an accident more severe than one which has yet occurred in a commercial power plant, all or much of the fuel may melt. How can we know that a small fraction of this fuel will not collect or be compressed until it explodes?"

ERDA Response:

Any implication that reactor fuel material containing a hundred pounds of plutonium could undergo a disassembly of potentially damaging energy is in error. For example, it has been estimated that at least 40% of the uranium/plutonium oxide contained in the FFTF reactor would have to accumulate in the bottom of the reactor vessel (following a hypothesized meltdown accident) to even achieve criticality and, further, that this amount of material would generate sufficient heat to provide dilution and turbulence to prevent criticality.

Comment (pp. II-6, II-7):

> "Neither the AEC nor, apparently, anyone else is therefore in a position to draw an upper bound on the force of explosions possible in LMFBRs short of the force of a nuclear weapon. A common-sense view would be that no such upper bound can ever be drawn. Implicitly conceding this point, the AEC declined to take into account all accidents which are physically possible. Instead, the AEC chose to rely on its research program to demonstrate that such accidents are either so unlikely that they need not be taken into account, or that once identified and understood properly, adequate measures can be taken to prevent them."

ERDA Response:

While it is not now possible to place a precise upper bound, valid for all reactor designs and accident sequences, on LMFBR accident energies, the laws of nature make it physically impossible for such energies to in any sense be comparable to that of a nuclear weapon. Based on the R&D already completed, it is clear that energy releases beyond the ranges which are generally hypothesized in safety evaluations of LMFBR core disruptive accidents are not achievable. Further, it is expected, as indicated previously, that R&D efforts will in the near future provide a basis for the conclusion that core disruptive accidents resulting in the generation of any significant amounts of mechanical energy are, not only so unlikely that they need not be taken into account, but actually physically unrealizable in responsibly designed LMFBRs. While it is not yet possible to show that moderately energetic core disruptions are impossible, such events would, at most, lead to limited potential for damage to the seals of the reactor primary system. Such limited damage would have no direct impact on the protective enclosure.

Comment (p. II-9):

> "All that seems certain is that we do not know how big an explosion is possible or likely in an LMFBR, and that calculations are inadequate to predict them. Perhaps full-scale experiments in which fast reactors are built and then melted down will provide the needed information, but these are not planned so far as the public has been told."

ERDA Response:

The R&D referred to previously includes both the development of analytical techniques and experimental work to confirm these techniques.

Although some uncertainties in analytical techniques exist they can be taken into account, as explained earlier, by conservative design. Full-scale meltdown experiments would not be meaningful because of the wide variety of possible design parameters affecting accident sequences (e.g., meltdowns, such as occurred in EBR-I and Fermi and which did not result in any injury to the public, would not provide adequate assurance that a meltdown under somewhat different conditions would not have greater consequences.)

Comment (p. II-9, II-10):

> "In the second large category of risks posed by the LMFBR, the hazards of theft of plutonium, even less apparently can not be said with certainty. The Statement acknowledges that its present security systems will not be adequate to protect an expanded plutonium-based electric power industry, but just what measures will be needed, and how we are to know whether they will be effective, cannot now be decided. The decision awaits the outcome of future study .... Until then, of course, the risks are unknown but may be very great indeed."

ERDA Response:

You express concern over the dependence of future safeguards adequacy upon the success of safeguards research. The acknowledgment in the PFES that the present safeguards and security systems are inadequate to protect the future fuel cycles in no way implies any doubt that adequate systems can be devised. Safeguards and security systems which would more than satisfy the needs of the nuclear industry have been used in other areas. Decisions relating to the LMFBR security and to nuclear industry security in general will reflect choices of how much security is adequate for the needs of society as a whole. The R&D program outlined in the PFES (Volume IV, Section 7.4.8) indicates the areas in which cost-effective decisions must be made and describes the paths which will be followed to gain the knowledge needed to arrive at these decisions. Additional material on the safeguards program is provided in Section III C of the FES. Specific decisions cannot now be made with the confidence that will derive from the R&D program. This is not a case of "hoping that research will vindicate the LMFBR" but is rather a proper reticence to commit to specific safeguards techniques until the available options have been explored and compared.

Chapter III

Projections of Future Electrical Demand

Comment (p. III-2):

> "To support its position, the Statement uses projections of demand that were made by the Federal Power Commission from 1969 through 1973 (pp. 2.1-14, 15). However, projections released by the FPC in December 1974 (the date of the Statement) are 'substantially lower' than these, 'partly explainable in terms of the passage of time and the occurrence of significant events'."

ERDA Response:

The Federal Power Commission (FPC) projections have been and are supportive of the electric energy demand projections used in the PFES. Note that the FPC comments on the PFES in a letter to W. H. Pennington, ERDA, dated April 3, 1975 indicates that "Although it now appears that through 1980, actual demands may be below the projections of the 1970 National Power Survey, the Bureau of Power believes it is quite possible that the electric loads by 1990 would equal or exceed the National Power Survey projections if there is extensive substitution of coal and nuclear energy, via electricity, for present oil and natural gas applications. We believe that the long-term need for the LMFBR has not been diminished by the current slowdown in load growth."

Comment (p. III-7):

> "In a chapter entitled 'Current Situation' (p. 2.1-12), a sentence is inserted which indicates there was some attempt to make the Statement seem current: 'Over the past year, however, growth in the use of electric energy in the U.S. decreased to about 0.6% as compared with the 7+% growth rate of prior years' (p. 2.1-13). However, the Statement denigrates the efforts of other experts to incorporate this new information in their future planning: 'Relatively abrupt revisions in growth projections seem likely to be more a reaction to current uncertainties than to hard assessments of future demands' (p.1.1-7)."

ERDA Response:

The PFES does not cast aspersions on the efforts of energy forecasting experts to include current data. However, ERDA does feel that long-term planning based on short-term downswings or upswings in the electric energy demand is short-sighted and inadvisable. Obviously, the long-term energy growth trend contains many instances of short-term accelerated and decelerated growth. The current deceleration in the face of recessionary pressures and artificially increased petroleum

prices is understandable. But the current lull in energy growth is not due to an abrupt change in the relationships between GNP and total energy, total energy and electric energy. In fact, recent experience only too clearly defines the relationship between energy costs and economic growth. Abundant, low cost energy is vital to economic prosperity.

Comment (p. III-8):

> "Beginning from 1980 only, and through 2020, cases were run in the Statement's model down to -50% of the base case projection, at which point the benefit-cost ratio was generally shown to approach or fall below 1.0, whatever the other variables, at the 10% discount rate (p. IV.D-3, 4). The Statement claims, however, that benefits are reduced below costs only when a number of assumptions are simultaneously weighted in a manner which is considered unlikely to occur (p. 11S-1)."

ERDA Response:

First, it should be noted that the -50% energy demand case is *not* considered likely to occur. Second, as stated on p. 11S-1, the benefits are reduced below costs only if the capital cost estimates of the LMFBR are escalated, or if plentiful, low-cost uranium ore resources are hypothesized in addition to the unlikely event that the projected electric energy demand is reduced 50% by the year 2020. Further, if uranium prices and separative work prices are increased to reflect current prices, the benefits are increased substantially as indicated in Section III F, 11.2S of the FES.

Comment (pp. III-9, 10, 11):

> SIPI notes that others have made population projections which are less than the projection used in the PFES and concludes that the PFES electric power demand projections are thus too high.

ERDA Response:

The population projection updates you describe and their subsequent impact on the electric energy projections are small relative to the parameter variations already considered in the PFES. As stated earlier, all population projections listed in the comment fall within the envelope of energy projections used in the cost-benefit study. In particular, the 1975 Bureau of Census report referenced by SIPI appears to differ only slightly from the 1972 E-series projection used in the PFES.

Comment (p. III-11):

"In its projections of future electricity demand, the Statement estimates the size of the work force from the historical population in the 18 to 64 age group (p. 11.2-53). It states that the effects of changes in age composition of the population would not be apparent until the late 1990s (p. 11.2-138). In contrast, the McGraw-Hill study predicts "...the U.S. labor force, because of the changing age composition of our population, will grow less rapidly beginning with the late 1970s than in earlier years." The Statement does not consider changes in the unemployment rate, which is currently over 8%."

ERDA Response:

The material you referenced on p. 11.2-138 was taken out of context and does not relate to the work force assumption as you imply. The full statement is as follows: "The trend toward lower birth rates, if accelerated, could lessen future energy demand, through changes in population and age-group distributions, although the effect of these changes would not be apparent until the late 1990's."

As previously stated, ERDA does not feel that short-term trends are necessarily indicative of long-term trends.

Comment (p. III-12):

"Similarly, the Statement assumes a continuation of the historical 2.6% increase in productivity per employee per annum (p. 11.2-53). It does not consider changes in working hours, which the McGraw-Hill study predicts will be down 6% per employee by 1988, or efforts at conservation of energy, which would reverse the increase in labor productivity. Although the McGraw-Hill study predicts a resumption of the 2.6% rate of increase after 1974, it estimates an overall decline to 2.3% from 1973 to 1988 as a result of the decline in 1974 alone."

ERDA Response:

Reductions in working hours per employee are certainly not indicative of decreased productivity. Working hours have historically dropped just as productivity has historically increased. Energy conservation is not synonymous with decreased total energy use. Energy conservation does not only imply preservation but also energy thrift in the sense of less waste and increased energy end-use efficiency. Further as noted in the ERDA response to the comment (p. I-11), the above mentioned differences in productivity growth estimates are minor.

Comment (p. III-15):

1. "Accelerating energy prices and high unemployment may herald a return to an 'intermediate technology' which is more labor-intensive, yielding a lower GNP."

ERDA Response:

Forecasters, in light of recent events, still predict GNP growth rates similar to the 3.9% assumed in the PFES. For example, the Hudson-Jorgenson growth model projects the GNP to have an annual average growth rate of 3.85% over the period 1975 to 2000.*

*Hudson, E. A., and Jorgenson, D. W., "U.S. Energy Policy and Economic Growth, 1975-2000," Bell Journal of Economics and Management Science, (Spring, 1975), p. 490.

Comment (p. III-16):

2. "An increasing portion of the GNP will be claimed by activities which are less energy-intensive than the production of commodities: education, leisure, health care, government activities and other services. This has been evidenced by a decline in recent years of incremental kwhr/incremental constant dollars."

ERDA Response:

There are some indications that the communication, trade and services growth will lag overall GNP growth.* Also, there is evidence to indicate that services are relatively energy intensive.**

*Strout, Alan M., Technological Change and United States Energy Consumption, 1939-1954, (Unpublished PhD dissertation), Univ. of Chicago, 1966.
**Hudson and Jorgenson, Op. Cit., p. 490

Comment (p. III-16):

3. "Market saturation may be approaching in radios, television, refrigerators and other home appliances, illumination, automation of many industrial processes, air conditioning in the commercial sector."

ERDA Response:

Historical experience has shown that new markets have developed as old markets were saturated. For example, the television market was borne

as the radio market approached saturation. In the light of the increases in labor force participation by women in recent years, a movement toward more labor saving household devices seems likely.

Comment (p. III-16):

4. "There may be less capital available from loans. In September 1974, Bank of America, the world's largest bank, reported a year to year loan growth of 31%. By December 1974, it had fallen to 26%, and the intention was reported in February 1975 to purposely lower it to 10%, a rate that was considered one they could "sustain on a long-term basis."

ERDA Response:

Capital availability is a complex problem with many facets. One must also note other trends and events such as:

1) the recent increase in the investment tax credit;
2) the decline in interest rates;
3) new capital financing techniques such as employee stock-owning options.

Comment (pp. III-16, 17, 18):

5. "The future of electricity-intensive industries such as aluminum, petro-chemicals and uranium enrichment is uncertain:..."

ERDA Response:

Obviously, the composition of the U.S. and world economy is not and has not been static. The PFES does not assume an absolute continuation of today's economic conditions. However, the PFES does assume that historical trends of GNP, total energy and electric energy growth will continue although perhaps modified by future circumstances. Of course, historic growth and future growth stems from technological and social changes.

Comment (pp. III-18, 19):

"Though SIPI's comments specifically asked for an evaluation of the Council on Environmental Quality's 'half and half' plan, which results in an annual energy growth rate of 1.8% by 2000, this was not mentioned. Nor is the impact discussed of the effect on demand of the Federal Energy Office's plan (SIPI, p. IV-8). The FEO is now the Federal Energy Administration, which produced the Project Independence Report. This projects a range of growth rates from 3.2% down to 2.1% by 1985."

ERDA Response:

The Council on Environmental Quality's "half and half" plan is discussed on pages 6C.6-8 through 6C.6-10. A number of other approaches to energy conservation are described in Section 6C.6.1.

Although FEA electrical demand growth projections are less than the ERDA base case projection, the FEA projections do fall within the range of parameters considered in the cost-benefit study. In their letter* of May 1, 1975 the FEA stated that if a program of national conservation and demand management could be achieved, electrical growth could be 25% less than that projected by ERDA. The PFES considered cases of a 50% reduction in electric demand, and additional cases assumign an intermediate 25% reduction have been included in Section III F, 11.2S of the FES. In addition, the FEA states in their letter that even with reduced demand that "...we are dependent on the use of nuclear generated electricity to meet our needs" and that "...it is especially important to continue with ERDA's present LMFBR Program."

*Federal Energy Administration, comment letter No. 89 on PFES.

Comment (p. III-19):

"The Conference Board has expressed a concern which was not reflected in the Statement:

> Energy prices rose nearly 11% faster than the general price level (26.5% compared with 14.1%) from 1970 to 1973, and by the third quarter of 1974 had widened the margin by an additional 50% (over the 1973 average). Increases in relative energy prices of this magnitude should bring about substantial changes in energy use.

However, the Board concludes that energy use could grow at an annual rate of only 1.5% till 1985 without damage to the economy, assuming "adjustments in production and consumption that will permit less energy to be consumed per unit of product."

ERDA Response:

Energy prices rose as a result of imported oil price escalations. Obviously if we continue to depend on imported oil we will suffer the economic penalties. However, increased dependence on domestic coal and nuclear resources can counter the energy price rise effects on energy demand and economic growth.

Comment (p. III-20):

"SIPI's comments requested an evaluation of how recent price increases would affect future electrical demand (SIPI, p. IV-5 to 7). This was not found, though there was mention of the Chapman, Tyrrell and Mount study on price elasticity, which was said to project consumption of 1.9 to 4.6 trillion kwhr by 2000 (p. 11.2-56). This study estimates that a 1% increase in price causes electrical demand eventually to be an average of 1.5% less than it would otherwise have been.** Price elasticity studies by Fisher and Kaysen, Anderson, and Wilson were not referred to*** nor was the study in the Project Independence Report."

**Chapman, Tyrrell, Mount, pp. 703-8.
***M. R. Seidel, S. E. Plotkin, & R. O. Reck, Energy Conservation Strategies, Implementation Research Division, Office of Research and Monitoring, U.S. Environmental Protection Agency, Washington, D.C., July 1973, pp. 16-19.

ERDA Response:

The following data shows the range of price elasticities computed by various investigators:

	Study Date	Data Base	Range of Price Elasticity
Fisher-Kaysen	(1962)	1946-'57	- .22 to - .99
Wilson	(1971)	1968	-1.33
Anderson	(1972)	1947-'69	- .58 to - .77
Halvorsen	(1972)	1961-'69	-1.09 to -1.14
Chapman et al.	(1972)	1946-'70	-1.3 to -1.7
Griffin	(1974)	1953-'71	- .51 to - .52

Price elasticities of Chapman et al. are the highest among your references and those shown above. Note that the PFES did not include electric energy demand increases due to reduced power costs of the LMFBR. Price elasticity of energy demand and its effect in changing energy use may have been overemphasized as witness the continued increase in gasoline consumption despite a near doubling in its cost.

Comment (p. III-22):

"In general, their (Chapman et al.) conclusions may turn out to be conservative. Their lowest projections were based on the assumption

of an average annual electricity price increase of 3.33% of 1970 values for thirty years, or a doubling of price by the year 2000. Their demand projection of 2.01 trillion kwhr in 2000 used that rate of price increase, coupled with a population growth of 1.4% per year, GNP of 4% and per capita personal income growth of 2.9% per year. The experience in 1974 makes this low demand seem more possible: a price increase of 24% over the 1973 level, population growth of 0.7%, GNP decline of 2.1%, and unemployment reaching 8% by early 1975."

ERDA Response:

A more recent projection by Tyrrell indicates a base projection of 5.1 trillion kwhr in 2000. The value of 2 trillion kwhr in 2000 is unbelievably low since the value for 1974 was 1.8 trillion kwhr.

Chapter IV

Conservation

Comment (p. IV-1):

With regard to energy conservation, the Proposed Final Environmental Statement reported that:

"Some measures are said to offer minor relief but involve economic and environmental penalties, while others are admitted to be 'worth pursuing and should be implemented where practical' (p. 6C. 7-1).

"Among the former are improvements in resource extraction and power plant conversion efficiencies, 'whose total contributions might result in savings equivalent to approx. 5% of U.S. generating capacity in the year 2000' (p. 6C. 7-3). This is below the estimate of 9.7 to 15.9% discussed in SIPI's comments (SIPI, p. IV-17 and 18). There is no discussion of why the higher estimate is not accepted, or even of the implications of the 5% projected savings."

ERDA Response:

The estimate of 9.7 to 15.9% used in SIPI's testimony on the Draft Statement (pp. IV-17 and 18) was predicated on a different basis from that of the results of conservation measures as discussed in the Draft Statement. SIPI's Table 5 (page IV-17) clearly shows that their estimate included a "credit" of 7% for improved energy conversion devices. These devices were discussed by the AEC in a different section of the Draft Statement (6B) from that in which energy conservation was examined, and were not included in the 5% AEC figure noted in the comment. On this basis, it is seen that AEC's 5% savings should be compared to SIPI's "Extraction" projection (SIPI Table 5) of 2.7-8.9%, and not to a range of 9.7-15.9%. Therefore, considering the uncertainties in both estimates, the AEC and SIPI projections are more or less comparable.

The implications of a 5% savings would not, as discussed in the Statement, be of major significance with regard to the question of whether or not conservation could replace the need for the breeder. However, as also discussed, a 5% savings or any savings is desirable and steps should be taken to achieve these savings if economically and technically justified. Reduction in energy usage via conservation measures will be needed along with several new energy sources, of which the breeder is one option, to narrow the gap between future energy supply and demand.

Comment (p. IV-1):

> "The Statement considers that end-use conservation is a measure that can result in very substantial and worthwhile energy savings and could appreciably lower U.S. demand for both electricity and total energy usage in the years to come (p. 6C. 7-3). The consensus is noted that a vigorous, successful conservation program could reduce total energy consumption by 30% by the year 2000 (p.C. 7-6). However, the reduction of 20% of demand is then the only example of savings by conservation in a table entitled Energy Sources for Electricity Projection in the Year 2000 without the Breeder (p. 11.1-24)."

ERDA Response:

The 20% figure was selected as an example or point of departure for discussion of a possible mixture of energy sources as shown in the table. Considering the many uncertainties associated with achieving a 30% reduction by the year 2000 as discussed in Section 6C.8, it is believed that a discussion or table based on a 20% reduction is not improper.

The commentor apparently failed to notice that a reduction of 50% was used in Table 11.1-4 for the year 2020. An assumed reduction of this magnitude is greater than that which might be reported as the consensus of the studies examined in Section 6C.6.

Comment (p. IV-2):

> "The Statement does not make clear that the conservation of 30% of demand projected for 2000 still represents a 50% greater per capita energy use than in 1970 (Table 11.2-7, p. 11.2-53) or over 3 1/2 times greater per capita electrical use than in 1970 (p. 11.2-58)."

ERDA Response:

We are in complete agreement that even conservative projections of future energy demand show that substantially larger quantities of energy (especially electricity) will be required in the future on a per capita as well as on an absolute basis. These projections point up the need for additional energy sources, of which the breeder reactor is one option.

Comment (p. IV-2):

> "The Statement states that the inconveniences to the public and changes in life style that would be caused by a savings of 30% of

energy through conservation by 2000, would be "moderate to severe" (p. 6C.8-1). However, our review of the seven programs described on pages 6C.6-1 through 19 indicates that those allowing for 1.7% to 2.0% future energy growth rate as opposed to historical growth of about 3.5% imply no hinderance of national economic growth or change in life style, yielding up to a projected 36% projected total energy savings by 2000. The Subpanel XIII program for 30% savings, for example, depends on increased efficiency of processes and products, and not on such measures as gas rationing, prohibitive taxation, or deliberately keeping houses less comfortable (p. 6C.6-16)."

ERDA Response:

The suggestion that the seven programs imply "no hinderance of national economic growth or change in life style" is debatable. Even the Ford Foundation's technical fix scenario relies on smaller cars, which some people would consider a change in their life styles, and the EPA study relies extensively on economic policies and mechanisms such as price-elasticity to "force" some degree of savings. Further, since all the studies concluded that energy consumption would be significantly reduced, and most economists would agree that energy consumption is closely tied to the Gross National Product and/or living standards, it would appear that a less direct but equally important impact on life styles could result from these conservation programs. We believe that characterization of changes in life styles by a 30% reduction in energy as being "moderate to severe" remains appropriate in view of the indicated changes and the uncertainties associated with the economic impacts of reduced energy consumption.

Comment (pp. IV-2, IV-3):

"Moreover, the Statement's discussion of these programs is not sensitive to how their predictions relate to recent developments. In particular, the concurrent effect of savings through conservation coupled with lower demand is not considered... Likewise, the Office of Emergency Preparedness program projects a total energy savings of 23% to 25% by 1990 if the electrical growth rate falls from 6% to 4.5% (p. 6C. 6-3). In 1974, this rate actually fell .56% under the 1973 level."

ERDA Response:

We are well aware that projections have been made of circumstances or scenarios in which future energy demand is significantly lower than projected levels, and are similarly aware of the almost zero electricity growth rate in 1974 which some suggest "validates" these low growth projections. On the other hand, we also realize that projecting future

energy demand is fraught with uncertainties, and that the recent low growth experience appears closely related to the adverse economic situation existing during that period. More recent projections or indications suggest to some that we may be returning to historic growth levels in electricity consumption. The point to be noted is that hopefully lowered future energy demand based on current projections is a perilous basis on which to make important current energy supply decisions, and that the consequences of failing to develop promising energy supply technologies such as the breeder, if needed, could be much more severe than that of having the option available but unused.

Comment (p. IV-3):

"The Statement's section on specific conservation actions does not give sufficient coverage to the merits of automatic energy and electricity conservation systems."

ERDA Response:

The merits of automatic energy control systems are recognized, and there was no intention to disregard them. The attempt was made to make the PFES section on specific end-use energy conservation measures as comprehensive as possible; however, it does not discuss every single conservation measure that might be suggested.

Comment (p. IV-4, IV-5):

"Rather than expand its own rationale of why abandonment of the breeder in favor of conservation programs might be unwise, the Statement relies for reinforcement on several brief quotes from people outside the lead agency, who express their opinions that "conservation is not the complete or final answer to the energy crisis" as follows:

1) J. W. Simpson, in an address to the American Nuclear Society, said that conservation alone cannot solve the long-term problem, and that a reduced standard of living for Americans would not solve the world energy problem (p. 6C.7-10,11).

The breeder alone, of course, does not solve the long-term problem either, its maximum projection being for the supply of 23% of need in the year 2000."

ERDA Response:

ERDA is in complete agreement with the comment that the breeder alone will not solve the long-term energy supply problem. As we have stated repeatedly, a mixture of several energy supply concepts will be necessary to meet future needs, and the breeder is only one of the options that may be used for this purpose.

Comment (p. IV-5, IV-6):

> "Jack Moore, Southern California Edison Company, wrote that conservation measures can go only so far and provide only temporary relief (p. 6C.7-11). In contrast, the Project Independence Report suggests that 'we may view conservation measures or the energy which is otherwise wasted, as a potential energy resource'. Among the benefits of conservation noted in the report are the elimination of pollutants associated with production and consumption of that energy, and phasing out of use the 'smaller, dirtier power plants more rapidly', as well as reducing growth in new areas for energy production."

ERDA Response:

One may argue that the two views are not inconsistent. Certainly conservation may be viewed as a potential energy resource, but it has its limits. To the extent that conservation measures eliminate waste, are technically feasible, and economically attractive, there is little question that they should be implemented as soon as practical.

Comment (p. IV-6):

> "Carl Bagge, National Coal Association, wrote that conservation is difficult to mandate, and that adoption of measures would represent a hardship to industry (p. 6C.7-11)."
>
> "In this regard, the Statement failed to consider such experience as the response of Los Angeles to their shortage in generating fuels."

ERDA Response:

The Los Angeles instance is certainly an interesting case in point, but without further information it is difficult to judge whether it is a valid exception to Mr. Bagge's suggestion that mandated conservation measures would represent a hardship to industry. With regard to the subject of reduced electricity consumption, the following comment

received in Letter No. 51, Southern California Edison Company, is of interest:

> "While Edison's kilowatt-hour sales during the first quarter of 1974 were down 6.1% from the corresponding period in 1973, this amount or reduction did not last for the entire year. The average for the year was 5.1% reduction, while in the month of December 1974 the reduction was only 3%. During the first three months of 1975 we have averaged a 2.3% increase in energy sales over 1974.
>
> The 1974 net Edison peak demand of 9,997 MW occurred on July 25, 1974. This peak was 2.5% less than the 1973 peak of 10,253 MW occurring June 21, 1973. The peak in the first three months of 1975 was 8,389 MW on January 30. This was almost 4% greater than that peak demand (8,094 MW) recorded in the first three months of 1974. Thus, in the first few months of 1975 we have seen evidence of positive growth in both energy and peak demand in spite of both the economic recession gripping the country and the previous conservation efforts."

Comment (p. IV-7):

> "Milton Levenson, Electric Power Research Institute, wrote that historical projections of population and per capita use of electricity indicate increased production will be a prime societal demand, rendering the net success of conservation unlikely. (p. 6C.7-12)."
>
> "Our chapter on 'Projections of Future Electrical Demand' showed repeatedly that historical projections are no longer valid. For instance, Mr. Levenson said in April 1974 that 'even with the most conservative projections of population growth during the next 30 years, we expect a 30% to 40% increase in the nation's total population". In contrast, the 1975 projections of the U.S. Bureau of the Census range between 13% and 26% increase over present population by the year 2000. Using the latest projections for the fertility rate assumed in the Statement, even the AEC would accept a population growth of 19% by 2000."

ERDA Response:

As indicated in a previous response, we are well aware that energy projections are a risky business, and may be shown to be too low or too high as new information comes to light. It is for this very reason that ERDA feels it must be conservative and conduct its energy planning such that sufficient energy supplies are available if needed. The lessons of history in energy usage bear this point out. The consequences of failing to provide needed energy would be more severe than having energy options available but unused.

Comment (p. IV-7):

> "The Statement's passive attitude toward promoting conservation measures is at variance with ERDA's new mandate 'toward the goal of reducing total energy consumption to the maximum extent practicable, and toward maximum possible improvement in the efficiency of energy use. Development of new and improved conservation measures shall be conducted with the goal of the most expeditious possible application of these measures'."

ERDA Response:

We do not believe the energy conservation section in the Proposed Final Environmental Statement conflicts with these goals. The Statement reported that energy conservation in combination with increased reliance upon coal and current nuclear power systems is the best hope for meeting the Nation's short term energy needs. Conservation was also cited as having a substantial potential as a supplement to new energy sources. The Statement did point out certain uncertainties and limitations in the ability of conservation to meet its full potential, but we feel it is only proper to discuss a technology's limitations as well as its potential. Our conclusion that "those conservation measures that meet all... appropriate criteria should be made a part of the Nation's energy use pattern as soon as practicable" is believed valid and not indicative of a "passive attitude" toward promoting conservation measures. ERDA is now pursuing research and development of many conservation measures, and is implementing a vigorous conservation program on an expedited and well-funded basis.

Chapter V

Evaluations Regarding Alternate Technologies

Comment (pp. V-1, V-2):

> The PFES's treatment of alternative energy mixes or strategies is inadequate.

ERDA Response:

In the Draft Environmental Statement, we examined a number of energy mixes both with and without the breeder. In response to comments by SIPI and others we further extended the analyses in the PFES to include cases without the breeder and using optimistic assumptions about the market penetrations of unconventional energy sources. The combination of unconventional systems consisted of solar, geothermal, organic wastes, and fusion, and these were examined in the context of various degrees of energy conservation. No economic cost-benefit studies were made for these cases because the technical and economic data for most of the unconventional systems are poorly defined. As an alternative we simply assigned portions of the energy demand to unconventional and other non-fission energy sources with the remainder to be satisfied by nuclear fission power plants. Based on inferences from other cost-benefit cases that included about the same fission energy production, it was concluded that, even with optimistic assumptions about the success of unconventional alternatives, the benefits of introducing the LMFBR would still justify its development. We believe the treatment of alternative strategies in the PFES is adequate and the conclusions are valid. Nevertheless, we expanded the scope of our alternative strategy study and the results are given in Section III F, 11.1S of the Final Environmental Statement.

Comment (pp. V-2 to V-9):

> The PFES minimizes the contribution of solar energy between 2000 and 2020 and also fails to mention that beyond the year 2020 solar may ultimately supply 100% of our electrical demands.

ERDA Response:

No attempt was made to minimize the contributions of solar energy. The PFES draws certain conclusions about the extent of solar applications and the reasons for these conclusions are clearly stated. Your comments give no specific reasons for altering the conclusions. Concerning the suggestion that solar could supply 100% of our needs beyond 2020, you should note that the PFES does not examine energy demands nor energy systems beyond the year 2020. The energy systems in existence at 2020 are simply run to the end of their design life.

Comment (pp. V-3, V-4):

"The Statement reports the total electric contribution of solar energy according to NSF/NASA to be less than 5% (p. 6A.5-18). Elsewhere it claims that it has adopted the NSF/NASA estimate of 1% as the potential contribution of solar to electric conversion by the year 2000 (p. 11.1-19)." ..."Nowhere do they [NSF/NASA Solar Energy Panel] select the potential of 1% or less than 5% as quoted in the Statement."

ERDA Response:

The comment relative to the text on page 11.1-19 is valid. The error will be rectified in the Final Statement.

The less than 5% figure given on page 6A.5-18 is believed to be a fair inference based on the NSF/NASA Solar Energy Panel Projections. Note that the discussion in this section is related to solar energy systems based on artificial collection (thermal conversion, photovoltaic, and managed photosynthesis). Wind, ocean thermal, and organic wastes are discussed elsewhere.

Comment (pp. V-4 to V-6):

If economical energy storage or backup systems were developed for home use, photovoltaic systems on buildings would eliminate the need for transmission and distribution. A fuel cell operating on solar-produced hydrogen may be desirable as a backup system.

ERDA Response:

The original SIPI comment on the Draft Statement indicated that the NSF/NASA Solar Energy Panel report supported the contention that photovoltaic systems on buildings would eliminate the need for transmission and distribution. The response to the SIPI comment given in the PFES merely pointed out that the NSF/NASA report does not support this contention.

Comment (pp. V-6 to V-9):

Solar thermal conversion plants operating as supplemental power sources may now be competitive with oil and are getting close to being competitive with coal.

ERDA Response:

In discussing supplemental power sources, the word "competitive" is misleading since such energy sources would not compare with conventional power plants; the conventional capacity would need to be built whether or not supplemental power is available. The PFES indicated that the most likely application of thermal conversion and photovoltaic plants would be as fuel-displacers for oil-fired peaking plants (see pp. 6A.2-56 and 6A.5-28). Oil is the highest cost utility fuel and the capital investment that can be made to displace the burning of oil is high. Nevertheless, this would seem to be a rather limited market for solar power because: (1) the cost estimates for solar plants on which the assumption of economic viability is based, are for southwestern U.S. locations and (2) it is National policy to reduce the consumption of oil in power plants through the substitution of more plentiful, lower-cost fuels.

Concerning your view that solar supplemental power plants are near the point where the displacement of coal may be economical, we believe your data leads you to a conclusion that may be too optimistic. You use the highest current price for low-sulfur coal to an Eastern utility and compare this with cost estimates that are at least two years old for a developmental concept. As you know, coal prices have responded to oil prices, neither of which have any relationship to cost at the present. Even so, the price you assume for coal exceeds the average paid by utilities by a factor of 2 or more.

The central question to be answered in the LMFBR Program Environmental Statement is whether alternative energy sources will be available that will make the LMFBR unnecessary. We believe your comments on the feasibility of solar displacing high-cost fossil fuels are irrelevant to the central question.

Comment (pp. V-9 to V-11):

The PFES concludes that because ocean thermal systems are only in the conceptual stage there is little basis for making a meaningful assessment. "However, a demonstration plant such as Claude's in 1930 (p. 6A.6-5), and the findings reported in the 1972 NSF/NASA, 1973 MITRE, and 1973 Subpanel IX reports all show significant basis on which to make a 'meaningful assessment'." Also, the cost figures given in the PFES for ocean thermal systems are not significantly higher than those for the LMFBR. The PFES also fails to consider the substantial contributions by the year 2020 projected by some groups.

ERDA Response:

We believe the assessment of ocean thermal systems given in the PFES is adequate. We also believe that any objective assessment of ocean thermal systems would conclude that not only is there little basis for making a meaningful assessment, there is no basis whatsoever for postponing or halting other promising energy programs.

Concerning cost, the PFES reports the range of estimates given in the literature but also presents an independent analysis (p. 6A.6-7) that shows present cost estimates for ocean thermal systems are probably much too low.

Your comment that we fail to consider projections of market penetrations to the year 2020 is in error. We considered them and rejected them as meaningless.

Comment (p. V-11):

> "...there is no single section examining all of the direct and indirect solar energy systems coupled with their possible storage subsystems. This omission deprecates the large role solar energy can play in electrical power production.
>
> "If even short-term storage facilities (3 to 6 hrs) are economically developed using conventional generating systems as a backup, the resulting savings in fuel might be sufficient to show that development of the breeder is unnecessary."

Response:

If low cost energy storage systems of 3 to 6 hours capacity are developed, the LMFBR could be used to meet peak-load as well as base-load needs. Thus, the need to burn oil for peaking would be eliminated and, with it, the best potential market for solar electric systems. The development of energy storage systems would make the breeder even more desirable, not less as you imply.

Comment (p. V-12):

> "In discussing the technology of pumped storage, (6A.3), the Statement makes no reference to the concept, mentioned by SIPI, of building solar stations next to existing hydroelectric facilities, which could double as pumped storage facilities."

Response:

Pumped storage is a highly desirable concept even with the existing power system, and it is being implemented where acceptable sites can be found. But acceptable sites are limited. Nevertheless, if pumped storage could be expanded, the advantages for the breeder would be further enhanced as described in the previous response.

Comment (pp. V-12 and V-13):

> The PFES does not examine solar-produced hydrogen and its storage as a means of increasing reliability of solar electric plants.

Response:

If economical electrolytic cells are developed the choice of application would be (1) use them with solar electric plants at a 20% use-factor or (2) use off-peak power from the grid at a 50% use-factor. In this comparison, the value of the solar electric power would be even less than the value of the conventional fuels displaced.

Comment (p. V-13):

> "One concept the Statement also fails to comprehensively treat is the development of a national grid system. Such a system would help to even out the fluctuations of solar power in combination with storage facilities."

Response:

True, we did not make a comprehensive examination of the implications of a national grid. If we had, it is evident that the benefits to the LMFBR would be substantial. The market for base-load plants would increase because of the increased load diversity.

Comment (pp. V-14 to V-17):

> The PFES does not adequately treat the potential of fuel cells for meeting our future electrical power needs.

Response:

The treatment in the PFES of fuel cell technology is believed adequate for the purposes of the environmental statement. Fuel cells do not provide a new source of energy but do allow more economical utilization of existing energy sources through their energy storage capabilities. Fuel cells may be worth developing for energy storage and specialized applications but do not offer a realistic alternative to coal and nuclear systems for bulk power generation.

Chapter VI

International Cooperation

Comment (pp. VI-1, 2):

> "This provision (in the Energy Reorganization Act of 1974) for easy international cooperation reflects a growing realization that energy issues and not military issues are what connect one nation with another.--Unfortunately, the Statement was issued too soon to reflect this new policy or the efforts presumably initiated by the assistant administrator."
>
> "While the Statement considers and rejects the possibility of wholly imported breeder technology, it does not consider working together with other nations in the research and development of the technology."

ERDA Response:

This commenter implies that prior to enactment of the Energy Reorganization Act of 1974, there was little exchange of technical information between the U.S. and foreign countries.

This is simply not true - the exchange of technical information between the U.S. and foreign countries is not a new policy. Since the formation of the Atomic Energy Commission, there has been an Office for International Affairs, one of whose functions it was to promulgate technical exchange arrangements. The provision of the Energy Reorganization Act of 1974, cited above, reemphasized the importance of an ongoing function of the Atomic Energy Commission in carrying on international exchanges in civilian nuclear technology.

For example, in connection with fast reactor technology, there has been an exchange of information between the U.S. and the United Kingdom since February 1956. Technical exchanges with the West German nuclear R&D establishments have been active since the 1960's. There have been contacts with the two government laboratory centers at Karlsruhe and Julich and the German industrial nuclear development organization, Interatom. In cooperation with the General Electric Company, the Germans were parties to the construction and operation of the SEFOR experimental fast breeder reactor. Since 1963 there have been technical information exchanges with the French. Effective for a ten-year period beginning in March 1969, there will be technical exchanges with the Japanese for fast breeder reactors. The Japanese cooperated in the Fermi fast reactor power plant project. As a result of the agreement for cooperation between the U.S. and USSR, signed June 21, 1973, there has been active cooperation on fast reactor research and development and other technologies between the two parties.

Generally these technical exchange agreements are implemented by visits, meetings and seminars and by exchange of reports, correspondence, drawings and specifications. In some cases, arrangements have been made for the irradiation of U.S. test materials in a foreign reactor or vice versa. In other cases, there may be an exchange of representatives for one or more years between specific facilities in the two countries. In summary, technical exchanges have been ongoing for many years and have been beneficial to all parties involved with them. However, as stated in the PFES, there is understandable reluctance for the U.S. to become wholly dependent on foreign technology for a major energy source with access to technical information only through licensing agreements.

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9 April 1975

James L. Liverman
Assistant General Manager for Biomedical and
Environmental Research and Safety Programs
United States Atomic Energy Commission (ERDA)
Washington, D.C. 20545

RE: Proposed Final Environmental Statement,
LMFBR Program (WASH-1535)

Dear Dr. Liverman:

Enclosed are my comments relating to the above.

Yours truly,

Donald P. Geesaman
Associate Professor

DPG/lam

Encl.

V.67-2

COMMENTS ON THE AEC
PROPOSED FINAL ENVIRONMENTAL STATEMENT
LIQUID METAL FAST BREEDER REACTOR PROGRAM

April 8, 1975

Donald P. Geesaman
School of Public Affairs
University of Minnesota
Minneapolis, Minnesota 55455

These comments are structured around the responses of AEC staff to my initial comments on the AEC Draft Environmental Statement, Liquid Metal Fast Breeder Reactor Program.

1-1

Regarding Comment #1. Accidents.

The following commentary is referenced to the attached.

1) Note that this Comment applies to the entire nuclear fuel cycle, not just to reactors, as the Commission would imply here.

2) As a paraphrase of my Comment, the phrase 'in principle' should be inserted here.

3) This is not to say, however, that major accidents would not occur in the process of making 'the likelihood of occurrence' small.

4) This sentence is irrelevent, and is not necessarily true. The definition of a destructive act is value based. A destructive act may, in fact, result in more or less order in the system in question.

The argument made in the Comment is that it is easier to disrupt physical order than it is to create it. This argument is consistent with the Second Law of Thermodynamics, and while I can not cite a more general theorem from non-equilibrium statistical mechanics or from information theory (which is not to say that such a theorem does not exist), I would suggest that the empirical support for this argument is considerable, and that therefore as a valid pragmatic principle, it must be given most careful consideration. For when this argument is applied to a physical element of the nuclear fuel cycle, such as a reactor (which is the quintessence of physical order), then it would necessarily imply that it is much easier to selectively disrupt the reactor, even catastrophically, than it was to construct it. The Commission must recognize that in this comparative sense it is a minor technological task. Consider the 100s of millions of dollars that went into the energy, labor, and resources associated with the design and construction of the reactor. Then

consider the stability of that system against system-disruptive processes that are orders of magnitude less intensive in their capital demands in the form of energy, labor, and resources. (Witness, for instance, the non-deliberate disruptive effect produced by a candle in the recent accident at the Brown's Ferry reactor.) The Comment's discussion of the physical stability of jet aircraft developed the same thesis around a comparable and existing technology. As was pointed out there, however, the two technologies do have very different potentials for societal disruption.

Recognize that a broad spectrum of possible disruptive techniques exists. Consider two limiting cases of deliberate catastrophic reactor disruption. The first would be energy intensive;- an explosive device detonated in such a manner as to breach the reactor's containment and to disperse its contents. This is a possible approach; it involves relatively low technology; it emphasizes the grossly disruptive use of energy.

The second case would be information intensive; little energy need be involved. A person or persons who are aware of the specifics of the reactor system are able to disrupt that system to a comparable catastrophic end by a much more refined, information intensive intervention. A continuum of possibilities connects these two possibilities.

Bear in mind when evaluating these arguments concerning deliberate disruption, that the criminal traditions are no longer properly thought of as residing exclusively in the domain of underworld and terrorist organizations. In our contemporary society, those evil traditions have cast their shadows across the highest echelons of national governments and industry, and have penetrated even into our own security forces and military. The potential of rational or irrational criminal deviance exists both inside and outside of established institutions.

1-3

In conclusion, no one would argue that the nuclear fuel cycle does not contain the flows of substantial quantities of ultrahazardous materials. No one would argue that the nuclear fuel cycle is intrinsically stable against the physical release of a significant fraction of these ultrahazardous materials. No one would argue that such a release would not have a potential for great societal disruption in an extended vicinity. With this perspective the question can then be posed: Is the dimension and character of this social disruption such that it is likely to have appeal to rationally or irrationally motivated groups of limited size and of modest or substantial technological means? Neither I nor the Commission know the answer. Accepting the human condition for what it is, I can only suggest that the answer is yes. If so, then the inherent frailty of highly ordered physical systems, the diversity of modes and techniques available for disruption, the relative ease of human penetration into the fuel cycle (the most significant population may be those who have the easiest access), all argue that the probability of successful catastrophic sabotage is significant.

5) In the end the issue comes down to a clear focus. The integrity of this fuel cycle is sustained by the stability of society. The Commission can not hope to guarantee that necessary stability without considering active totalitarian intervention into society itself.

The Commission has been unresponsive to the Comment. Without some deeper scrutiny of the issues raised there and here, the Commission's discussion will be parochial. The arguments made now and upon which the LMFBR decision will be founded, must sustain themselves years hence when the implications of that decision are realized. At that future date the Commission's tendered discussion of those issues will assume a place in history along side the blueprints for the Maginot Line.

6) Agreed, but the same arguments apply to these systems individually or in the aggregate.

Enclosure 1

AEC Staff Response to Comments by Dr. Donald P. Geesaman

1. Accidents

Comment (pp. 1-5):

1 Various causes of reactor accidents[1], such as human error or random failure of engineered components may be postulated, but their incidence
2,3 or likelihood of occurence can[2] be made small.[3] However, "... the primary causal agent for technological events in contemporary society" is deliberate human action. "Reactor accidents will happen when men want them to happen... Sabotaging a reactor is necessarily a minor technological task compared to building one. There is a technology of disordering order. It is a low technology and it cannot be ignored."

Response:

4,5 By definition, the successful execution of a destructive act will produce a higher degree of disorder than existed earlier.[4,5] It does not follow that such execution is necessarily a minor technological task on any comparative or absolute basis. In the case of sabotage, an assessment of the difficulty involved must include evaluation of inherent capability to resist attack and the effectiveness of any separate protective features
6 which may have been provided.[6]

The AEC does not agree that sabotaging a reactor or other fuel cycle facility would be a minor task, now or in the future. Specific information supporting this position is given in Section 7.4.5.2.1, 7.4.7.2 and 7.4.8 of the Final Statement.

2-1

Regarding Comment #2. Plutonium Toxicity.

The following commentary is referenced to the attached.

1) This point was specifically addressed in para. 2, p. 15 of the Comment.

2) The mechanisms underlying the origins of cancer are poorly known. The disease profile of animals is highly species specific. In this context, extrapolation of results from fragmentary animal experience, while scientifically interesting, is an uncertain basis for public health judgments.

3) The phrase "in effect" should have been included.

4) The corollary is equivalent to the Comment's citation of the number of alveoli involved.

5) Previous recognition is not denied in the Comment, nor is it a matter of contention. The Commission acknowledges that knowledge, of the biological effects associated with the exposures in question, is contained within an envelope of uncertainty. The issue is: How does a public health policy (and an associated description of risks) properly accommodate this envelope of uncertainty? The Comment argues for a more conservative accommodation.

6) The origins and intent of this reference to 'philosophical arguments' is unclear.

7) This is an analogy of form more than of substance. If it confuses the Commission, it can be withdrawn from the Comment without loss.

8) The Comment was descriptive and not accusative.

9) Other experimental results involving other tissues show this conclusion to be incorrect for certain ranges of total energy. The Commission

is referred to the work of Albert.

10) The Comment argues against this conclusion.

11) This is a mistaken inference.

12) This statement is incorrect, since they do not fall commensurately. See para. 2, p. 10 on this point.

13) The Commission is referred to the works of Albert, of Barendson, and of Withers. The issues raised here are obviously interesting and have not been ignored in the formation of the arguments set forth in the Comment. On these points, the author is unaware of any experimental results that would qualitatively effect those arguments. If the Commission is aware of such results, its sharing of that knowledge would be appreciated.

14) The implication is also that this omission does not affect the arguments as framed.

15) The Commission is referred, in particular, to the work of Albert and of Maldague. In general, the comparison is made on the obvious basis, i.e., the region of tissue irradiated.

16) This is acknowledged explicitly in para. 2, p. 17 of the Comment.

17) These results are hardly dispositive for the issue, even if one accepts this interpretation of the experimental results.

18) This should read "hypothesis" rather than "theory."

19) Unhappily, increased sophistication in postulation of causes does more to extend the envelope of scientific uncertainty, than it does to resolve the public health dilemma as posed.

20) True, but the relationship of these processes to carcinogenesis, and to radiation carcinogenesis in particular, are unknown. They may, in fact, enhance rather than suppress.

21) This may be true, or alternatively the contrary may be true. Either is speculative, as is the assumed image of "suppression of potential tumors by the body's defense system."

22) But grave public health judgments depend upon a reliable answer, or in its absence, then upon a conservative answer.

23) The Commission is in error here, and is referred to para. 2, p. 13 of "Testimony Concerning The Acceptability of Existing Public Health Guidance for Plutonium" attached to (46) after.

24) Experiments, such as Albert's, make it obvious that there is no "inherent conservatism" in the averaging procedure.

25) The NCRP's inability to define "the algebraic sign of the error" is an open admission of uncertainty, both as to the response in the postulated situation, and as to the worth of the considered procedure for evaluating that response.

26) The meaning of this statement is unclear.

27) It is supported by the language of the citations.

28) This is evidently the Commission's opinion.

29) This is an inference of the Commission.

30) The example appears to have been explicitly chosen for its relevence to the point.

31) The Commission is referred to p. 15-16 of the Comment. The argument made there does imply that these calculations may well be in error. In their responses the Commission has acknowledged the validity of the argument.

32) The remarks in the Comment are intended to caution the Commission against the implicit imposition of the concept of "threshold burden" through the figure in question.

33) The Commission is referred to Appendix 24, AEC Authorizing Legislation - Fiscal Year 1971, Part 4, or AEC Draft Environmental Impact Statement, Rocky Flats Plant Plutonium Recovery Facility.

34) Albert or Maldague's dose-response curves imply precisely this conclusion.

35) The experiments of Albert and of Barendson were chosen because the elegance and intelligence of their conception led to results of meaningful content from which reasonable hypothesis could be constructed.

36) Acknowledged and cogent scientific uncertainties should, however, bear directly upon public health judgments.

37) As to the frailty of these conclusions, the Commission is referred to para. 2, p. 13 of "Testimony Concerning the Acceptability of Existing Public Health Guidance for Plutonium," attached to (46) after.

38) The Comment argues to contrary and the Commission has not refuted the validity of the argument.

39) A substantial plutonium industry existed for some 20 years prior to the inception of the public controversy over plutonium standards. Throughout this period the possible economic significance of plutonium was well recognized,

as was plutonium's substantial, but poorly defined, radiological toxicity. The given context would imply that it was imperative during this period to develop an extensive epidemeological program to determine the hazards of plutonium. Since this epidemeological program should have antedated the standards controversy by decades, this controversy could hardly have interfered with that program's function. Moreover, if the conclusions derived from that program were dispositive, no uncertainties could have existed later within which gross exaggerations of hazard or safety could breed.

40) It would be useful for the Commission to indicate the nature of these legal implications.

41) The Comment does not sustain this remark. The issue is not awareness of this human data, but rather its significance. The Commission is referred to the final sentence of the cited reference. "A more comprehensive interpretation of these data will be the subject of a future report."

42) No, the observations may place limits on the parameters associated with the hypothesis, it does not contradict it. On this point, the Commission is referred concurrently to McInroy,et. al., "Studies of Plutonium in Human Tracheobronchial Lymph Nodes," and to "NRDC Supplemental Submission to the Environmental Protection Agency Public Hearings on Plutonium and the Transuranic Elements," February 24, 1975.

43) Fundamental theories in combination with scientific observation define the limits of uncertainty.

44) The judgmental or philosophical principle proposed here requires clarification.

2-6

45) The concern is not that current decisions are being made blindly, but instead with a one-eyed vision, tragically deficient in perspective.

46) The Commission has attempted to respond to this Comment. Unfortunately the Commission seems so generally confused by the Comment, that there is no responsible alternative except to resubmit the arguments posed there, but in the more expanded form in which they were presented in testimony at the Environmental Protection Agency's Public Hearing on Plutonium Standards, Denver, Colorado, January 10, 1975. (See attached.) The Commission's attention is called particularly to that testimony's Summary and Conclusion which provide the conceptual framework for the arguments set forth there, and which will, perhaps, allow a clearer discrimination between scientific and public health issues in the Commission's understanding of the arguments. It is hoped that this clarification will avoid the Commission's agonizing over what it sees as philosophical discussion.

2. Plutonium Toxicity

AEC Introductory Remark

The comments provided on this subject were difficult to review and respond to because they are primarily a philosophical discussion based upon assumptions of the author. Since the evidence pertaining to particle effects is already discussed in the Environmental Statement, only representative comments will be addressed. It is also noted that this material - "Comment #2, Estimation of the Health Effects of Plutonium and Other Alpha-emitting Transuranics" - appears to be presented in support of the conclusion on page 12 that "plutonium induced lung cancer is a legitimate concern for humans." Because this view is shared by everyone associated with the problem (AEC, NRDC, EPA, EIAP, and individuals in the employ of and/or associated with these organizations), it would appear unnecessary to discuss the various paths by which we all arrive at the same conclusion.

Comment (p. 6):

"The estimate of lung cancer incidence associated with the inhalation of plutonium (or other transuranics) in particulate form is a critical factor, along with source terms and resuspension, in defining the probable impact of the LMFBR's plutonium based fuel-cycle. This subject is discussed in Section 4.G.5 'Particle Lung Dose Effects' of WASH-1535. I quote the first sentence from that section:

> 'The estimates of lung cancer incidence associated with the inhalation of transuranics used in this report are based upon a calculation of the average radiation dose delivered to the lung and application of tumor incidence estimates for the uniformly irradiated lung as estimated in the BEIR report.'

This cited basis and hence the derived estimates are indefensible."

Response:

With respect to use of the average radiation dose to the lung, ICRP Publication 14 states that "...a mean tissue dose would probably introduce a factor of safety." Even though the ICRP Task Group indicates in the sentence following the above, the need for continued study of the problem with reference to plutonium particles, this in no way contradicts or retracts the above statement which is the ICRP Task Group's considered opinion. It is true that risk estimates from the BEIR report are based primarily on the results from relatively uniform

irradiations of human lung. In the Final Statement risk estimates are also included which were calculated from the results of experimental animal exposures to particulate transuranium elements. Risk
2 estimates obtained in these two ways are comparable.[2]

Comment (pp. 6-8):

"Section 4.G.5 acknowledges that 'insoluble' particles of radioisotopes, when deposited in tissue, provide focal spots of high radiation dose rates close to the particle, so there is no presumption that the exposure by particulates of plutonium is uniform. The deep respiratory tissue of the lung is made up of 10^8 alveoli. 'Each aveolus is a complexly organized unit of tissue. If an insoluble alpha-emitting particulate is deposited in this tissue some 10 to 100 alveoli will be exposed. A crude measure of the nonuniformity of this exposure is that at most about one-millionth of the lung's alveoli are affected by a single particulate.

"The significance of the preceding is that in the actual lung exposure by an alpha-emitting particulate, the energy of the ionizing radiation is deposited in a very limited volume of tissue, and hence that the actual radiation dose to lung tissue scaled roughly a million times larger than the dose associated with an averaging of the equivalent radiation energy over the entire lung.

"A multiplicative difference of a million in a significant physical quantity generally suggests a qualitative difference. Suppose, for example, that the problem were to estimate the effects of small projectiles on human organisms. Suppose that the projectiles weigh 1/2 ounce and have a velocity of 1000 ft/sec. Note that the effect of the projectile depends on the energy, and note that a 6 ton vehicle moving at 1 mile per hour has similar energy. There is experience with humans stopping slow moving vehicles by exerting strenuous counterforces. Using this experience the effect of the projectiles on humans is inferred to be oxidation of the biological fuel necessary to do the work of stopping the vehicle. But this reasoning is manifest nonsense. Even though the energies involved are similar, a fast moving rifle bullet is quite different from a truck weighing a million times more and moving at a one-thousandth the velocity. The former dissipates its energy in the local disruption of tissue, the latter leads to the ordered and non-injurious oxidation of biological fuel. The end results become very different as the physical characteristics of the situation change, and a new biological phenomenon intercedes. Obviously the way to estimate the effects of rifle bullets is either from past experience that is explicitly applicable, or alternatively, to calculate the effects considering the physical characteristics of the rifle bullet and knowledge of the biological and physical characteristics of the human organism.

"This nonsense example has much the same logical structure as the method of estimating hot particles effects set forth in Section 4.G.5 of WASH-1535. There, by introducing a fictitiously large mass of exposed tissue, the calculated dose becomes commensurately small. In passing from the real situation in which a hot particle irradiates 10 to 100 alveoli, to the fictional situation in which the ionizing radiation from the hot particle is averaged over 10^8 alveoli, the dose scale has decreased by roughly a factor of a million."

Response:

Regarding the comment that, "A multiplicative difference of a million in a significant physical quantity generally suggests a qualitative difference," we assume that the words "in effect" are implied at the
3 end of this statement.[3] However, the obvious corollary is not stated -- a difference which divides the number of cells involved by a factor of a million in a biological system also generally suggests a quali-
4 tative difference "in effect."[4] It is the balance between these two
5 which determines the outcome, as has been recognized for years.[5] Unfortunately, we know of no "knowledge of the biological and physical characteristics of the human organism" which would permit resolution of this question, nor do we believe that it can be resolved by
6 philosophical arguments based on prior assumptions.[6] Indeed, one must depend on experimentation. As the Draft Statement indicates, the results of such experimentation are still not complete, but preliminary data, plus observations of the experimenters and other experts lead to the view that use of a homogeneous dose is appropriate.

The purpose of the analogy of a bullet and a truck is unclear. In the example given, the projectiles differed in momentum, shape and size and, therefore, the type of interaction and volume of tissue involved. Thus, the comparison between the two involves considerably more complex understanding than is implied, and the logic of the comparison has no
7 obvious relation to the hot particle situation.[7]

The Draft Statement is accused of "introducing a fictitiously large mass of exposed tissue" for the purposes of dose calculation that
8 the energy is uniformly absorbed throughout the lung;[8] it is not assumed that the biological effects observed are due to uniform absorption. Experimental results indicate that an exposure of the entire organ to the same total energy from alpha radiation would be the more
9 damaging case.[9] Therefore,[10] dose calculations made on that basis
10 would be conservative.

Comment (pp. 8-9):

"Living tissue shows extensive intra-cellular and inter-cellular organization. Several regimes of biological response would be expected as physical characteristics of exposure are varied. Carcinogenic response to whole organ exposure by non acute doses of radiation will fall in one of these regimes, and this will be a regime in which there is human experience. From the physical characteristics of plutonium aerosols, from the lung deposition experience with aerosols, and from the lung clearance experience with plutonium particulates, it can be inferred that at least one class of particles exist which subject lung tissue to an exposure associated with a different carcinogenic response regime. This is because other biological phenomenon has intervened.

"For hot particle exposure that phenomenon is mitotic death of cells, i.e., loss of the cell's ability to divide. There is an extensive literature on the subject. Radiologically induced mitotic death is, in fact, the basis for treating malignant tissue with ionizing radiation, and is the cause of most acute symptoms consequent to radiation exposure. Even though the intercession of extensive mitotic death of cells must inevitably place certain particulate exposures in a different response regime from whole lung, non-acute exposures, a compelling argument might be made that the carcinogenic response in the former case is necessarily less than the carcinogenic response in the latter. This argument would appear to have merit since mitotic death of cells, as well as reducing the general viability of the tissue, would also reduce the number of irradiated cells with carcinogenic potential. Usually implicit in this argument is a conceptualization of all radiation carcinogenesis as a single-cell, direct-injury process.

"To confirm this argument, there is a respectable literature in which carcinogenesis is described as occurring after doses of radiation that are sufficiently local as to not be organism lethal, and that are sufficiently high for the fraction of mitotically competent cells to be greatly reduced, i.e., to 1% or less. Unfortunately, in at least some of these experiments, carcinogenesis is inversely related to the fraction of mitotically competent cells, i.e., cancer induction in the regime where mitotic competence is greater than 1% is small compared with the cancer induction in the regime where mitotic competence is much less than 1%.

"There are several points to be made here. Loss of mitotic competence and carcinogenesis are two indices of radiation effect in tissue. They cannot be independent, and their relationship can tell us something about some radiation carcinogenesis."

Response:

11 The author considers only the rising part of the dose-response curve.[11] At doses above those producing maximum tumor incidence, both mitotic competence and tumor incidence fall together, and the objection becomes
12 invalid.[12] The statement that cancer induction in the region where mitotic competence is much less than 1% is not documented or referred to any specific experiments, nor is the nature of these experiments and important variables such as fraction of total organ irradiated, methods of determining mitotic competence, or even whether they are
13 in vivo or in vitro discussed.[13] The phrase "...at least some of these experiments..." implies that others gave different results which are
14 not discussed or included in the conclusion.[14] there is even a question as to what is meant in this statement by "...cancer induction... is small compared with the cancer induction in the regime where mitotic competence is much less than 1%." It is not clear on what basis this comparison is made: a total animal basis, a single organ basis, or
15 irradiated cell basis, or a surviving cell basis.[15] Transfer of the general conclusion on the relation between damage, as measured by mitotic competence, and cancer induction to the localized dose from particles also requires consideration of the possibility of an effect
16 caused by the size or volume of the irradiated tissue.[16] The evidence from the Albert studies on the atrophy of hair follicles and induction of follicle or sebaceous gland tumors in Sprague-Dawley rats, while very specialized as to type of tumor, does indicate a decrease in
17 effectiveness as the size of the area irradiated is decreased.[17]

18 It would appear that before the author's theory[18] can be supported it requires considerably more quantitative consideration. The question which immediately comes to mind on review of this material is whether the mechanism of tissue disruption in a very limited volume, taking into account the possibility of a decrease in effectiveness of cancer induction with decreasing volume, outweighs in importance the possibility of other mechanisms not involving tissue disruption if the dose is spread more uniformly. Such mechanisms, as listed in the BEIR report, include somatic cell mutations or chromosomal abberrations, changes resulting from the actions of viruses (connection with radiation not now clear), or changes in systemic growth factors. This question is, of course, almost identical to that posed in the Draft Statement concerning dose-distribution, although with increased sophistication in
19 the postulation of causes.[19] Since the comments of the author appear to lead to the same question which we have discussed in the Draft Statement, we must conclude that the issue remains as stated.

Comment (pp. 10-11):

"It is obvious that as a local exposure becomes more intense, a stage must finally be reached where the carcinogenic efficiency of the exposure (on a per unit energy basis) is reduced. This is not pertinent to previous arguments. It would, however, be important to know the characteristics of the most carcinogenetically efficient exposures.

"The following excerpt taken from the BEIR report (p. 95) summarizes the state of knowledge concerning the causation of cancer (emphasis added):

> 'Although the mechanisms of carcinogenesis, or of radiation carcinogenesis in particular, are not fully known, available information implies that most, if not all, types of cancer develop as a result of the combined effects of multiple factors. These causative factors may include: prezygotic (inherited) mutations of chromosomal aberrations, which can spread during development to many kinds of cells; somatic cell mutations or chromosomal aberrations, which can be acquired at any time after conception; changes resulting from the action of viruses; and changes in systemic growth factors (e.g., depressed immune competence, hormonal imbalance) and in local tissue regulation (disorganization, damage), such as may result from diseases other than cancer or from advancing age (1).
>
> 'Although point mutations, chromosomal aberrations, and other changes at the cellular and molecular level may require only small doses, tissue disorganization and gross disturbances in physiology are unlikely without larger doses (2).
>
> 'Of the many types of changes which radiation can cause in cells or tissues, none is considered to be unique for radiation. Many, if not all, such changes can presumably result from a variety of other agents.'

"This summary view on carcinogenesis is compatible with the ideas leading to the conclusion reached earlier, that fictitious dose averaging to larger tissue masses need not be conservative. The possibility of various modes of carcinogenesis is acknowledged, and in particular, mention is made of a pathway mediated by tissue disruption."

Response:

The BEIR conclusions regarding the importance of tissue disorganization, far from supporting the hypothesis that dose averaging to larger tissue masses need not be conservative, may be strong evidence against it. Tissue is very resistant to disturbance by small volumes of damage, however intense. The healing, reconstruction, repair, and/or regeneration mechanisms are most effective when normal, unaffected tissue surrounds
20 a small focus.[20] Thus, the localization of damage near a hot particle may be the most favorable situation for the suppression of potential
21 tumors by the body's defense systems.[21] The large surface-to-volume ratio of such foci provides maximum access by humoral and cellular suppressors, by scavenging macrophages, and by other circulating and local control agents. An important question here is the scale of the local tissue structures, and a reliable answer cannot be based on
22 qualitative, generalized arguments.[22] Published results by Little and co-workers indicate that Ceesaman's conclusions are wrong. Little's results are supported by animal studies at the LASL which appear in the LASL documents and which were reported at the Seattle Conference on Respiratory Carcinogenesis in June 1974. These experiments demonstrate the extraordinary radioresistance of the hamster lung when exposed to hot particles as compared with diffuse irradiation of the
23 lung.[23]

Comment (p. 11):

"Disease profiles are highly species specific. Cancer is no exception. Gross characteristics are obviously highly species specific also. A rat and a mouse are distinct and yet incredibly similar. The gross tissue differences are articulated out through subtly different informational resonances amongst cell populations, the collective behavior being phased ultimately, though perhaps remotely, by the genetic controls of the cells. Not to belabor this point unnecessarily, - cancer profiles are species specific; gross characteristics and, of course, genetic material are also species specific. Collective detuning of tissue, by tissue disruption seem as acceptable an origin for the tissue instabilities of cancer as does an isolated single cell event.

"Return now to the problem of risk estimates associated with radioactive particulates in human lungs. Most of what has been said earlier in this comment has been general, and has been aimed at showing that there was no inherent conservatism in the method of estimating cancer risks set forth in the first sentence of 4.G.5, and that moreover the method could be far from conservative. The conclusion could as well be applied to lymphatic tissue or to bronchial tissue."

Response:

Appendix II.G.6 and the references stated therein show that these arguments are in disagreement with experimental results and fail to show "that there was no inherent conservatism..." in the averaging procedure as claimed[24]

24

Comment (pp. 12-15):

"The following is a review of the official guidance for estimating the carcinogenic effects from exposure to radioactive particulates.

I '(210) The NCRP has arbitrarily used 10% of the volume of the organ as the significant volume for irradiation of the gonads. There are some cases in which choice of a significant volume or area is virtually meaningless. For example, if a single particle of radioactive material fixed in either lung or lymph node may be carcinogenic, the averaging of dose either over the lung, or one cubic centimeter may have little to do with the case. Use of significant volumes or areas must be looked on as one of the round off devices which in special cases must give way to detailed study.'

NCRP Report #39
Basic Radiation Protection Criteria
January 15, 1971
(emphasis added)"

"The recommendations of the National Council on Radiation Protection and Measurement set forth in I, and the recommendations of the International Commission on Radiological Protection set forth in III, are explicit in offering no guidance."

"II is a discussion of the hot particle problem taken from the report of an ICRP Task Group. It is not intended to give dispositive official guidance. The discussion is useful commentary, but inconclusive. The very conditional statement made in the first and second sentence of II (41) is not generally convincing. (Quotes from ICRP Publications 14 and 9 follow.)

"40. The problems of high local concentration of dose are at their most severe with radioactive particulate material in the tissue, especially with α-emitters. Here the local dose can reach very high values even though the mean tissue dose may be very low. Certainly it cannot be assumed that linearity of dose and effect will hold at these high doses and dose rates. On the other hand, there may be a great deal of cell death, and particularly with α-emission, with its short and well-defined range, the number

of affected but viable cells may be small compared with the number of killed cells. However, this ratio will depend on the size and activity of the particles, the extent to which they aggregate, and their movement within the tissue, and the movement of the cells past them.

"41. On the basis of general considerations and of some experimental data and clinical experience the Task Group were of the opinion that, for late effects, the same radiation energy absorption might well be less effective when distributed as a series of "hot spots" than when uniformly distributed. Thus, with particulate radioactive sources within a tissue, a mean tissue dose would probably introduce a factor of safety. However, a severe practical problem has now been recognized in connection with the inhalation of plutonium particulates, and is now being considered in detail by a Task Group of Committee 1 of ICRP...

"20. In the case of non-homogeneous distribution of absorbed dose in the lung, an estimate of the Dose Equivalent to the whole lung, determined merely by the product of QF and the mean absorbed dose, may be greatly in error, but our full understanding of this problem must await further experimental evidence. In the meantime there is no clear evidence to show whether, with a given mean absorbed dose, the biological risk associated with a non-homogeneous distribution is greater or less than the risk resulting from a more diffuse distribution of that dose in the lung. When irradiation results from the inhalation of thoron or radon and daughter products, the relevant Dose Equivalent is that in the bronchial mucosa which is the tissue considered to be most heavily irradiated. Here the use of the whole lung would be an inadequate substitute for that of the irradiated tissue.

"28. Within the range of the Maximum Permissible Doses (see paragraph 37) specified for occupational exposure, when it is assumed that there is no threshold and that effects are linearly related to dose, it is justifiable to consider the average dose to the whole organ or tissue, although it is recognized that when more information is available, it will be more appropriate to use the mean dose for cells of any given type, as is already done when the bronchial mucosa is irradiated by daughter products of radon and thoron.

> The use of the mean dose has practical advantages in that the significant volume can be taken as that of the organ or tissue under consideration. In fact, this principle has necessarily been used already in calculating maximum permissible burdens of radionuclides in tissues. However, with extreme inhomogeneity of dose (for example, with particulate radioactive material of high specific activity) such a procedure may be inappropriate. This is a matter upon which further work is needed."

"With regard to the previously cited method of risk estimation described in the first sentence of 4.G.5, that section continues with the following supportive references:

> 'This approach has been used by the Environmental Protection Agency in recent reports on the potential health consequences of the nuclear fuel cycle.[2-5] The approach leads to estimates comparable to those of Gavankar[6] following Thompson et al [7] based on linear non-threshold extrapolation of observations on beagle dogs administered $^{239}PuO_2$ aerosols.'

"As to the first, consensus in error may provide amiable agreement amongst federal agencies, but seems hardly a desirable basis for decisions involving the public health and safety. The observations on beagle dogs are discussed further on 4.G-117 and deserve separate consideration."

Response:

The NCRP report quoted does not identify the algebraic sign of the error resulting from an irrelevant volume assumption but rather says
25 that averaging "may have little to do with the case."[25] If cooperative phenomena among cells or the saturation of defense mechanisms are important, averaging over too small a volume may be just as misleading and irrelevant as the converse. Most importantly, the NCRP concludes "special cases must give way to detailed study." The astronomical doses favored by the author tell us little or nothing about actual tumor probability because he assumes arbitrary results unsupported
26 by even hypothetical mechanisms.[26]

The statement that the recommendations of the ICRP and the NCRP "...
27 are explicit in offering no guidance..." is an opinion of the author.[27] The past record of these groups is one of conservatism toward problems
28 for which the evidence is not clear.[28] Their published documents indicate

that they have been aware of this potential problem and its magnitude. The fact that they have chosen not to revise methods of arriving at
29 limits is clear and implicit guidance as to their beliefs.[29] We note in the quoted passage from the NCRP the fact that it is an example to be used in interpreting another point, and the conditional nature
30 of the first clause makes it clear that only an example is intended.[30]

A comment is made on a reference to similar calculations made by an independent source with similar results. Since no evidence has been
31 presented that these calculations were in error,[31] the point does not seem to be meaningful.

Comment (pp. 15-16):

"It requires pathological optimism to find reassurance in the results of the now completed Hanford beagle experiment. Dogs were given initial aerosol burdens of approximately 1-10 microcuries of $Pu^{239}O_2$. By nine years post-exposure the lung cancer response was virtually saturated and multicentric origins were noted in some dogs. Those receiving larger lung burdens greater than 10 microcuries died of pulmonary insufficiency within 4-1/2 years. Twenty-one dogs survived for more than 4-1/2 years, and only one of these did not exhibit lung cancer at death. A relationship observed between initial lung burden and time to death with cancer has been often used to infer a threshold burden below which no life shortening of dogs would be expected. This is shown in Figure 4.G.10 on 4-G 118. Note that the fibrotic deaths there have no bearing on cancer incidence and inclusion of those points in the constructing extrapolated curves is a senseless exercise. Note also that the results are exhibited on a log-log graph which virtually obscures all differential detail. Most important, recognize the nature of the experiment, i.e., the lung burdens were large, the results were saturated, and the number of animals was small. The crude relationship observed between initial lung burden and time to death with lung cancer does not necessarily imply that a threshold burden exists for beagles. Quite to the contrary, the range of exposures above the inferred threshold burden may be interpreted as a region of saturated carcinogenic response, that is a burden regime in which lung cancer induction in a beagle population approaches 100% during a normal life span. The point is that the observed time to death is more likely related to the burden, through a population depletion effect, rather than through a burden dependent latent period. In the former interpretation appreciable cancer would be anticipated

at lower burdens. This is again consistent with extensive observations of radioisotope-induced bone tumors in mice, which support the interpretation that 'latent period is constant and that the apparent relationship between increasing dose and decreasing time to death with tumor is due to the effects of dose-level on survival and on tumor expectancy.' (See "Toxicity of Ra-226 in Mice," M. Finkel et al., in Radiation-Induced Cancer, IAEA, Vienna, 1969.)"

Response:

The figure in question is a straightforward presentation of the results of measurement of the survival time of beagles as a function of pulmonary burden. While some may not find these data helpful for their particular use, they are nonetheless objective results of the experiment and have considerable bearing on the total picture of lung damage and on the interpretation of the experiments. The criticism that the "log-log graph...obscures all differential detail" is contradicted by the data points on the graph itself. (The Final Statement includes Figure II.G.5-1 in which the tumor data points were fitted separately from the pulmonary insufficiency data points.) The graph reveals that the scatter of the data (as is common in biological experiments) is the limiting factor and that this scatter is generously displayed on the chosen scales. Likewise, the author's criticisms of the text fail to correspond with the statements actually made on page G-117 of the Draft Statement in the discussion and interpretation of this figure. "Threshold burden" is discussed by the author, but this concept is not mentioned in the Draft Statement and is introduced by
32 persons whose opinions are not those of the AEC.[32]

We are not aware that anyone has found "reassurance" in the results
33 of the Hanford beagle experiment.[33] The limitations of the portions of the experiment which are complete, such as saturation of response, have been reviewed many times in the literature and are alluded to here. This, of course, is the reason for the continued experiments at lower doses. The author's comments on the relationship between latent period and dose are well taken and add one interpretation to the data presented in the report.

Comment (pp. 16-17):

"The domain of this comment is broadened here in order to summarize a specific concern with plutonium, and to a lesser extent, other transuranics. Under a number of circumstances plutonium forms

aerosols. The physical character of these aerosols is such that on inhalation by humans they are preferentially deposited in respiratory tissue. Because of slow clearance and because of their insoluble character, particles may experience long residence times in tissue. An appreciable mass fraction of the aerosol is usually associated with particles sufficiently large that small but physiologically significant volumes of tissue will be exposed to intense (i.e., organism lethal or greater) radiation doses within a meaningful physiological time. Studies of the effects of intense local radiation to skin and kidney tissue indicate that despite the near mitotic sterilization of the involved tissue, an enhanced carcinogenic response may occur, in the sense that energy dissipated in a limited volume may be far more carcinogenic than if the same type of radiation were to dissipate its energy over a much larger tissue mass. The question is then: do particulates of plutonium lead to exposes that have enhanced carcinogenic potential? If they do, then present standards can be in error by orders of magnitude.

"Notice that the emphasis here is on the anomalous hazard associated with a single particle; and that if any threshold is relevant, it is not a dose threshold since local exposures are large, but rather a possible volumetric threshold that must be exceeded by the physical extent of the exposure. Plutonium, as an insoluble aerosol-forming, long-lived alpha-emitter, constitutes a very special case of the low exposure problem.

"In conclusion, it is indefensible to base estimates of cancer risk on the method of dose averaging over fictitiously large volumes. Similarly, estimates based on nonconservative interpretations of the Hanford beagle results are highly suspect."

Response:

We know of no information which leads to the conclusion that "...energy dissipated in a limited volume may be far more carcinogenic than if the same type of radiation were to dissipate its energy over a much larger
34 tissue mass."[34] In fact, the evidence cited in the Draft Statement leads to the conclusion that partial irradiation of an organ seems to have a lesser effect. This, of course, is the heart of the
35 question. In the experiments used by the author,[35] "localized" irradiation refers to the exposure of large volumes in comparison to those of concern in the particle problem. For example, Albert's work with

electrons and beta particles involved 5 to 24 cm^2 of skin. The kidney irradiations of Maldague involved an entire kidney, and even the skin transplant work of Barendsen involved some 6 cm^2 of skin with the results further compounded by the fact that at time of irradiation the full skin volume (including subcutaneous tissue) was involved with tumor formation there, in unirradiated but foreign surroundings. Experimental evidence on the effect of changing the "localized" volume or mass of tissue to permit extrapolation of the effects in these gram volumes to lower volumes (or larger volumes) is meager although, as we have noted earlier, the studies of Albert have indicated a possible decreasing effectiveness with decreasing volumes involved for one situation. Theories on the mechanisms of carcinogenesis are not well enough developed to give any guidance on this question of extrapolation, even for presumably defined causative factors such as
36 "tissue damage and disruption."[36] Therefore, we find no basis for making the extrapolation from gram quantities involved in "local" irradiations to the microgram or tens of micrograms of tissue in the case of particles. Without such a basis for extrapolation, it is impossible to predict from these irradiations of comparatively gross volumes the possible effects of irradiation of the smaller volumes.

We do have some evidence, however, on the effects at volumes approaching those of interest in the particle question. This is based on the results quoted in the Draft Statement from the work of Grossman and Little, Sanders, and Richmond using alpha emitters and that of Cember using beta emitters. In each case, the conclusion has been that the focal distribution of energy was no worse than the
37 measured or presumed homogeneous distribution.[37] Finally, there are no data from animal experiments or from human occupational exposure cases that indicate an "enhanced carcinogenic potential" for plutonium
38 particles.[38] Alpha radiation is more effective than beta-gamma radiation emitted from inhaled particles, but the difference is consistent with data obtained on the relative biological effectiveness of these radiations.

Comment (p. 18):

"A plutonium industry has existed for more than 2 decades. By this time there must be a significant history of human exposure. Considering the recognized toxicity of plutonium, and its obvious potential for much expanded commercial use, the exposed population must have been

closely followed. A plutonium registry exists. An acceptable way to make estimates of cancer incidence is to argue compellingly and conservatively from human experience. The open literature contains little information on the history of humans after exposure to plutonium. It is an insufficient base for useful argument. It is hard to conceive that information of this importance would not be available. If it is not, then one is left with an obligation to public health traditions, and with more conservative and defensible methods of evaluating the cancer risks of alpha-emitting particulates. (See for example, "Petition to Amend Radiation Protection Standards as They Apply to Hot Particles," in the Matter of RADIATION PROTECTION STANDARDS - AS THEY APPLY TO HOT PARTICLES brought before the Environmental Protection Agency and the Atomic Energy Commission by the Natural Resources Defense Council, Inc., on February 14, 1974.)"

Response:

We concur with the comments on the importance of human information and have initiated studies in this area, including the establishment of the U.S. Transuranium Registry. Unfortunately, such information does not come easily or rapidly when dealing with humans, as they are not controllable in the sense that an animal population in the laboratory is controllable.

They are subjected to various pressures which can be contrary to the goals of a scientific program. For example, there are some who, under the influence of articles grossly exaggerating the potential hazards of plutonium, refuse to cooperate either out of reluctance to face the prospects outlined for them in such articles[39] or because of legal implications.[40] Investigators have published on these studies in the past as, for example, in the Los Alamos group, the exposure at Rocky Flats, and the Lushbaugh article on the skin lesion, and this will continue as results become available.

The human data about which Geesaman claims to be unaware were, in fact, discussed in the Draft Environmental Impact Statement (pages 4.G.106 and 4.G.107) and have been published [Hempelmann et al., Health Phys. 25. 461-479 (1973)].[41] The data are limited both because strict safety standards have limited, in both number and severity, the exposures which have occurred and because the long delay times expected before the appearance of damage might occur has required decades of delay in the interpretation. However, sufficient time has

now elapsed since the war-time exposures to draw the conclusions that the tumor incidence observed is in complete contradiction to
42 the predictions of the Geesaman hypothesis[42] (see page 26, reference 102).

Ultimately, judgment between the conflicting opinions must be based on the entire body of evidence, interpreted on the basis of sound scientific judgment. Considering the primitive state of our knowledge of the processes leading to initiation and development of cancer from radiation or from any biological stressing agent, one
43 should not expect fundamental theories to be of much help.[43] Heuristic principles, based on the sum of past experience, are likely to be better indicators of how to make the extrapolations which are still
44 unavoidable.[44] The most profitable procedure at this time would appear to be heavy reliance upon human experience and animal experiments, especially those which can be designed to decide between alternatives and thus set limits on the range of possibilities to be explored. Erroneous predictions by a model is the classic scientific criterion for rejection of this model. Current decisions are not being made
45 blindly.[45] The ever growing body of information on the effects of radiation on living systems is reducing the uncertainty of our
46 conclusions, which are continually under review.[46]

3-1

Regarding Comment #3. Diversion and Safeguards of Fissionable Materials.

The following commentary is referenced to the attached.

1) The construction placed upon the Comment, "as a request to estimate the probability of occurrence," is mistaken. In fact, the Comment suggested that the cost-benefit analysis should properly include a sensitivity study for the perturbative economic effects of a disruptive plutonium diversion upon the conclusions of the analysis. No presumption need be made concerning the probability of occurrence. It is sufficient that the possibility can be realistically supposed. Ample basis certainly exists for that supposition. Even a barren imagination can conceive of various disruptive events consequent to a plutonium diversion. For example, conjecture a .1-10 kt device exploded in various urban areas. The approximate damage of such an explosion can be calculated, the economic loss can then be inferred.

More generally, disallowing consideration of possible hypothetical events because of unquantifiable probability, is certainly not a traditional constraint on policy analysis. A large literature exists on the effects of thermonuclear war, though no thermonuclear war has ever occurred. This literature constitutes a significant part of the basis for related policy decisions. The importance of that literature is not muted by the fact that the probability of thermonuclear war is unquantifiable.

No adequate reason has been presented as to why such a sensitivity study has not been included in the cost-benefit analysis.

2) Again here, the Commission's interpretation that the Comment "would require a method for determining the rate of occurrence of nuclear calamities" is erroneous. The suggestion was that the Commission specify a maximum

acceptable rate for diversion related calamities, and that the Commission provide an explicit specification of the technological and political means considered necessary to assure that this maximum acceptable rate of diversion was not exceeded. These policy judgments should be initially disjoint from a determination of the rate of occurrence of nuclear calamities. To argue otherwise, would be to imply that the observed rate of occurrence of nuclear calamity would determine the acceptable rate. In a policy issue of this transcendental nature, such a negative and responsive posture would be grotesquely irresponsible.

For this issue it is imperative that the responsible agency state its specific policy position on what are "acceptably low levels" of nuclear calamities, and that it state what technological and institutional means it considers adequate to guarantee these acceptably low levels. The Commission must not take refuge in amorphous generalities.

The Commission states that "the assessment of risk is necessarily a matter of judgment." But the assessment of risk is not the issue here. The issue is the risk that the Commission considers acceptable, or equivalently "the rate of occurrence of nuclear calamity" that it considers as an "acceptably low level." The Commission is the responsible agency; its judgment on acceptable risks necessarily reflects its judgment of acceptable social and physical effects associated with these specific risks; this judgment is therefore required in the Environmental Statement, along with a comprehensive description of those social and physical effects. Omission would constitute a manifest defect of the Statement.

3) The Commission has been generally unresponsive to this Comment. See also (5) from Regarding Comment 1. Accidents. before.

3. Diversion and Safeguards of Fissionable Materials

Comment (p. 19):

"Immense economic loss and disruption are a probable impact from any diversion of fissionable materials. The discontinuity of the event will not make the economic impact any less real. Moreover, the magnitude of such potential losses will scale similarly to the discounted savings derived from the continuing economics of the cost-benefit calculations."

Response:

This comment can be interpreted as a request to estimate the probability of occurrence and financial loss associated with a variety of destructive acts which could follow the diversion of fissionable material, and to factor these data into the treatment of cost-benefit in the Final Statement. The AEC has not acceded to this request because there is no sound basis which would permit the development of such data. In this connection, your attention is invited to the AEC response to comments received from Dr. L. Douglas De Nike, Zero Population Growth, a copy of which is incorporated into the Final Statement.

The Final Statement does, however, present information on the physical consequences of illegal nuclear explosions in Section 7.4.5.1.1, and on the socio-political implications in Section 5.4.2.

Comment (pp. 20-21):

"As to diversion and safeguards of fissionable material, an analogy suggests itself with the treatment of radionuclide release in the nuclear fuel cycle. There, one has material flow, material losses, primary standards, secondary standards, and exhaustive examination of consequences. The material flows and losses of fissionable materials could be similarly considered. The equivalent of the primary standards for radiation exposure would be some maximum acceptable rate for diversion related nuclear calamities. The equivalent of the secondary emission standards would be an explicit specification of the technological and institutional means believed necessary to assure compliance with the primary standards. Finally, the direct and real consequences of diversion related nuclear disasters could be discussed along with the accessibility of information and support material necessary to create these disasters.

"Such an analysis would provide a basis for appreciating the impacts from actual and potential diversion of fissionable material. The draft

Statement does not provide such a basis, and without it the interests of society must be poorly served."

Response:

The proposed approach would require a method for determining the rate of occurrence of nuclear calamities and, as the Final Statement makes clear,
2 that is not, at present, possible.[2] However, the approach being taken by the AEC is similar in some respects to your proposal, where the risks associated with theft or sabotage must be reduced to acceptably low levels, but where the assessment of the risk is necessarily a matter of judgment. The general approach being taken is described in Section 7.4.8 of the
3 Final Statement.[3]

ATTACHMENT

TESTIMONY CONCERNING THE ACCEPTABILITY OF EXISTING PUBLIC HEALTH GUIDANCE FOR PLUTONIUM

Donald P. Geesaman
School of Public Affairs
University of Minnesota
Minneapolis, Minnesota 55455

January 10, 1975

(Statement presented at the public hearing on plutonium standards held by the United States Environmental Protection Agency in Denver, Colorado on January 10, 1975. The material of that oral presentation is annotated and expanded here.)

Referencing is deliberately minimized in this testimony. The reader is referred to the attached Appendices, which are the basis for much of the testimony, and which have detailed referencing.

PERSONAL DESCRIPTION

My name is Donald P. Geesaman. I reside at 815 Heinel Drive, St. Paul, Minnesota. I am an Associate Professor in the School of Public Affairs of the University of Minnesota (Minneapolis). My principal research interest is the relationship between policy and technology with particular emphasis on nuclear technologies.

I am a citizen of the United States of America. I was [redacted] I am a theoretical physicist by training. I was employed for 13 years at the Lawrence Radiation Laboratory (Livermore) of the University of California, where from 1960 to 1966 I was a member of the Theoretical Physics Division, and from 1967 to 1973 I was a member of the Biomedical Division. (The Lawrence Radiation Laboratory is a nuclear research laboratory operated under contract for The Atomic Energy Commission by the University of California.) While in the Biomedical Division at Lawrence Radiation Laboratory my work was primarily concerned with analysis of the hazards associated with nuclear technologies. In September of 1973 I joined the faculty of the School of Public Affairs at the University of Minnesota (Minneapolis).

SUMMARY

Plutonium is an effective radiological carcinogen in laboratory animals. Alpha-emitters, such as plutonium, are proven generic carcinogens in man.

The mechanisms underlying the origins of cancer are poorly known. Radiation-induced carcinogenesis is no exception.

Present standards for plutonium are based on the assumption of a uniform exposure by the material. For exposures by plutonium particulates, such an assumption is manifestly erroneous; and as a basis for making public health evaluations associated with particulate exposures, the assumption may be far from conservative. Human experience with plutonium exposures is insufficiently documented to provide meaningful support for existing standards.

Radiation exposures of tissue by plutonium particulates are notably inhomogeneous, diverse and complex. The concern is that amongst that considerable diversity, unrecognized resonant situations may exist with anomalously large carcinogenic responses which dominate the overall hazards associated with exposure. An animal experiment, such as Albert's, demonstrates the existence and hence possibility of such a resonance; others may exist. Scientifically respectable hypotheses can be developed around their existence; the disruptive particle hypothesis was so conceived.

If plutonium becomes a common element in commerce, the standards specifying its control acquire profound public health significance. Beneath the determination of those standards is the judgment of how scientific uncertainties relate to public health decisions. Considering the gravity of the decision and the imperfect knowledge on which this decision must be grounded, I would suggest that a proper basis for establishing plutonium standards is the most conservative hypothesis consistent with scientific experience. For this basis the hot particle hypothesis or the Martell hypothesis commend themselves for careful consideration.

STATEMENT

I consider it a privilege to testify here today. I have no fondness for giving testimony but I have paid my way here to appear because of what I consider a historical obligation to see through an issue which I helped to raise several years ago, and which I consider to be pertinent to your deliberations. I will be historical in my presentation. In that way the material and perspectives presented will be more meaningful to me. Most of what I have to say derives from concepts formed in the past at a time that I had formed no strong bias against nuclear power.

* * *

Shortly after joining the Biomedical Division of Lawrence Radiation Laboratory (Livermore), I was asked to assess the potential public health hazards associated with plutonium aerosols. Consequently, in February 1968 I published "An Analysis of the Carcinogenic Risk from an Insoluble Alpha-Emitting Aerosol Deposited in Deep Respiratory Tissue" (included as Appendix I). I quote some conclusions from the analysis in that report:

> "While no realistic evaluation of the total carcinogenic risk is accomplished, the results are such as to clarify the nature of the problem. In particular, if the loss of mitotic competence by a local cell population is sufficient to guarantee no origin of cancer within that population, then the carcinogenic risk from particulate sources does not scale to the total energy dissipated. To say what dose characteristics are significant to the risk would require an accurate knowledge of clearance, local shielding responses, and the mechanisms of cancer induction. In the absence of this detailed knowledge the suggested course is an experimental determination of the number of source particles per induced cancer."

and

"The particle problem is unique in that: (1) there is enormous variation in the dose level and dose characteristics to which different cell populations may be exposed, and (2) volumes involved are small so that disruptive doses are not necessarily organ fatal. Implicit in the problem is considerable diversity, and I would be concerned that somewhere in this diversity are unanticipated resonant situations where the risk is large compared with predictions made from linear dose effect relations.

"The risk does not scale with the total energy from a source, and with present knowledge it is precarious to try to describe in a detailed way the relationship between radiation level and carcinogenic tissue response. It would seem that the most reasonable and hopeful approach is to attempt an experimental determination of the number of cancers per source particle as a function of source strength at relatively low tissue burdens. With this, a meaningful estimate of risk would be readily accessible."

* * *

Subsequent to that report I reviewed experiments involving skin and lung carcinogenesis in mammals after intense localized doses of ionizing radiation. As a result of this analysis I published an addendum to the original report (included as Appendix II). There I reached the following conclusions:

"Summing up, intense radiation exposure of mammalian skin and lung tissue commonly results in cancers. Tissue injury and disturbance are a primary consequence of intense radiation insult, and are observed in association with carcinogenesis. Albert has exhibited a simple proportionality between skin carcinomas and atrophied hair follicles. No general description of precarcinogenic injury exists, but in a crude sense the available observations are compatible with the idea of an injury-mediated carcinogenesis. Cancer is a frequent instability of tissue. Since tissue is more than an aggregate of cells, and has a structural and functional unity of its own, it would not be surprising if some disrupted local integrity, a disturbed ordering, comprises a primary pathway of carcinogenesis. The induction of sarcomas with inert discs of Mylar, cellophane,

> Teflon and Millipore (Brues et al.) is indicative that such a mechanism exists. Presumably mitotic sterilization is an important factor in any carcinogenesis mediated by radiation-induced tissue injury. The functional relation of this factor to the carcinogenic response may be quite different from a linearity in the surviving mitotic fraction.
>
> "While regrettably unquantitative, the hypothesis of an injury-mediated carcinogenesis is suggestively descriptive. If the respiratory zone of the lung contains a structure analogous to the rat hair follicle, and if a radioactive particulate deposited in the respiratory zone has the capacity to disrupt one or more of these structures and create a precancerous lesion, then cancer risks of the order of 10^{-3} to 10^{-4} per particle can be expected for burdens much less than 10^{8} particles."

and

> "For occupational exposure the maximum permissible lung burden (MPLB) of Pu^{238} or Pu^{239} is 0.016μ Ci. Assuming a particle diameter of 0.3μ, this burden is equivalent to 3×10^{6} particles of $Pu^{239}O_2$ or 10^{4} particles of $Pu^{238}O_2$. If there is a possibility of tumorigenic risks of the order of 1/2000 per particle, this raises serious doubts as to the applicability of current MPLB to risk judgments involving particulates."

* * *

During the following year the analysis was extended, and discussion of the conclusions and their potential implications was given considerable internal distribution within Lawrence Radiation Laboratory (Livermore) and the Atomic Energy Commission. In November 1969, Arthur Tamplin and myself sent a letter (included as Appendix III) to John Totter, then Director of the Division of Biology and Medicine (AEC), with a copy to Glenn Seaborg, then Chairman of the Atomic Energy Commission. I quote from that letter:

> "This problem concerns the biological hazard attendant upon the inhalation of plutonium oxide particles. Our analysis of this problem suggests that these particles may represent a unique carcinogenic risk--that, when the lung exposure

occurs as a result of PuO_2 particles, the existing maximum permissible lung burden may be too high by orders of magnitude. If our suspicions are correct, the AEC could be confronted with a situation similar to the uranium miners in the plutonium industry. The enclosed report, UCRL-50387, ADDENDUM, is the basis for the above statements.

Our interest in this problem resulted from being requested to be members of the DBM Committee of Space Nuclear Systems Radiological Safety Matters. As you can see from the enclosed letters to Dr. Bruner, we disagreed with the Committee's conclusions beginning in August 1967. The more we studied the problem the more concerned we became as evidenced by the letter to Dr. Bruner of October 2, 1968. In this letter and the memo to Dr. Gofman we expressed our concern with respect to exposure of workmen in the very vital plutonium industry. We again expressed this concern at a briefing of the AEC Staff inn Germantown on October 25, 1968 (copy enclosed).

We are calling this problem to your attention at this time because it appears that it will soon become a subject of public debate. As a result of the fire at Rocky Flats, Dr. E.A. Martell has been conducting an environmental survey to determine the levels of Pu-239 in the Colorado area. As we understand it, he will probably be releasing his results in December. His results will show evidence of contamination from the Rocky Flats plant. Our impression is that he will at that time raise the question of permissible exposure.

It is important to note that there is no official guidance concerning exposure to these hot-particles. ICRP publication #9, page 4, paragraph 20 states, 'In the meantime there is no clear evidence to show whether, with a given mean absorbed dose, the biological risk associated with a non-homogeneous distribution is greater or less than the risk resulting from a more diffuse distribution of that dose in the lung.

Now, quite obviously, we do not feel that the Division of Biology and Medicine can adequately support the position taken by the Committee on Space Radiological Safety. Hopefully, the scientific community-at-large will be more receptive to their arguments but we doubt it."

* * *

In April of 1970 I was invited to the University of Colorado to debate with Chester Richmond (Los Alamos Scientific Laboratory) on the potential significance of the offsite contamination discovered around the Dow Chemical Rocky Flats Facility. I concluded my talk, "Plutonium and Public Health," (included in slightly modified form as Appendix IV) with this statement of perspective:

> "Finally I would like to describe the problem in a larger context. By the year 2000, plutonium-239 has been conjectured to be a major energy source. Commercial production is projected at 30 tons per year by 1980, in excess of 100 tons per year by 2000. Plutonium contamination is not an academic question. Unless fusion reactor feasibility is demonstrated in the near future, the commitment will be made to liquid metal fast breeder reactors fueld by plutonium. Since fusion reactors are presently speculative, the decision for liquid metal fast breeders should be anticipated and plutonium should be considered as a major pollutant of remarkable toxicity and persistence. Considering the enormous economic inertia involved in the commitment it is imperative that public health aspects be carefully and honestly defined prior to active promotion of the industry. To live sanely with plutonium one must appreciate the potential magnitude of the risk, and to be able to monitor against all significant hazards.
>
> "An indeterminate* amount of plutonium has gone offsite at a major facility 10 miles upwind from a metropolitan area. The loss was unnoticed. The origin* is somewhat speculative as is the ultimate deposition.
>
> "The health and safety of public and workers are protected by a set of standards for plutonium acknowledged to be meaningless.
>
> "Such things make a travesty of public health, and raise serious questions about a hurried acceptance of nuclear energy."

* * *

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*The offsite contamination was, of course, ultimately fixed at several curies; the source of the contamination was concluded to be leaking barrels of plutonium-contaminated cutting oil which were located in outside storage.

In a July 8, 1971 letter (included as Appendix V) to Stanley Greenfield, then Assistant Director of the Environmental Protection Agency, I commented on the treatment of plutonium hazards in the Atomic Energy Commission's Draft Environmental Impact Statement on the Proposed Rocky Flats Plant Plutonium Recovery Facility:

> "More specifically, the exposition in paragraph 4 of Section 2.0 is an inadequate and unrepresentative description of the uncertanties in human risk attendant to exposure by plutonium aerosols. Human lung tissue has a well known carcinogenic potential under a number of situations, including radiation exposure; the Hanford beagle study demonstrates induction of lung cancer by plutonium aerosols. These are sufficient basis to establish plutonium induced lung cancer as a legitimate concern for humans. Judged in this context the negative results of the cited mouse study have little public health relevance. In addition, it requires pathological optimism to find reassurance in the results of the Hanford beagle experiment. Dogs were given aerosol burdens of ∿1-10 microcuries of $Pu^{239}O_2$. At nine years post exposure the lung cancer response was virtually saturated and multicentric origin were noted in some dogs. A correlation observed between initial burden and time to cancer death was used to infer the limit burden for no life shortening that was mentioned in the draft statement. The exclusive interpretation of this crude correlation to mean a practical threshhold of burden is no more than a promotional indulgence. The observations do not necessarily imply that a practical threshhold exists below which no plutonium induced cancer will occur. Moreover, the range of exposures above the inferred limit burden may in fact, be interpreted as a region of saturated response, that is a burden regime in which cancer induction in a population approaches 100% during a normal life span. The point here is that the time to death may be related to the burden through population depletion, rather than through the latent period. In the former case, appreciable cancer incidence would be anticipated at lower burdens. To summarize a specific concern with the plutonium problem: 1) under a number of probably circumstances plutonium forms aerosols; 2) the physical character of these aerosols is such that on inhalation by humans they are preferentially deposited in the deep respiratory tissue; 3) because of slow clearance and because of the insolubility of the aerosol, particles deposited in this tissue may experience long residence times (hundreds of days);

4) an appreciable mass fraction of the aerosol is associated with particles sufficiently large that significant (≥ 1 alveolus) volumes of lung tissue will be exposed to intense radiation exposure (≥ 1000 rem) within a meaningful physiological time; 5) studies of the effects of intense local radiation (Albert, Hulse (skin), Maldague (kidney), deposition hotspots in bone seeking alpha emitters) suggest that despite the near mitotic sterilization of the involved tissue an enhanced carcinogenic potential may exist, in the sense that energy dissipated in a limited volume may be far more carcinogenic than if the same radiation were to dissipate its energy over a larger volume. The question is then do the larger particulates in a plutonium aerosol lead to associated alveolar exposures that have enhanced carcinogenic potential. If they do, then present standards can be in error by 2-3 orders of magnitude. Notice that the emphasis here is on the anomalous risk that may be associated with a single particle; and that if any threshold is relevant, it is not the dose threshold since local exposures are large, but rather a structural or volumetric threshold that must be exceeded by the physical extent of the exposure; and finally that this is a very special case of the low exposure problem, a case that is peculiar to plutonium as an insoluble aerosol-forming, long lived alpha-emitter.

"In relation to the preceding, the Hanford beagle study (~1-10 microcuries initial lung burden) showed cancers appearing in conjunction with radiation induced lesions. In addition, a dog having substantially less burden was prematurely sacrificed and no lesions or cancers were found. It would, however, be precarious to infer that absence of lesions implies no carcinogenic potential, or equivalently that radiation induced lesions are a necessary condition for high dose carcinogenesis. This point is illustrated by Albert's rat skin experiment, where carcinogenesis was optimal in a pre-ulcerative regime of less drastic radiation injury.

"It would be useful to have a formal documentation of past plutonium experience for humans, in order to judge the extent to which that experience can be used to quantify the hazards of plutonium. In the past 2 years the AEC has established a plutonium registry at Hanford. If any currently useful documentation is available from the registry, I am unaware of it.

"Dr. Langham at LASL has for some 25 years followed 12 humans with burdens in excess of a MPL. It is my impression, perhaps erroneous, that these burdens largely derive from exposures experienced in a waste recovery area where the plutonium aerosol was in fact

a dilute solution. If this is the case the relevance of this documentation to particulate exposure would be speculative.

"Independent of the biological questions, there are substantial and significant uncertainties associated with the resuspension of plutonium surface contamination. The subject receives essentially no comment in the draft statement. In the case of accidental release of plutonium with consequent contamination of an uncontrolled area, resuspension phenomena along with carcinogenic injury will determine the hazard to inhabitants of the area. Uncertainties in these two factors will be important in the public determination of an acceptable level of surface contamination, especially in the absence of official guidance for this latter quantity. The acceptable level of contamination will in turn determine the costs of cleanup of property and long term displacement of people."

* * *

Most recently I presented my views in a formal comment on the discussion of health effects of plutonium in "Particle Lung Dose Effects" of WASH-1535, Draft Environmental Impact Statement, Liquid Metal Fast Breeder Reactor Program, March 1974. What follows here closely approximates that comment.

The estimate of lung cancer incidence associated with the inhalation of plutonium (or other insoluble alpha-emitting transuranics) in particulate form is a critical factor, along with source terms and resuspension, in defining the probable impact of a plutonium based fuel-cycle. In the past, most administrative estimates of lung cancer incidence associated with the inhalation of plutonium particulates have been based upon a calculation of the average radiation dose delivered to the lung, and application of tumor incidence estimates for a uniformly irradiated lung. (See for instance, "Particle Lung Dose Effects" in WASH-1535, Draft Environmental Impact Statement, Liquid Metal Fast Breeder Reactor Program, March 1974.) In my

judgment this procedure is not a scientifically defensible basis for public health evaluations of plutonium hazards.

It is generally acknowledged the 'insoluble' particles of radioisotopes, when deposited in tissue, provide focal regions of high radiation dose rates. There is no presumption that the exposure by particulates of plutonium is uniform.

The structure and function of lung tissue is such that this tissue is peculiarly accessible and vulnerable to such particulate exposures. The deep respiratory tissue of the lung is made up of $\sim 10^8$ alveoli. Each aveolus is a complexly organized unit of tissue. If an insoluble alpha-emitting particulate is deposited in this tissue some 100 or less alveoli will be exposed during its residence. A crude measure of the nonuniformity or inhomogeneity of this exposure is that at most about one-millionth of the lung's alveoli are affected by a single static particulate.

The significance of the preceding is that in the actual lung exposure by an alpha-emitting particulate, the energy of the ionizing radiation is deposited in a very limited volume of tissue, and hence that the scale of the actual radiation dose to lung tissue is roughly a million times larger than the dose associated with an averaging of the equivalent radiation energy over the entire lung.

A multiplicative difference of a million in a significant physical quantity generally suggests a qualitative difference consequent to that quantitative difference. Suppose, for example, that the problem were to estimate the effects of rifle bullets on human organisms. Suppose that the bullets weighed 1/2 ounce and had a velocity of 1000 ft/sec. Note that the effect of the projectile depends on the energy, and note that a 6 ton vehicle

moving at 1 mile per hour has similar energy. There is experience with humans stopping slow moving vehicles by exerting strenuous counterforces. Using this experience the effect of rifle bullets on humans is inferred to be oxidation of the biological fuel necessary to do the work of stopping the vehicle. But this reasoning is manifest nonsense. Even though the energies involved are similar, human tissue distinguishes between a fast-moving rifle bullet and a truck weighing a million times more and moving at a one-thousandth the velocity. The former dissipates its energy in the gross disruption of local tissue, the latter leads to the ordered and non-injurious oxidation of biological fuel. The end results become very different as the physical characteristics of the situation change, and a new biological phenomenon intercedes. Obviously the way to estimate the effects of rifle bullets is either from past experience that is explicitly applicable, or alternatively, to calculate the effects considering the physical characteristics of the rifle bullet and knowledge of the biological and physical characteristics of the human organism.

This nonsense example has much the same logical structure as the usual administrative method of estimating the effects of hot particle or other highly inhomogeneous exposures. There, by introducing a fictitiously large mass of exposed tissue, the calculated dose becomes commensurately small. In passing from a real situation, in which a static radioactively hot particle irradiates 10 to 100 alveoli, to the fictional situation in which the ionizing radiation from the hot particle is averaged over 10^8 alveoli, the dose scale has fictitiously decreased by roughly a factor of a million.

One could argue here that energy averaging over statistically exposed volumes is also a physically meaningless radiological procedure because the

energy of the ionizing radiation is deposited in a narrow columnar region surrounding the path of the ionizing particle. The point is, however, that in certain exposure regimes biological effects do correlate with average ionizing energy to the exposed volume, and the merit of the procedure is thus established. It is sufficient in these cases to bear in mind that one is observing the statistical aggregation of discrete events.

Living tissue shows extensive intra-cellular and inter-cellular organization. Several regimes of biological response would be expected as physical (spatial, temporal, energetic) characteristics of tissue exposure are varied. Carcinogenic response to whole organ exposure by non-acute doses of radiation will fall in one of these regimes, and this will be a regime in which there is human experience. From the physical characteristics of plutonium aerosols, from the lung deposition experience with aerosols, and from the lung clearance experience with plutonium particulates, it can be inferred that at least one class of particles exist which subject lung tissue to an exposure associated with a different carcinogenic response regime. This is because another biological phenomenon has intervened.

For hot particle exposure that phenomenon is mitotic death of cells, i.e., loss of the cell's ability to divide. There is an extensive literature on the subject. Radiologically induced mitotic death is, in fact, the basis for treating malignant tissue with ionizing radiation, and is the cause of most acute symptoms consequent to radiation exposure. Even though the intercession of extensive mitotic death of cells must inevitably place certain particulate exposures in a different response regime from whole lung, non-acute exposures, a compelling argument might be made that the carcinogenic response in the former case is necessarily less than the carcinogenic response in the latter. This argument would appear to have merit since mitotic death

of cells, as well as reducing the general viability of the tissue, would also reduce the number of irradiated cells with carcinogenic potential. Usually implicit in this argument is a conceptualization of radiation carcinogenesis as originating with a single-cell, direct-injury process.

To confirm this argument, there is a respectable literature in which carcinogenesis is described as occurring after doses of radiation that are sufficiently local as to not be organism lethal, and that are sufficiently high for the fraction of mitotically competent cells to be greatly reduced, i.e., to 1% or less. Unfortunately, in at least some of these experiments, the most elegant of which is Albert's experiment on rat's skin, carcinogenesis is contrarily related to the fraction of mitotically competent cells, i.e., cancer induction in the regime where mitotic competence is greater than 1% is small compared with the cancer induction in the regime where mitotic competence is much less than 1%.

There are several points to be made here. Loss of mitotic competence and carcinogenesis are two indices of radiation effect in tissue. They cannot be independent since cancer cells are mitotically competent, hence the relationship between these indices can tell us something about modes of radiation carcinogenesis.

Mitotic competence, i.e., the fraction of mitotically competent cells, is not generally related in a linear way to carcinogenic response. Moreover, it is a major anomaly that an increased carcinogenic response is observed in dose regimes associated with greatly reduced mitotic competence. It is difficult to reconcile this result with any single-cell, direct-effect origin for radiation induced cancer in high dose regimes. (On this point see the results and discussion in "Tumor Induction in Rat Skin by 300-kv X-rays and 15 MeV Neutrons" in IAEA-SM-118/22, G.W. Barendson.)

Mitotic competence of a cell population decreases exponentially with increasing alpha-radiation dose and is a fairly general index of radiation effect in tissue. If radiation carcinogenesis universally decreased with mitotic competence, then estimates of carcinogenesis based on a fictitious averaging of a local inhomogeneous dose over a much larger volume would be necessarily conservative. Since radiation carcinogenesis can, and in fact, does increase to anomalously large values while the mitotic competence becomes vanishingly small, the fictitious averaging of dose over larger volumes is not necessarily conservative. Instead it would appear that situations exist in which an intense local dose of ionizing radiation can be a far more efficient carcinogen than a diffuse tissue exposure with the same type of ionizing radiation and the same total energy. The above then implies that averaging of dose over fictitiously large volumes may be far from conservative, especially if the averaging obscures much diversity and detail of the actual exposure.

It is obvious that as a local exposure becomes more intense, a stage must finally be reached where the carcinogenic efficiency of the exposure (on a per unit energy basis) is reduced. This is not pertinent to previous arguments. It suggests caution, moreover, in generalizing relative carcinogenic efficiencies from the comparative results of high dose inhomogeneous and homogeneous exposures. This caution applies to the discussion of the rat skin experiments of Passonneau et. al. and the hamster respiratory tissue experiments of Little et. al., in "A Radiobiological Assessment of the Spatial Distribution of Radiation Dose from Inhaled Plutonium" (WASH-1320), W. Bair, C. Richmond and B. Wachholz.

What one wishes to know is the characteristics of the most carcinogenically efficient exposures and the amplitude of that carcinogenic

response. In the absence of an understanding of the mechanisms of carcinogenesis, this is the knowledge most useful in defining the conservative limits of theoretical risk associated with the diverse and complex tissue exposures by plutonium particulates. Albert's experiments were unique in providing that kind of refined description. For example, cancer induction was observed to be large only in a dose region where virtually all cells were mitotically sterilized, i.e., where only 1% to .0001% of the cells would be expected to have the ability to divide. Cancer induction was maximum for pre-ulcerative exposures, i.e., exposures where no gross lesions (total tissue disruption) were produced. Cancer induction was nearly proportional to the production rate of atrophied (disordered) hair follicles, and correlated with the dose to the minimally exposed germinal cell population of the hair follicle. Most importantly, with carefully chosen exposures, cancer production rates could be made as anomalously high as $\sim$ 1 cancer per 10^5 ergs which differs by orders of magnitude from cancer induction rates per unit energy associated with indiscriminant exposures. The observation of such a carcinogenic resonance (anomalously large response) for a specific tissue and a specific exposure regime is significant because it demonstrates the existence of such energetically efficient exposure situations. The amplitude of this response can then provide a reasonably conservative estimate of risk for the diverse and complex exposure of another tissue.

The Albert experiment illuminates the difficulties associated with describing radiation carcinogenesis and predicting the response, in the absence of an understanding of the underlying mechanisms. Even though a relatively simple tissue was involved, if the experiment had not been so carefully structured, much of the detail would probably have been lost, and with it the knowledge of this resonance in radiation induced skin cancer in rats. Detailed predictions in the anomalous regime would then have been erroneous.

Returning to the question of plutonium risks, a picocurie of Pu^{239} emits $\sim$ 10 ergs of ionizing radiation per year; a maximum permissible lung burden (occupational) emits $\sim 10^5$ ergs of ionizing radiation per year. Considering the wide variations in tissue irradiation following exposure to a plutonium aerosol, and considering the energy of the associated radiation exposure, when compared with the energy required per cancer in Albert's experiment, one is compelled to a concern that the wide diversity in plutonium particulate exposures will discover similar resonant responses, and that the amplitude of these responses and their extent in the total domain of exposures will be sufficient to dominate the overall carcinogenic risk. This concern is further exacerbated by inclusion of a compensating RBE factor of $\sim$ 10.

A comment should be introduced here on the concept of "waste radiation." Depending upon one's assumptions about the mechanisms of radiation carcinogenesis certain radiation induced biological effects may be considered unnecessary or undesirable for cancer induction and hence the radiation expended in producing those effects is wasted or without carcinogenic potential. Examples are cell sterilization, if one assumes that dead cells can not contribute to carcinogenic potential; or multiple sterilization of the same cell, if one assumes that while a sterile cell may increase carcinogenic potential, duplicate sterilization leads to no further increase. The most frequent example is the radiation wasted in exposures subsequent to induction of an autonomous cancerous lesion by a chronic exposure. This list is obviously not intended to be exhaustive. The point is that the hypothesis underlying the use of the concept should be differentiated to distinguish its meaning in a particular case. By invoking the notion of "wasted radiation," and by hypothesizing and proving certain exposure situations to be without carcinogenic potential, one could, in principle, quantitatively modify the previous concern,

by, for instance, showing that virtually all of the energy was without carcinogenic potential. Given the state of uncertainty surrounding both tissue function and radiation carcinogenesis, it seems doubtful that such an approach can make a significant contribution to hazard evaluation. More sensibly, if one knew the risk one could probably infer something about the appropriate conceptualization of wasted radiation and carcinogenesis.

The following excerpt taken from "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, NAS/NRC, summarizes the state of knowledge concerning the causation of cancer (emphasis added):

> "Although the mechanisms of carcinogenesis, or of radiation carcinogenesis in particular, are not fully known, available information implies that most, if not all, types of cancer develop as a result of the combined effects of multiple factors. These causative factors may include: prezygotic (inherited) mutations of chromosomal aberrations, which can spread during development to many kinds of cells; somatic cell mutations or chromosomal abberations, which can be acquired at any time after conception; changes resulting from the action of viruses; and changes in systemic growth factors (e.g., depressed immune competence, hormonal imbalance) and in local tissue regulation (disorganization, damage), such as may result from diseases other than cancer or from advancing age.
>
> "Although point mutations, chromosomal abberations, and other changes at the cellular and molecular level may require only small doses, tissue disorganization and gross disturbances in physiology are unlikely without larger doses.
>
> "Of the many types of changes which radiation can cause in cells or tissues, none is considered to be unique for radiation. Many, if not all, such changes can presumably result from a variety of other agents."

This summary view on carcinogenesis does not conflict with the ideas leading to the conclusion reached earlier, that fictitious dose averaging to larger tissue masses need not be conservative. The possibility of various modes

of carcinogenesis, including tissue disruption, is acknowledged. In particular, the number of causative factors proposed is a measure of the considerable range of hypotheses available to describe experience.

Disease profiles are highly species specific. Cancer is no exception. Gross characteristics are obviously highly species specific also. A rat and a mouse are distinct and yet morphologically are very similar. The gross tissue differences are articulated out through subtly different informational coherences amongst cell populations, - the collective behaviour being phased ultimately, by a biochemical dialogue between cell neighborhoods whose functional potential is genetically moderated. Not to belabor this point unnecessarily, - cancer profiles are species specific; gross characteristics and, of course, genetic material are also species specific. In high dose carcinogenesis collective detuning of tissue by tissue disruption seems as acceptable an origin for the tissue instabilities of cancer as does an isolated single cell event involving the cell's genetic material. This is not to say that tissue disruption is a necessary condition for carcinogenesis, or even a sufficient one without some specific qualifications.

* * *

Return now to the problem of risk estimates associated with radioactive particulates in human lungs. Most of what has been said earlier in this comment has been general, and has been aimed at showing that there was no inherent conservatism in the tissue averaging method of estimating cancer risks, and that moreover the method could be far from conservative. The conclusion could as well be applied to lymphatic tissue or to bronchial tissue.

Having this background, notice that human lung tissue has a well known carcinogenic potential under a number of situations, including exposure to

ionizing radiations; and that in the Hanford dog study induction of lung cancer was observed after exposure to plutonium aerosols. These are a sufficient basis to establish plutonium induced lung cancer as a legitimate concern for humans.

The following is a review of the official guidance for estimating the carcinogenic effects from exposure to radioactive particulates:

> "(210) The NCRP has arbitrarily used 10% of the volume of the organ as the significant volume for irradiation of the gonads. There are some cases in which choice of a significant volume or area is virtually meaningless. For example, if a single particle of radioactive material fixed in either lung or lymph node may be carcinogenic, the averaging of dose either over the lung, or one cubic centimeter may have little to do with the case. Use of significant volumes or areas must be looked on as one of the round off devices which in special cases must give way to detailed study."
>
> NCRP Report #39
> Basic Radiation Protection Criteria
> January 15, 1971.

> "(20) In the case of non-homogeneous distribution of absorbed dose in the lung, an estimate of the Dose Equivalent to the whole lung, determined merely by the product of Q F and the mean absorbed dose, may be greatly in error, but our full understanding of this problem must await further experimental evidence. In the meantime there is no clear evidence to show whether, with a given mean absorbed dose, the biological risk associated with a non-homogeneous distribution is greater or less than the risk resulting from a more diffuse distribution of that dose in the lung."
>
> ICRP Publication 9
> Recommendations of the
> International Committee
> on Radiological Protection
> (adopted September 17, 1965).

"41. On the basis of general considerations and of some experimental data and clinical experience the Task Group were of the opinion that, for late effects, the same radiation energy absorption might well be less effective when distributed as a series of "hot spots" than when uniformly distributed. Thus, with particulate radioactive sources within a tissue, a mean tissue dose would probably introduce a factor of safety."

ICRP Publication 14
Radiation Sensitivity and
Spatial Distribution of Dose
(Publication 14 appears as a
report of two Task Groups,
and not as the official
recommendations of the ICRP.)

The recommendations of the National Council on Radiation Protection and Measurement set forth in Report #39, and the recommendations of the International Commission on Radiological Protection set forth in ICRP Publication #9, are specific in offering no explicit guidance. Any implicit guidance intended in these recommendations would seem to bear most directly on the validity of existing standards when applied to highly inhomogeneous exposures.

The third citation taken from ICRP Publication #14 is a report of an ICRP Task Group and is not intended to provide dispositive official guidance. The discussion there is useful commentary, but is conditional and inconclusive without some quantitative definition. Certainly alpha-emitting particulates as they pass to sufficiently high activities must become energetically inefficient carcinogens. That, however, is not in itself an interesting issue.

With regard to the previously cited method of risk estimation based on dose averaging, supporting reference is often made to the Hanford beagle experience. The following statement taken from WASH-1585 is typical of such arguments:

"The average dose approach leads to estimates comparable to those of Gavankar following Thompson et al based on linear non-threshold extrapolation of observations on beagle dogs administered $^{239}PuO_2$ aerosols."

The observations on beagle dogs deserves separate consideration.

It requires unnatural optimism to extract reassurance from the results of the now completed Hanford beagle experiment. Dogs were given initial $Pu^{239}0_2$ burdens in the microcurie range. By nine years post-exposure the lung cancer response was virtually saturated and multicentric origins were noted in some dogs. Those receiving larger lung burdens greater than 10 microcuries died of pulmonary insufficiency within 4-1/2 years. Twenty-one dogs survived for more than 4-1/2 years, and only one of these did not exhibit lung cancer at death. A relationship observed between initial lung burden and time to death with cancer has been often used to infer a threshold burden below which no life shortening of dogs would be expected. These results are usually exhibited on a log-log graph which obscures virtually all differential detail. Most importantly, recognize the nature of the experiment, i.e., the lung burdens were large, the results were saturated, and the number of animals was small. The crude relationship observed between initial lung burden and time of death with lung cancer does not necessarily imply that a threshold burden exists for beagles. Quite to the contrary, the range of exposures above the inferred threshold burden may be interpreted as a region of saturated carcinogenic response, that is a burden regime in which lung cancer induction in a beagle population approaches 100% during a normal life span. The point is that the observed time to death is more likely related to the burden, through a population depletion effect, rather than through a burden dependent latent period. In the former interpretation appreciable cancer would be anticipated at lower burdens. This is again consistent with the extensive observations in "Toxicity of Radium-226 in Mice" (IAEA-SM-118/11),

M. Finkel, et. al., of radioisotope-induced bone tumors in mice, which support their interpretation that "latent period is constant and that the apparent relationship between increasing dose and decreasing time to death with tumor is due to the effects of dose-level on survival and on tumor expectancy."

The significance of the Bair beagle experiment is that it demonstrates carcinogenic potential in bronchiolar-alveolar tissue of beagle dogs after their having been exposed to microcurie quantities of plutonium. Cancers were observed in conjunction with fibrotic lesion.

* * *

The domain of this comment is broadened here in order to summarize a specific concern with plutonium, and certain other active alpha-emitters, such as U-233. Under a number of circumstances plutonium forms aerosols. The physical character of these aerosols is such that on inhalation by humans they are preferentially deposited in deep respiratory tissue. Because of slow clearance and because of their insoluble character, particles may experience long residence times in tissue. An appreciable mass fraction of the aerosol is usually associated with particles sufficiently large that small but physiologically significant volumes of tissue will be exposed to intense (i.e., doses that if given whole body would be organism lethal) radiation doses within a meaningful physiological time. Studies of the effects of intense local radiation to skin indicate that despite the near mitotic sterilization of the involved tissue, an enhanced carcinogenic response may occur, in the sense that energy dissipated in a limited volume may be far more carcinogenic than if the same type of radiation were to dissipate its energy over a much larger tissue mass. The question is then: do particulates of certain classes of plutonium lead to exposures that have enhanced carcinogenic potential? If they do, then present standards can be in error

by orders of magnitude.

Notice that the emphasis here is on the anomalous hazard associated with a single particle; and that if any threshold is relevant, it is not a dose threshold since local exposures are large, but rather a possible volumetric threshold that must be exceeded by the physical extent of the exposure. Plutonium, as an insoluble aerosol-forming, long-lived alpha-emitter, constitutes a very special case of the low exposure problem.

* * *

A plutonium industry has existed for more than two decades. By this time there must be a significant history of human exposure. Considering the early recognition of plutonium's toxicity, and its obvious potential for much expanded commercial use, the occupationally exposed population must or should have been closely followed. A plutonium registry has existed since 1968. An acceptable way to make limiting estimates of cancer risks would be to argue conservatively from past human experience. Considering the extent of past experience, the open literature contains relatively little detailed information on the history of humans following plutonium exposure. While I am no epidemiologist, it is clear that the existing literature is an inadequate base for rigorous argument in support of existing standards. Statements affirming that there have been no recorded cases of human cancer as a result of plutonium exposure must obviously be qualified by supporting epidemiological analysis of human experience. In the limit, not to have seen an effect would be a logically sterile observation, if one had not looked.

In the absence of such necessary argument, one is left with an obligation, through public health traditions, to more conservative and defensible methods of evaluating the cancer risks of alpha-emitting particulates. For this reason I commend to your attention, "Petition to Amend Radiation Protection Standards as They Apply to Hot Particles." in the Matter of RADIATION PROTECTION STANDARDS AS THEY APPLY TO HOT PARTICLES brought before the Environmental Protection Agency and the Atomic Energy Commission by the Natural Resources Defense Council, Inc., on February 14, 1974, and the supporting report of Arthur Tamplin and Thomas Cochran.

The hypothesis developed there is scientifically respectable and represents a state-of-the-art, conservative basis for public health judgments. I believe that a responsible joining of the public health and scientific issues would be accomplished by having any reduction in the conservative guidelines proposed there be argued from compelling refutation of the hypothesis, or from epidemiological studies of human experience.

WASH-1320, "A Radiological Assessment of the Spatial Distribution of Radiation Dose from Inhaled Plutonium, September 1974," I take to include a reasonable review of the scientific experience bearing on those two points. I do not find the material presented there a compelling refutation to the hot particle hypothesis, as a possible mode of carcinogenesis. By myopic and exclusive attention to the disjoint scientific experience that is available, WASH-1320 has obscured the sea of uncertainties in which these fragments of information are immersed. Moreover, I was disheartened that its discussion of human experience gave no new definition to that evidently limited body of knowledge. The aerosol characteristics associated with the early Los Alamos exposures were conjectured there, without any general discussion of possible

aerosol characteristics. Consequently, the relationship of the subsequent analysis to the validity of the hot particle hypothesis becomes similarly speculative, particularly when one remembers that many of the subjects were believed to have had a recovery area exposure to some form of plutonium solute.

To my mind the most significant observations in WASH-1320 were those associated with the recently completed Los Alamos experiment on Syrian hamsters. It appears anomalous that virtually no lesions of any sort were observed in conjunction with the plutonium microspheres. Certainly the cells contiguous to these particles were sufficiently irradiated to be mitotically sterile, and their apparent continued function and structural integrity for the lifetime of the animal raises the question of what are the appropriate time scales for the cells in lung tissue, and the question of how such necessarily sterile tissue would react to an overt stress such as a virus infection. In point, the Los Alamos hamster experiment confirms the opinion that the response of lung tissue to particulate radiation is poorly understood, especially when considered in conjunction with Little's experiments with Po^{210} showing a high incidence of bronchiolar-alveolar cancer in the same species. It is my recollection that the cancers of this type observed by Little and by Bair (beagles) were generally located in the peripheral region of the lung. Not knowing the distribution of the Los Alamos microspheres throughout the capillary matrix of the lung, I can not say whether these observations are of any possible assistance in reconciling the experiments. Another concern is that the imaginative technique of exposure used in the Los Alamos experiment may, in fact, have produced a particulate exposure that was too static.

Finally, I would like to commend to your attention Dr. Martell's research on the potential health effects of ambient alpha-emitters (see his

testimony before this Panel). It would be presumptuous of me to comment on that work more than to say his hypothesis concerns a different particle size, different target tissues, different mechanisms of carcinogenesis, and hence it is disjoint from the hot particle hypothesis even though its implications to plutonium guidelines may not differ substantially.

* * *

The preceding discussion has no pretensions of being a comprehensive discussion of the health hazards associated with plutonium. What it does purport to do, is examine some of the significant uncertainties that bear on evaluation of those hazards, and to suggest a framework in which such considerations can be conservatively incorporated into public health considerations.

Despite much scientific effort the mechanisms underlying carcinogenesis are not understood, and radiation-induced carcinogenesis is no exception. Radiation exposure from plutonium particulates is highly inhomogeneous and diverse. The carcinogenic potential from such exposures is poorly known for humans.

Present standards for plutonium exposure are based on the assumption of a uniform exposure by this material. For exposure by particulates such an assumption is manifestly erroneous; and as a basis for making public health decisions regarding the hazards associated with particulate exposures, the assumption may be far from conservative. Human experience with plutonium appears to be insufficiently documented to provide conclusive epidemiological support for existing standards.

Plutonium is being considered as a major energy source for the near future. If it becomes a common element in commerce, the guidelines specifying

its control acquire profound public health significance. Beneath the determination on those standards is the judgment of how scientific uncertainties relate to public health decisions. Considering the gravity and irreversibility of this decision I would suggest that a legitimate basis for establishing standards would be the most conservative hypothesis consistent with scientific experience. For this basis the hot particle hypothesis or the Martell hypothesis commend themselves for careful consideration.

* * *

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APPENDICES

I. An Analysis of the Carcinogenic Risk From An Insoluble Alpha-Emitting Aerosol Deposited in Deep Respiratory Tissue

II. An Analysis of the Carcinogenic Risk From An Insoluble Alpha-Emitting Aerosol Deposited in Deep Respiratory Tissue - Addendum

III. Letter - A. Tamplin/D. Geesaman to J. Totter

IV. Plutonium and Public Health

V. Letter - D. Geesaman to S. Greenfield

V.67-66

APPENDIX I

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UCRL-50387

AN ANALYSIS OF THE CARCINOGENIC RISK FROM AN INSOLUBLE ALPHA-EMITTING AEROSOL DEPOSITED IN DEEP RESPIRATORY TISSUE

Donald P. Geesaman

February 9, 1968

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AN ANALYSIS OF THE CARCINOGENIC RISK FROM AN INSOLUBLE ALPHA-EMITTING AEROSOL DEPOSITED IN DEEP RESPIRATORY TISSUE

Abstract

This paper is concerned with evaluating the carcinogenic risk from an insoluble alpha-emitting aerosol deposited in deep respiratory tissue. Pulmonary deposition and clearance are described; and relevant times, lengths and geometries are noted in order to construct a simple model of deep respiratory tissue. $Pu^{238}O_2$ and $Pu^{239}O_2$ are taken as representative aerosols in making quantitative estimates of tissue exposure and response. While no realistic evaluation of the total carcinogenic risk is accomplished, the results are such as to clarify the nature of the problem. In particular, if the loss of mitotic competence by a local cell population is sufficient to guarantee no origin of cancer within that population, then the carcinogenic risk from particulate sources does not scale to the total energy dissipated. To say what dose characteristics are significant to the risk would require an accurate knowledge of clearance, local shielding responses, and the mechanisms of cancer induction. In the absence of this detailed knowledge the suggested course is an experimental determination of the number of source particles per induced cancer.

Introduction

The possibility exists that significant quantities of insoluble radioactive aerosols will be accidently released into the atmosphere. Inhalation of these aerosols by a population will involve some carcinogenic risk. This work arose out of an attempt to understand and evaluate that risk.

A general appraisal of the problem is closely related to several mechanisms and phenomena. In order to achieve a desirable level of completeness, gross and microscopic structure and function of the lung are briefly described relative to the questions of pulmonary deposition and clearance.* Relevant characteristic times and lengths are noted and used in constructing a simple model of lung structure and function in the deep respiratory zone. The alpha-emitters, $Pu^{238}O_2$ and $Pu^{239}O_2$, are taken as representative aerosols** in making quantitative estimates of tissue exposure and response. While no realistic evaluation of the total carcinogenic

*The material for this description is principally derived from Ref. 1 and 2.

**References 3 and 4 deal specifically with the clearance of PuO_2 aerosols.

risk is accomplished, some results are obtained which clarify the nature of the problem and suggest the specific areas of interest in future study.

Pulmonary Deposition

Knowing the characteristics of an aerosol, i.e., the size, geometry, density and concentration, it is then possible to make a reliable estimate of the deposition in the respiratory airways. Figure 1 shows in schematic a numan respiratory tree along with the associated lengths, diameters, velocities and branching numbers. For a given aerosol the principal mechanism of deposition will vary among different regions of the lung.

		Branching number	Length (cm)	Diameter (cm)	Velocity (cm/sec)
Conducting zone	Trachea	0	11	1.6	150
	Main bronchi	1	6.5	1	190
	Bronchi	2	1.5	0.9	200
	Terminal bronchioles	16	0.3	0.06	2
Deep respiratory zone	Respiratory bronchioles	17 ↓ 19	0.15	0.05	1.4
	Alveolar ducts	20 ↓ 23	0.08	0.04	0
	Alveoli	24	0.03	0.03	0

Fig. 1. The respiratory tree, schematic drawing and approximate descriptive values (compiled from Refs. 1 and 2).

In the upper respiratory tract, i.e., nose-pharnyx-trachea, inertial deposition is dominant. It occurs when an airway branches or changes direction, and the flowing air is unable to act on the particle with sufficient force to cause it to follow the flow pattern; consequently the particle persists in the original direction of motion until it strikes the wall of the airway and adheres. This mechanism is especially effective when aerosols are dense, flow speeds are large, and airways are tortuous. These conditions exist in the nasal chambers where the removal of large particles is accomplished.

In the lower respiratory airways gravitational settling accounts for most of the deposition. It is important when the residence time in an air duct is such that the distance a particle falls in that time is of the order of, or greater than, the vertical size of the duct. Because the total duct cross-section increases enormously in the deeper respiratory airways, the flow velocity becomes commensurately smaller, hence residence times are long and the deposition condition is satisfied in the deep respiratory zone (DRZ) for micron-sized particles. It is worth noting that when the tidal air finally reaches the alveoli its velocity is almost zero and it moves nonturbulently into the expanding alveolar space, simply following behind the stagnant air.

For submicronic particles, deposition by Brownian diffusion is significant. Since the diffusion amplitudes for the residence times involved are generally small compared to the duct dimensions of the vestibular airways, the mechanism is only important for submicronic particles entering the stagnant alveolar air spaces where residence times are large.

It is easy to identify these effects in Fig. 2, which shows the percentage deposition of a plutonium oxide aerosol as a function of size. Note the maximum around 0.75 μ in the deep respiratory zone branch. While the general structure of the deposition curves is typical, there will be some curve displacement and variation in shape for aerosols of different density and geometry.

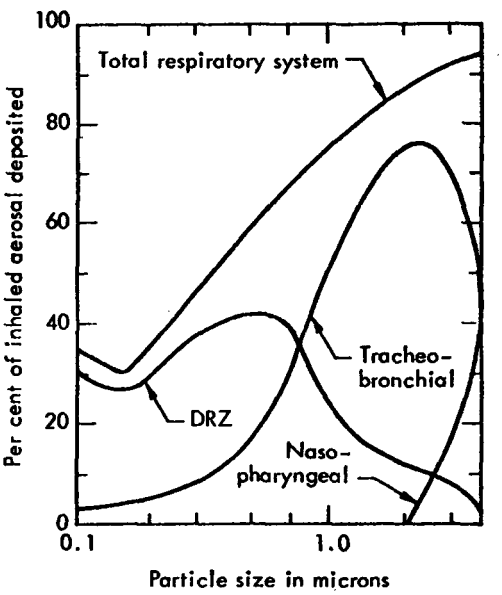


Fig. 2. Pulmonary deposition curves for a PuO_2 aerosol. (reproduced from HEALTH PHYSICS 13; 881, 1967 by permission of the Health Physics Society, after Fig. 6 of Mann and Kirchner (5).

Figure 2 should have been replaced by its improved counterpart in the Report of the ICRP Task Group on Lung Dynamics in Health Physics, 12:173 (1966).

Pulmonary Clearance

Once a particle is deposited in the respiratory tract its fate depends principally on its locality. Airways from the terminal bronchioles upwards are ciliated, and a mucous coat is propelled up the tract with a velocity of the order of 1 cm/min, though the velocity in the smaller bronchi is somewhat reduced from this value. Particles residing on this mucous coat are usually removed to the mouth in a matter of an hour.

In the deep respiratory zone the ducts are not ciliated; there is, however, a thin mucoid coat on all air tissue surfaces and macrophages adhere to the alveolar walls. It is thought that particles deposited in this region are ingested by macrophages and that most of these cells then detach from the alveolar wall and are removed in some poorly understood way to the mucous blanket of the terminal bronchiole. This transfer is not believed to be accomplished by actively directed macrophage motion, as no tropism has been demonstrated. Possibly the mucous movement in the terminal bronchiole induces, through viscosity, a slow flow in the mucous coat of the deep respiratory zone in much the way that a river would disturb a backwater. It is more likely, however, that the motion of the mucous-covered alveolar walls during breathing is such that it acts to pump surface debris out of the alveoli. Whatever the mechanism, there is observed a fairly rapid phase of clearance from the region. The half-life for this process is of the order of a few days, though this depends on the magnitude of the lung burden. For small burdens the rate of clearance seems to increase with the burden, at larger burdens the response is saturated and the clearance mechanism is less effective.

A much slower clearance is also observed from this region; it has a time scale of 100's of days.[3] Again the process is not well understood; it is assumed that some particles are rendered static in the deep respiratory zone of the lung, and a few of these are occasionally mobilized, at which time they may be susceptible to the usual clearance path. The mechanism of immobilization is conjectured to be macrophages that, for some unknown reason, do not detach after ingestion, and instead remain at the site, proliferating and developing a supporting structure of connective tissues. These anomalies, called plaques, tend to appear in regions that because of structure or injury are more rigid, for example, where an alveolus opens into a respiratory bronchiole. The plaques are rigid structures and hence tend to immobilize the surface still more, which is likely to further reduce the effectiveness of the clearance mechanism for that vicinity. The association of plaques with static regions in the alveolar wall tends to bear out the idea that the normal clearance of the deep respiratory zone is supported by the excursions of the alveolar wall. It does not, however, rule out the induced-flow explanation of clearance, and in fact the two mechanisms may complement each other. The later release of particles is taken to occur when macrophage death within the plaque allows the release of a fraction of the ingested particles.

Some particles find their way into the pulmonary lymph nodes. Though a few

may actually penetrate directly into the interstitium in regions where the capillary network is relatively diffuse, most of the lymph burden derives from the plaques which cause the adjacent alveolar walls to lose their capillaries and basement membranes, thus making it possible for a ruptured cell in the plaque to empty some of its contents directly into the interstitial space from where it finds its way to the lymph node. The time scale for this clearance is observed to be the same as slow pulmonary clearance to the outside, which is consistent with the explanation.

With this description of clearance, characteristic scales can be assigned to particles experiencing the various phases of clearance. These are given in Table I. Because of their potentially long residence times, radioactive particles in the deep respiratory zone constitute an unusual risk. This is the particular problem that I want to describe.

Table I. Characteristic scales of pulmonary clearance.

	Length	Time	Velocity
Upper respiratory clearance	~25 cm	~1/2 hr	~1 cm/min
Fast DRZ clearance (moderate burden)	~ 2 mm	~ 2 days	~1 mm/day
Slow DRZ clearance	0	~500 days	0

Deep Respiratory Zone Geometry

To obtain some notion of the bulk nature of a lung, refer to Table II showing the fractional composition by volume of typical human lung at three-fourths maximal inflation. Renormalized values compatible with half-maximal inflation are included in the table. Notice that the lung is about 80% air and that most of this is in the alveoli and their vestibular air spaces. This should give some appreciation of the porous and sponge-like character of an inflated lung. Ninety percent of the gross volume is made up of sac-like alveoli, about 10^8 in total, clustered about airways which have undergone from one to seven branchings between the terminal bronchiole and the alveoli. Many different clusterings occur, but all achieve the same effect; that is, close packed alveoli sharing the same thin walls, and ventilated by a set of vestibular airways with approximately one-half the alveolar volume. An alveolus is best represented geometrically as a truncated sphere; collectively they can be pictured as a honeycomb-like structure wrapped around a duct. The ducts are generally so branched or alveolated as to have no internal surface.

Table III gives some idea of the dimensions involved with the DRZ geometry. These will vary somewhat in other species because the alveolus size is an inverse function of the organism metabolic rate. For my purposes it was sufficient to regard the deep lung tissue as a cubical lattice characterized by the length of a side, d, and a wall thickness, r. These

Table II. Fractional composition of a human lung at three-quarters and one-half maximum inflation.

Three-quarters maximum inflation*				
	Connective and conductive structures		0.1	
	Air in alveolar ducts and respiratory bronchioles		0.29	
	Air in alveoli		0.54	
DRZ	Blood barrier	Epithelial 0.009	0.03	0.90
		Interstitial 0.012		
		Endothelial 0.009		
	Capillaries		0.03	
	Pre- and post-capillary		0.01	
One-half maximum inflation**				
	Connective and conductive structures		0.14	
	Air in alveolar ducts and respiratory bronchioles		0.27	
	Air in alveoli		0.49	
DRZ	Blood barrier	Epithelial 0.012	0.04	0.86
		Interstitial 0.016		
		Endothelial 0.012		
	Capillaries		0.042	
	Pre- and post-capillary		0.014	

*This portion of the table is taken from Ref. 2.

**Renormalization of the data for three-quarters maximum inflation.

Table III. Characteristic sizes (in microns) in the DRZ.

Alveoli	200 - 300
Alveolar duct	200
Respiratory bronchiole	500 × 1500
Alveolar septum	3 - 10

values can be chosen in a way that is compatible with DRZ densities, since this is the crucial parameter for determining the range of ionizing radiation. When this is done for the average lung data (see Appendix I) the results are $d = 200\,\mu$, $r = 8\,\mu$ at one-half maximum inflation; and $d = 230\,\mu$, $r = 6\,\mu$ at three-fourths maximum inflation.

In the lattice model the wall is treated as being elastic and uniform in thickness; in fact it is corrugated on length scales of a few microns. This structure primarily derives from distensions associated with the capillary mesh in the walls. The length scales of the radiation problem are sufficiently large that the approximation of uniform walls should have no appreciable consequences.

Tissue Exposure

To see what kinds of volumes are exposed by a radioactive source consider a 1-μ particle of $Pu^{238}O_2$ embedded in the lattice. From Fig. 2 this size is nearly optimal for deposition in the deep respiratory zone. Pu^{238} emits 5.5-MeV alpha particles and has a half-life of 89 years. A particle of this size is a 60-pCi source and has a total alpha flux of about 200,000 per day or 2.2 per sec. The range in tissue, R, of 5.5-MeV alpha is 41.5 μ; there is no appreciable attenuation because of the size of the particle.

Since the range in tissue is greater than a septal thickness, the geometric range of an alpha as a function of field angle works out quite simply to be as shown in Table IV. The reasons for this result are clear.

Table IV. Angular dependence of the geometrical range of an alpha source in a cubical lattice geometry. (For a derivation see Appendix II.)

1) Along lattice axes (defined by source)	$D \cong \frac{Rd}{r}$
2) In lattice plane (defined by source)	$D \cong \frac{Rd}{2r}$
3) In other directions	$D \cong \frac{Rd}{3r}$

where r = septal thickness
R = range in tissue
d = cube dimension
D = geometric range

and it is assumed that

$R > r$.

The geometric range D must scale like Rd/r, and a factor of 1, 2, or 3 must occur in the denominator depending on whether the field direction intersects with 1, 2, or 3 sets of the orthogonal planes which generate the lattice.

Hence the exposed volume can be thought of as a sphere of radius Rd/3r, on which are superimposed discs of radius Rd/2r and thickness d lying in the three 2-axis planes, on which in turn are superimposed arms of length Rd/r and cross-section d^2 in the six axis directions. The volume exposed is just

$$V = d^3\left\{\frac{4\pi}{81}\left(\frac{R}{r}\right)^3 + \frac{5\pi}{12}\left(\frac{R}{r}\right)^2 + 3\left(\frac{R}{r}\right)\right\}$$

where the bracketed expression is the number of alveoli in the volume, and the 3 terms are the sphere, disc and arm terms respectively. For the lattice model and a source with a solid tissue range of 41.5 μ, the geometric range is of the order of 1000 μ (Table V), and the number of alveoli exposed is of the order of 100 (Table VI). Figure 3 shows a cross-section view of an exposed volume in which the included alveoli are all appreciably exposed. The example exhibits an asymmetry of the order of d that can exist because of the location of the source within the alveolus.

The alpha flux around the source is described by a $1/4\pi x^2$ geometrical attenuation where x is the distance between source and field point. This leads to large dose rate gradients in the neighborhood of a source. The fluxes computed for a test source in a lattice (Table VII) give some idea of the intensities to which the tissue in the various regions is exposed. Notice that 6 orders of magnitude are covered over the exposed volume.

Bear in mind that this lattice model should not be taken too literally, but rather as a representative example of an

Table V. Geometric ranges (in microns) of a 5.5-MeV alpha source in a cubical lattice.

	$\frac{Rd}{3r}$ (sphere)	$\frac{Rd}{2r}$ (disc)	$\frac{Rd}{r}$ (arm)
1/2 maximum inflation $\left(\frac{R}{r} = 5\right)$	335	500	1000
3/4 maximum inflation $\left(\frac{R}{r} = 7\right)$	535	805	1610

Table VI. Number of alveoli exposed by a 5.5-MeV alpha source in a cubical lattice model of the DRZ.

	$\left(0, \frac{Rd}{3r}\right)$	$\left(\frac{Rd}{3r}, \frac{Rd}{2r}\right)$	$\left(\frac{Rd}{2r}, \frac{Rd}{r}\right)$	Total
1/2 maximum inflation $\left(\frac{R}{r} = 5\right)$	20	33	15	68
3/4 maximum inflation $\left(\frac{R}{r} = 7\right)$	53	64	21	138

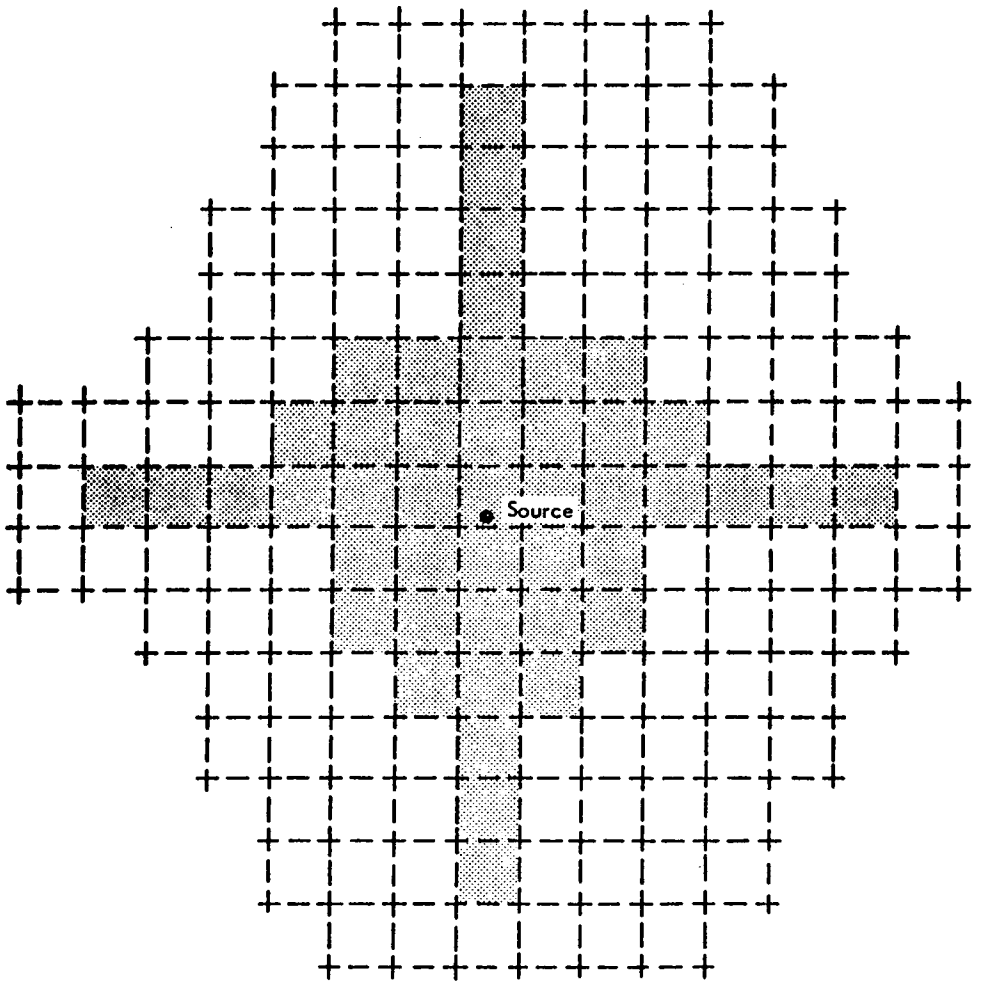


Fig. 3. An axis plane cross-section of an exposed volume in the lattice model; R/r = 7 (three-fourths maximal inflation).

Table VII. Alpha flux in number/μ^2/day.

	Distance from source				
	1 μ	10 μ	$\frac{Rd}{3r}$	$\frac{Rd}{2r}$	$\frac{Rd}{r}$
1/2 inflation	1.6×10^4	1.6×10^2	$14. \times 10^{-2}$	6.4×10^{-2}	1.6×10^{-2}
3/4 inflation	1.6×10^4	1.6×10^2	5.6×10^{-2}	2.5×10^{-2}	0.62×10^{-2}

exposed volume in a specific lattice geometry. It would not be representative in a region where masses of solid tissue occur whose characteristic size is of the order of 40 μ or more. Such masses are not usually encountered in the deep respiratory zone. From the model one can infer an effective absorption length of Rd/3r though many excursions can occur to 1-1/2 times and rarely to even 3 times that distance.

The effect of passing to a more realistic model with airways and wall corrugations would be to increase alveolar septal thickness by possibly as much as 30%. This would reduce the effective absorption length proportionally, but the presence of airways and wall corrugations would increase the length of excursions, and for active sources such as 1-μ $Pu^{238}O_2$, the distant alveoli exposed are probably the most significant. In any event, the simple lattice model gives order-of-magnitude geometric numbers, which is all that is required with the present state of the art.

Submicroscopic Structure

In order to talk about the response of the exposed cell populations it is necessary to say something about the tissue organization in the interalveolar septum. All air interfaces are covered by a single epithelial layer, all blood interfaces by a single endothelial layer. Each has its own basement membrane, these membranes usually adjoin each other, and the two tissues with their basement membrane comprise the thin (< 1 μ) blood barrier of the respiratory zone. The capillaries occur in an approximately hexagonal mesh[2] (see Fig. 4) that occupies most of the interalveolar septum. One can imagine that the nuclei of the epithelial and endothelial cells tend to congregate in the openings of the capillary mesh, while their thin cytoplasmic extrusions protect the adjacent capillary lumen. Interspersed in the interstitial space are the septal cells, and the connective tissue fibers which give the alveoli their structural properties, especially elasticity. Again they can be expected to concentrate in the openings of the mesh.

Some simple geometrical considerations make it reasonable to associate three endothelial cells and two epithelial cells with each opening in the capillary mesh. The three endothelial cells are sufficient to cover three capillary segments and by associating three segments with each opening the entire mesh can be generated. If one conjectures that an endothelial cell covers several segments then one is

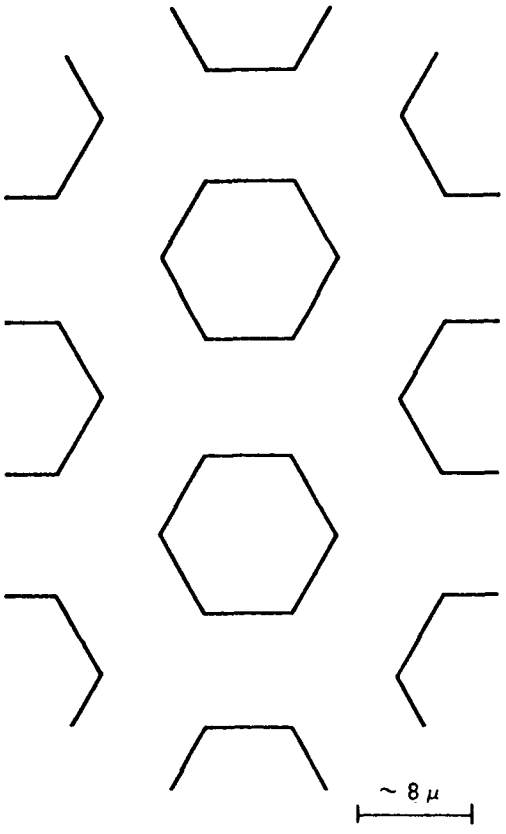


Fig. 4. The hexagonal array of the capillary mesh.

quickly led to very complicated three-dimensional geometries for the cell. The two epithelial cells are sufficient to cover the two sides of the hexagon. This assignment is consistent with the volume available in the center of the mesh. Again, the model should not be taken too literally, but rather as an order-of-magnitude estimate of cell population densitites that is not incompatible with electron micrographs of the alveolar septum.[1,2,6,7] There are ~3600 capillary segments in the walls of one alveolus.[2] Since each capillary segment is shared by two hexagons there are only three capillary segments countable with each hexagon, which implies that there are 1200 distinct, but not disjoint, hexagons on the surface. Each of these has of the order of three endothelial cells and two epithelial cells; hence the entire wall has ~3600 endothelial and ~2400 epithelial cells. Because this septum is shared, it follows that for an interior alveolus there are only 1800 endothelial and 1200 epithelial cells per alveolus. The number of epithelial or endothelial cells in a volume exposed by a $Pu^{238}O_2$ particle would be of the order of 10^5. (At one-half maximum inflation ~120,000 endothelial, ~80,000 epithelial; and at three-fourths maximum inflation ~250,000 endothelial, ~165,000 epithelial.) Septal cells have been ignored; presumably they are less numerous.

Radiation Response of Tissue

Knowing something about the lung geometry and the cell populations it is possible to make some comments about the radiation response. The carcinogenic implications of a nonuniform radiation environment will depend on the response of cell populations to the local radiation field. Since this radiation varies over many orders of magnitude it would not be surprising if several regimes of biological response were traversed. To try to relate radiation level and population response in a detailed way seems highly speculative. A more tractable aspect of the total problem is the loss of potentially cancerous cells by radiation injury. Barendson[8,9] has observed the effect of ionizing radiations in the arrest of clone

development from kidney T_1 cells. For alpha radiation he found the cell injury to be irreversible with a cross-section of the order of that of the cell nucleus. The latter result is consistent with Bloom's observations[10] with proton microbeams, where a large dose to the cytoplasm did not prevent mitosis while a small dose to the nucleus disrupted the separation of chromosomes. On this basis the cross-section for mitotic arrest by alpha radiation on lung tissue is taken by analogy from Barendson's observations with the added assumption that in all cases of interest the number density of chromosomes in the nuclear volume[11] is roughly equal to that in the kidney cell nuclei. Presumably the loss of mitotic capacity is sufficient to guarantee that cells are not potentially cancerous, which is not to say, however, that the disorder associated with their ultimate death may not have some implication of enhanced cancer risk by creating a region of trauma as a chemical irritant might do.

The radiation is random in direction, so a Poisson distribution applies. At a given radiation flux the number of mitotically fertile cells will decrease exponentially with a half-life of one over the flux through the effective nuclear cross-section. The tissue repair mechanisms of the organism must function on a similar or shorter time scale if the local cell population is not to be totally disrupted by the cumulative radiation dose. There are some clues to the history of lung cells after radiation. Phillips [12] gave 2000 R of X rays to rat lungs and then followed the tissue response for one year. He observed no widespread damage for up to three months, at which time some endothelial tissue sloughed and the affected region filled with plasma cells and mast cells. By six months the injured capillaries were largely reopened or replaced by collagenous deposits. In this period no manifestation of injury was noticed in epithelial cells. It is worth mentioning that usually the shape of the alveoli was undisturbed, which is probably accountable to the radiation indifference of the fibrous supporting structure.

These observations afford some idea of how long a cell persists after radiation insult. During this vulnerable time a cell population presents a static profile to radiation, and loss of mitotic capability should be cumulative. From Phillips' work it appears that for endothelial tissue this time is of the order of 100 days and for epithelial tissue a year or more. Note that these times may be in fact a decreasing function of dose[13] since it is possible that loss of mitotic capacity may derive from several injuries, each having a different time scale for manifestation. Two thousand R of X rays is, however, a sufficiently large dose that it should give representative numbers.

The epithelial time is probably of greater interest since the $Pu^{239}O_2$ induced pulmonary cancers in dogs appear to be largely epithelial in origin.[4] If consideration is limited to this tissue, Barendson's and Bloom's studies suggest that in regions where there is an alpha flux of more than 1 per year per cell nucleus cross section the population will lose of the order of one-half of its potential cancer cells. If there are more than 10 counts per tissue response time per cell nucleus cross section, the population is almost wholly depleted of potential

cancer cells. This roughly defines the radiation regimes of interest for a static source. In the example of a 1-μ $Pu^{238}O_2$ source embedded in a lattice lung at three-fourths inflation, the flux at the furthest perimeter is of the order of 90/year/$(5\ \mu)^2$, where $(5\ \mu)^2$ is taken to be a representative cross-section for an epithelial nucleus. If the response time of epithelial populations is one year or more then an alpha source of such intensity should sterilize all populations within the exposed volume. At the same time the carcinogenic risk associated with intracellular damage should disappear as the tissue loses its capacity for regeneration.

It would be useful to have an approximate idea of the source sizes for which the associated radiation is not population-lethal throughout the entire exposed volume. Ignoring the attenuation of the radiation by the tissue matrix, let x_{ep} be defined as the geometric distance beyond which the flux is less than 1/year/$(5\ \mu)^2$, i.e., the distance inside of which 63% or more of the epithelial cells in a local population are rendered mitotically impotent before repair begins. This quantity can be related to the source strength and hence to a source size, s, which is taken here to be a sphere diameter. For $Pu^{238}O_2$, $x_{ep} \cong 10^4\ s^{3/2}$ where s is in μ Similarly, for endothelial populations, $x_{en} \cong \frac{10^4}{2}\ s^{3/2}$. Since in the lattice model of the human lung the geometric range is limited by the attenuation in tissue to less than 1500 μ it is clear that unless the source size, s, is smaller than or of the order of 0.25 μ the yearly flux will be lethal for all ephithelial populations in the exposed volumes. The source size condition will only be slightly less stringent for endothelial populations $s < 0.35\ \mu$.

Pu^{239} emits alphas of similar energy and has a half-life that is approximately 300 times longer. The previous considerations for $Pu^{238}O_2$ apply with the exception that for equal source-strengths the source diameter of $Pu^{239}O_2$ will scale about 7 times larger. Hence the source size condition will be modified to $s \leq 1.75\ \mu$.

Implicit in the preceding was the assumption that the source was static in the lattice for a time greater than the tissue repair time. If instead the source is supposed to be removed in a time characteristic of fast DRZ clearance, then the exposure time of an alveolus is of the order of one to a few days depending on its initial separation and its position relative to the clearance path. Comparing this with the static case it is evident that source intensity must scale about 100 times larger to produce similar damage; or equivalently particles whose diameters are $\leq 1\ \mu$ will not be population-lethal throughout the whole exposed volume. With a moving source the exposed volume will be somewhat more extensive, but since the distance traversed before reaching a ciliated airway is only slightly greater than the geometric range, it is doubtful if the exposed volume would increase by an order of magnitude.

Implications

Finally, does this really tell us anything about the carcinogenic implications of $Pu^{238}O_2$ and $Pu^{239}O_2$ inhalation. Consider a particle larger than 0.25 μ that is immobilized in the deep lung tissues. From the geometric model of the DRZ it is possible to make an approximate estimate of the exposed volume. If one can accept the inferred tissue-response times (admittedly tenuous), and the model for cell injury by alpha radiation, then it follows that in the absence of local shielding all of the epithelial populations within the exposed volume should be rendered mitotically impotent by the resident particle. This is assumed to be a sufficient condition for no cancer induction within the exposed volume. With sources smaller than 0.25 μ the risk should increase.

Next, consider the effect of possible local responses. With a source as active as $Pu^{238}O_2$ it may be that a macrophage would die shortly after ingesting a particle, and if that is the case then plaque formation would be prevented. Possibly the source would have such a disruptive influence on adjacent tissue that the harboring alveolus would become static and fill with debris. Local edema or a shell of denatured protein is conceivable. Almost surely something of this sort happens and to a considerable degree lessens the source range. The peripheral volume will be subjected to transient radiation dose in the time before this local response occurs. For all but the very smallest particles, only this transient radiation dose would be of carcinogenic significance, the rest of the emitted radiation being so confined in volume as to have a lethal effect.

Similarly the particles that are cleared quickly may produce a transient radiation does that is disrupting but nonlethal over part of the exposed volume. The relative importance of two comparable particles, one static and one cleared, is contingent on the time scale of the dose they inflict. This is poorly known in both cases.

If the preceding reasoning is correct, $Pu^{238}O_2$ and $Pu^{239}O_2$ particles deposited in the deep respiratory zone of the lung do not constitute a carcinogenic risk commensurate with the total energy dissipated. The part of that energy that is potentially carcinogenic is dependent on the intensity of the source and on the time scales of clearance and local shielding.

While it is unrealistic to scale the carcinogenic damage to the total energy from a static source, I doubt if the effects of radiation are so well known that we can fix the risk from the nonstatic phases of the problem. The particle problem is somewhat unique in that: (1) there is enormous variation in the dose level and dose characteristics to which different cell populations may be exposed, and (2) volumes involved are small so that disruptive doses are not necessarily organ fatal. Implicit in the problem is considerable diversity, and I would be concerned that somewhere in this diversity are unanticipated resonant situations where the risk is large compared with predictions made from linear does effect relations.

The risk does not scale with the total energy from a source, and with present knowledge it is precarious to try to

describe in a detailed way the relationship between radiation level and carcinogenic tissue response. It would seem that the most reasonable and hopeful approach is to attempt an experimental determination of the number of cancers per source particle as a function of source strength at relatively low tissue burdens. With this, a meaningful estimate of risk would be readily accessible.

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Appendix I

Derivation of Parameter Values for the Cubical Lattice Model of the DRZ

From Tables II and III one can infer DRZ densities of approximately 0.12 g/cm^3 and 0.08 g/cm^3 for one-half and three-fourths maximum inflation, respectively. The model should reproduce these densities.

Consider a cubical lattice of side length d and finite wall thickness r, where d is measured between midplanes of the walls, and it is assumed that $d \gg r$. If all gross lattice dimensions are large compared with d, then surface corrections may be ignored and the gross lattice density is

$$\cong 1.05 \text{ g/cm}^3 \times 6\, d^2 \frac{r}{2} \times \frac{1}{d^3} = 1.05 \text{ g/cm}^3 \times \frac{3r}{d} ,$$

where the wall density is taken as 1.05 g/cm^3 and the density of the remaining volume is taken as zero.

At three-fourths maximum inflation of an average adult lung Weibel[2] gives an alveolar radius of 140 μ for an assumed spherical geometry. This implies a radius of 122 μ at half maximum inflation. To choose a compatible cube dimension it seems appropriate to require that the associated volumes be equal, in which case d = 1.62 × (radius). These values of d together with the density relations will fix the parameter values at $d = 197\ \mu \cong 200\ \mu$, $r = 7.7\ \mu \cong 8\ \mu$ for half maximum inflation, and $d = 226\ \mu \cong 230\ \mu$, $r = 5.8\ \mu \cong 6\ \mu$ for three-fourths maximum inflation, which are in reasonable agreement with descriptions of the alveolus.

Appendix II

Derivation of the Approximate Volume Exposed by a Point Source in a Cubical Lattice

Let
- $d \equiv$ cube dimension
- $r \equiv$ thickness of a cube wall (septum)
- $\bar{D} \equiv$ geometric range of a source
- $R \equiv$ range in tissue of source
- $i, j, k \equiv$ indices of the 3 Cartesian axes centered at the source
- $\theta_i \equiv$ angle that the direction of $\bar{D}$ makes with ith axis
- $m_i \equiv$ number of septal planes traversed that are perpendicular to the ith axis.

Assume that $R > r$. It is approximately true that

$$\text{(a)}\quad \frac{m_i}{\cos\theta_i} \simeq \frac{m_j}{\cos\theta_j} \simeq \frac{m_k}{\cos\theta_k} \simeq \frac{D}{d} \ .$$

These relations break down when one or two of the $\cos\theta$'s become small in the sense that $\cos\theta \lesssim \frac{r}{R}$. Consider the various possibilities:

Case 1. $\cos\theta_j$, $\cos\theta_k$ are small, in which case $\bar{D}$ very nearly lies along the ith axis. Then (a) reduces to

$$m_i \simeq \frac{D}{d}$$

and since $R \simeq m_i\, r$, it follows that

$$D = \frac{R}{r}\, d \ .$$

Case 2. $\cos\theta_k$ is small, in which case $\bar{D}$ is confined to the plane of the ith and jth axis. Then (a) reduces to

$$\frac{m_i}{\cos\theta_i} \simeq \frac{m_j}{\cos\theta_j} \simeq \frac{D}{d}$$

and since $R \simeq \frac{m_i}{\cos\theta_i}\, r + \frac{m_j}{\cos\theta_j}\, r$, it follows that

$$D \simeq \frac{1}{2}\, \frac{R}{r}\, d \ .$$

Case 3. $\cos\theta_i$, $\cos\theta_j$, $\cos\theta_k$ are not small. Hence (a) holds and

$$R \cong \frac{m_i}{\cos\theta_i} r + \frac{m_j}{\cos\theta_j} r + \frac{m_k}{\cos\theta_k} r, \text{ hence}$$

$$D \cong \frac{1}{3} \frac{R}{r} d .$$

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APPENDIX II

TID-4500, UC-48
Biology and Medicine

Lawrence Radiation Laboratory
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LIVERMORE

Bio-Medical Division

UCRL-50387, ADDENDUM

AN ANALYSIS OF THE CARCINOGENIC RISK FROM AN INSOLUBLE ALPHA-EMITTING AEROSOL DEPOSITED IN DEEP RESPIRATORY TISSUE: ADDENDUM

Donald P. Geesaman

October 9, 1968

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AN ANALYSIS OF THE CARCINOGENIC RISK FROM AN INSOLUBLE ALPHA-EMITTING AEROSOL DEPOSITED IN DEEP RESPIRATORY TISSUE: ADDENDUM

Abstract

Several experiments are reviewed involving skin and lung carcinogenesis in mammals after intense localized doses of ionizing radiation. A high incidence of cancer occurs for the exposures described. The observations suggest that the carcinogenesis is primarily mediated by injury or disruption of local tissue. It is concluded that there is a substantial possibility of enhanced cancer risk associated with the deposition of intense α-emitting particulates in deep respiratory tissue. Within this description lung cancer risks as high as 10^{-3} to 10^{-4} per disruptive source particle are indicated. The possibility of this enhanced risk places the present standards for maximum permissible lung burdens in serious question when applied to particulates such as $Pu^{238}O_2$ and $Pu^{239}O_2$. It is again suggested that in the absence of a detailed knowledge of pulmonary carcinogenesis, the best course of action is an experimental determination of the risk per disruptive particle for particle burdens $<< 10^8$ particles.

Introduction

The original report (UCRL-50387)[1] discussed lung structure and function in relation to radiation insult from insoluble α-emitting aerosols. Carcinogenic risk was treated principally within the assumption that cancer could nor originate in a population of mitotically incompetent cells. No credible risk evaluation was accomplished. This addendum extends the consideration of radiation-induced carcinogenesis. Several high dose experiments are reviewed and analyzed relative to the evaluation of carcinogenic risk in high dose situations. Conclusions are drawn and related to the original report.

Radiation Carcinogenesis after Intense Local Exposure

The induction of neoplasms by ionizing radiation is observed in diverse mammalian tissues and species. There is no comprehensive theory describing these observations.

As was previously indicated, particulate sources have the potential of exposing adjacent tissue to intense doses of radiation without being organ- or organism-fatal. Experiments involving carcinogenesis induced by intense local exposure are therefore especially relevant in judging whether particulate sources constitute a unique risk.

Albert's study of radiation-induced carcinoma in rat skin[2-4] gives some quantitative description of a high dose carcinogenic situation. Since such descriptions are rare, and since Albert's results have implications to risk analysis in general, his experiment is outlined here.

A skin area of 24 cm^2 was exposed to electron radiation with various depths of maximum penetration. The dose response curves are reproduced in Fig. 1. In all cases the response scale at sufficiently high doses was large,* ~1 to 5 tumors per rat at 80 weeks after exposure. It was noted by Albert that when the dose was normalized to a skin depth of 0.27 mm, the three response curves became continuous (Fig. 2). Since this depth is near the base of the hair follicle which comprises the deepest reservoir of epithelial cells of the germinal layer, it was suggestive that this might be a critical region in the observed carcinogenesis. The suggestion gained significance from the

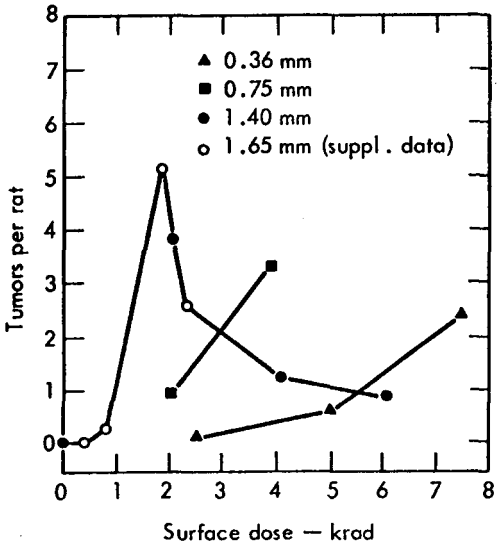


Fig. 1. Tumor incidence with respect to surface dose at 80 weeks for three penetration depths of electrons. (Reproduced with the permission of Academic Press, Inc., and Radiation Research after Fig. 5 of Albert, Burns and Heimbach.[2])

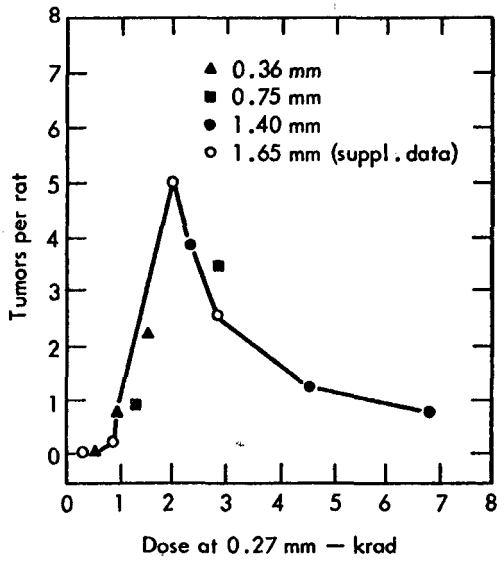


Fig. 2. Tumor incidence with respect to the dose at a depth of 0.27 mm in the skin at 80 weeks for three penetration depths of electrons. (Reproduced with the permission of Academic Press, Inc., and Radiation Research after Fig. 7 of Albert, Burns and Heimbach.[2])

*"Large" as used here describes tumorigenic responses which are greater than 1 tumor for 20 animals. For reference a whole body dose of 1000 R, and a cancer probability of 50 cancers per million per rad, implies a risk of 0.05 per animal.

observations that most of the tumors are similar to hair follicles, and that in the nonulcerogenic dose range the number of tumors per rat was in nearly constant ratio (1/2000 to 1/4000) with the number of atrophied hair follicles (Figs. 3 and 4). Thus the carcinogenesis in this experiment was remarkably correlated with the dose to and the specific damage of a particular skin structure. When exposures were made with stripe and sieve patterns of roughly 1 mm scale, geometrical effects were observed; most notably the cancer induction in the sieve geometry was suppressed at doses of 1700 R, but not at doses of 2300 R. The reduction, however, was again consistent with the reduction in damage as characterized by atrophied hair follicles.

For perspective it is valuable to relate these observations to cellular descriptions. Carcinogenesis in Albert's experiment is

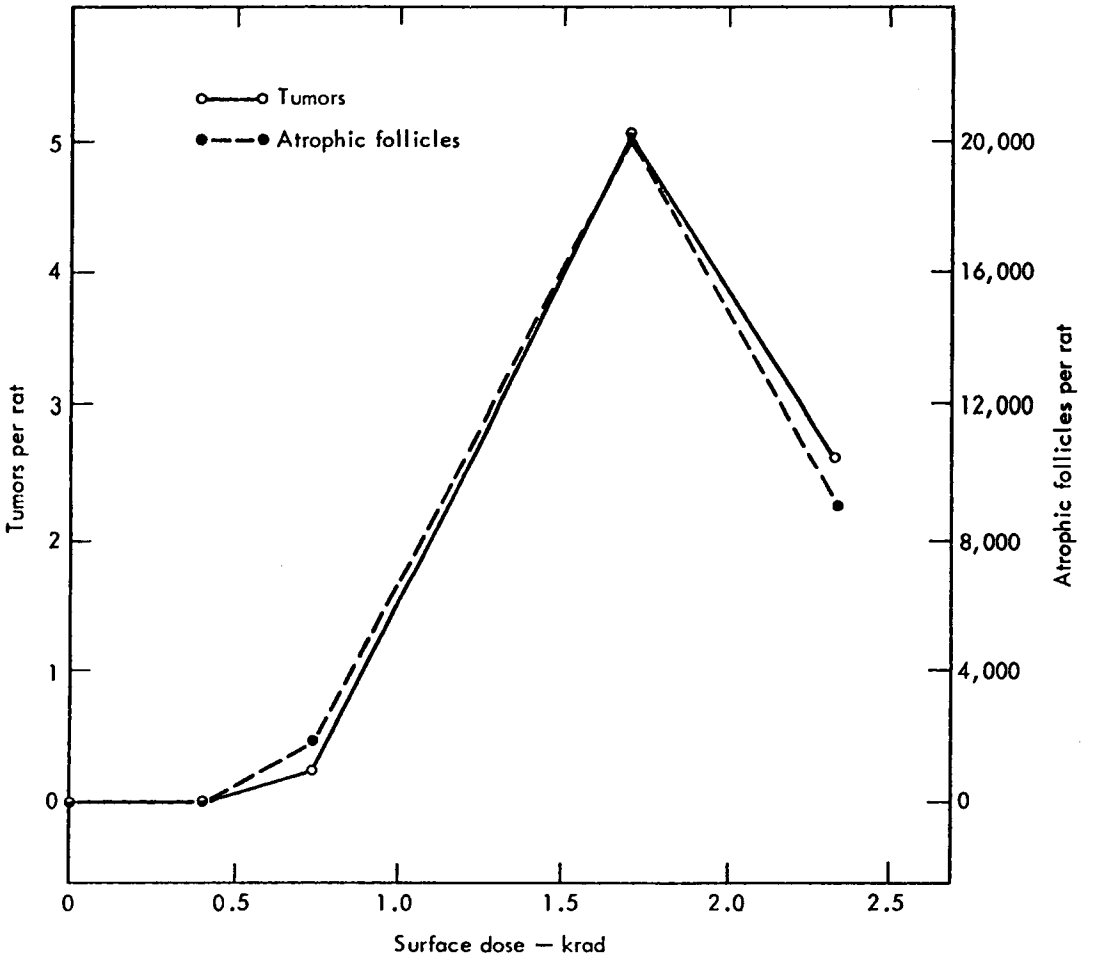


Fig. 3. Dose-incidence curves of skin tumors and atrophic hair follicles for 80 weeks after uniform surface irradiations of 24 cm^2 of skin with electrons that penetrated 1.65 mm. (Reproduced with the permission of Academic Press, Inc., and Radiation Research after Fig. 5 of Albert, Burns, and Heimbach.[4])

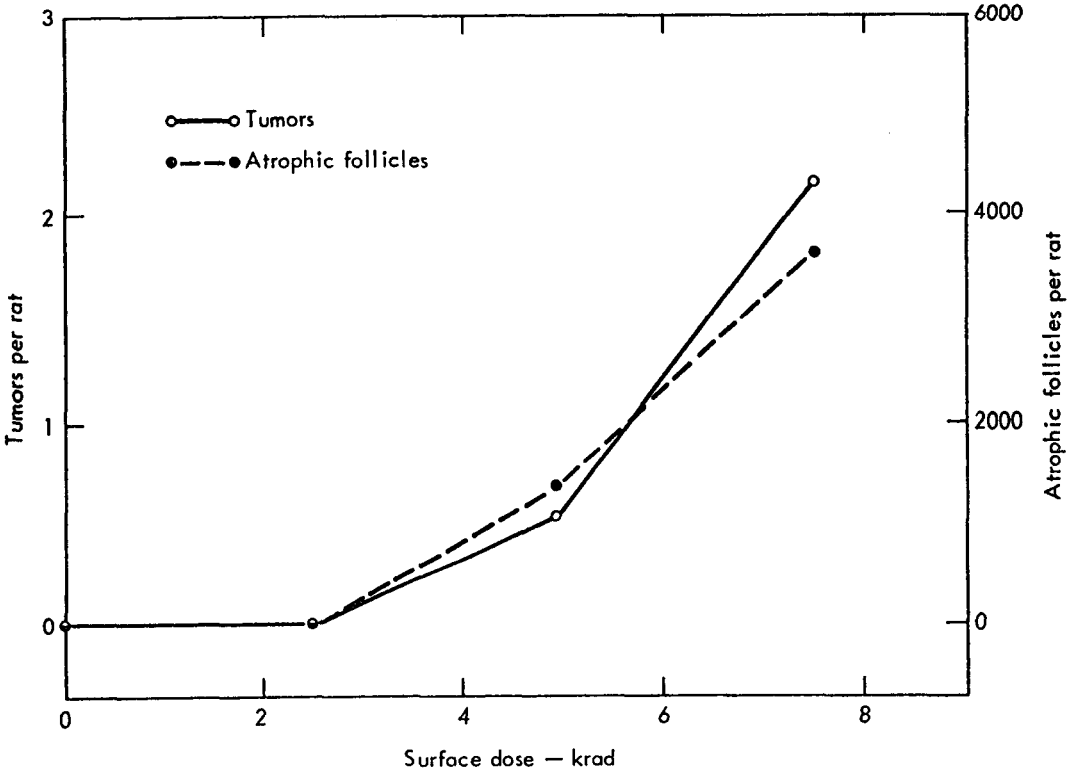


Fig. 4. Dose-incidence curves of skin tumors and atrophic follicles for 80 weeks after uniform surface irradiation of 24 cm^2 of skin with electrons that penetrated 0.36 mm. (Reproduced with the permission of Academic Press, Inc., and Radiation Research after Fig. 6 of Albert, Burns and Heimbach.[4])

maximum in the neighborhood of 2000 R. It is well documented in vitro and to a lesser extent in vivo[5] that the fraction of mitotically competent cells as measured by clonal formation decreases in a nearly exponential fashion with the dose. From these results a surviving mitotic fraction of approximately 10^{-5} would be expected in a population of germinal epithelial cells exposed to 2000 R. Even in this preulcerative dose regime the cell population suffers severe mitotic injury. It is significant that Albert's dose response curves show no simple relationship with the surviving fraction of mitotically competent epithelial cells. There is certainly no exponential decrease of the response in the neighborhood of D_{37},* and, in fact, the tumorigenesis is maximum in a dose region where the population of mitotically competent cells should be initially depleted by about 5 orders of magnitude.

To summarize this important experiment, a high incidence of cancer was observed after intense local doses of radiation, and the carcinogenesis was proportional to the damage or disordering of a particular skin structure.

Others have observed carcinomas and sarcomas in rats and mice after intense

*The dose which leaves 1/e of the cells mitotically competent.

Table I. Radiation-induced skin cancers observed in rabbits, sheep, and swine.

Animals	Surface dose	Exposed area	Cancer	Reference
2 rabbits[a]	16,000 R (P^{32} plaque)	20 cm^2	1 fibrosarcoma	8, 9
2 sheep[a]	16,000 R (P^{32} plaque)	20 cm^2	1 fibrosarcoma 1 karatocanthoma	8, 10
? swine	19,470 μCi-hr (Ru^{106} plaque)	?	1 squamous cell carcinoma	11

[a]Similar exposures at 2000 R and 8000 R with P^{32} plaques induced no observed cancers, nor did exposures of 2000 R, 8000 R, and 16,000 R with Sr^{90} plaques.

exposure of the skin to ionizing radiation (for a summary see Ref. 6). Cancer induction is generally a frequent event in these experiments. Even at elevated doses such as 12,000 R of 1-MeV electrons, Boag and Glucksmann[7] induced ~5 sarcomas per 100 cm^2 in rats.

A few results for rabbits, sheep and swine are collected in Table I. Despite the small number of animals involved, surface doses of 16,000 R from a P^{32} plaque induced several cancers, which is indicative that larger mammals are similarly susceptible to skin cancer after intense radiation insult. Again, these gross observations demonstrate that enhanced tumor incidence does occur after very high doses.

The skin experiments are remarkable in that a highly disruptive dose of radiation to a reparable mammalian tissue produced frequent carcinogenesis. There is no compelling reason to believe that respiratory tissue behaves similarly, but with the well documented carcinogenic potential of human lung tissue, and the disruptive capacity of radioactive particulates such as $Pu^{238}O_2$, it is reasonable to expect that a comparable development occurs for lung tissue. While a number of radioactive substances have been used to induce lung cancers in mice and rats (see Ref. 12), it is difficult to derive any characterization of carcinogenesis from these experiments. The work of Laskin et al.,[13,14] though not specifically involving deep respiratory tissue, does demonstrate a source-intensity response curve which is reproduced in Fig. 5. A Ru^{106}-Rh^{106} cylindrical source was implanted in the bronchi of rats, and cancers were observed to arise from the bronchial epithelium. The response curve indicates a substantial response (0.07)

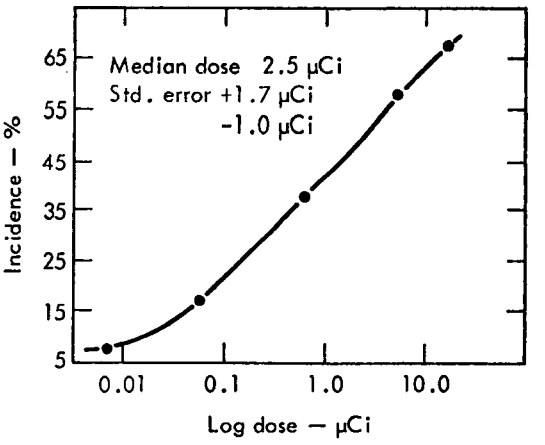


Fig. 5. Dose response relationship in μCi after exposure of the bronchial mucosa of rats to the β-radiation of Ru^{106}-Rh^{106} pellet implants. Squamous cell carcinoma in survivors beyond 143 days. (Reproduced with the permission of the Journal of the National Cancer Institute after Fig. 2 of Laskin et al.[13])

even at 0.008 μCi burden, and a slow, approximately logarithmic increase of tumor incidence over three orders of magnitude in the source intensity. Corresponding first-year doses to adjacent bronchial epithelium varied from 10^3 R to 10^6 R. Animals were followed until death, and it was observed that the tumor incidence generally increased with the dose accumulated at death. The lowest accumulated dose associated with a cancer was 1400 R. For an accumulated dose of the order of 10^6 R the incidence was ~2/3. Cember[12] fortified glass beads (0.3 μ diameter) with several microcuries of Sr^{90}-Y^{90}, and single beads were implanted in the lungs of rats. Tumors were observed in 7 of 23 animals. In a second experiment Cember exposed rat lungs to $Ce^{144}F_3$ particulates. For a burden range of 0.5 μCi to 50 μCi the observed tumor incidence fluctuated between 0.04 and 0.3.

All of these experiments involved intense exposures and a significant level of carcinogenesis. Severe damage and disruption of tissue were associated with the exposure. The nonuniformity of the exposures, the relatively long range of the β-emitters involved, the complex structure and function of the lung, and a general ignorance of the mechanisms of carcinogenesis, make more detailed interpretation largely speculative. There are few clues as to the critical tissue or dose parameters in the observed carcinogenesis.

The most relevant lung experiment is Bair's $Pu^{239}O_2$-inhalation study with beagles.[15,16] Exposure was to particulates of 0.25 μ or 0.5 μ median diameter; burdens were in the μCi range. In the period 2 to 7 years after exposure, 19 of 35 animals died and 13 of those 19 including the 9 most recent mortalities showed pulmonary neoplasia. Many of these cancers were multicentric in origin. The cancers again appeared in conjunction with severe lung injury. Since the natural incidence of the disease is small, it appears that at this level of exposure the induction of lung cancer is almost certain during the normal beagle life span. When the pathological response is this saturated, and the mechanism of induction is not understood, then it is doubtful that one can draw any inference about the response at smaller burdens. The smallest burden (at death) in a dog showing lung cancer was ~0.2 μCi. Presumably this would correspond to a particle burden of about 10^7 particles. Burdens which are smaller by orders of magnitude may still induce a substantial incidence of cancer.

Conclusions

Summing up, intense radiation exposure of mammalian skin and lung tissue commonly results in cancers. Tissue injury and disturbance are a primary consequence of intense radiation insult, and are observed in association with carcinogenesis. Albert has exhibited a simple proportionality between skin carcinomas and atrophied hair follicles. No general description of precarcinogenic injury exists, but in a crude sense the available observations are compatible with the idea of an injury-mediated carcinogenesis. Cancer is a frequent instability of tissue. Since tissue is more than an aggregate of cells, and has a

structural and functional unity of its own, it would not be surprising if some disrupted local integrity, a disturbed ordering, comprises a primary pathway of carcinogenesis. The induction of sarcomas with inert discs of Mylar, cellophane, Teflon and Millipore (Brues et al.[17]) is indicative that such a mechanism exists. Presumably mitotic sterilization is an important factor in any carcinogenesis mediated by radiation-induced tissue injury. The functional relation of this factor to the carcinogenic response may be quite different from a linearity in the surviving mitotic fraction.

While regrettably unquantitative, the hypothesis of an injury-mediated carcinogenesis is suggestively descriptive. If the respiratory zone of the lung contains a structure analogous to the rat hair follicle, and if a radioactive particulate deposited in the respiratory zone has the capacity to disrupt one or more of these structures and create a precancerous lesion, then cancer risks of the order of 10^{-3} to 10^{-4} per particle can be expected for burdens much less than 10^{8} particles.

Bair's work[15,16] does not contradict this. As well as showing a saturated response, his experiment involves particle burdens like 10^{8}, and since this number is comparable with the number of alveoli, it follows that there are many overlapping exposures. In this situation the particles do not necessarily produce isolated effects and the results can not be used to infer a risk per particle applicable at lesser burdens.

For occupational exposure the maximum permissible lung burden (MPLB) of Pu^{238} or Pu^{239} is 0.016 μCi.[18] Assuming a particle diameter of 0.3 μ, this burden is equivalent to 3×10^{6} particles of $Pu^{239}O_2$ or 10^{4} particles of $Pu^{238}O_2$. If there is a possibility of tumorigenic risks of the order of 1/2000 per particle, this raises serious doubts as to the applicability of current MPLB to risk judgments involving particulates. Aside from this question of enhanced risk from disruptive particulates, Bair's observation of a burden of ~0.2 μCi in a dog with lung cancer is precariously close to the presently prescribed MPLB. Experiments at lower particle burdens are crucial to defining the risk from insoluble α-emitting particulates.

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November 26, 1969

Dr. John R. Totter, Director
Division of Biology and Medicine
U. S. Atomic Energy Commission
Washington, D. C.

Dear John:

We wish to continue our efforts for constructive discussions with you and your colleagues concerning the vital matters of Atomic Energy Development and the Public Health and Safety. We have repeatedly indicated our urgent desire to be constructive and to apprise you at the earliest possible time of problems of serious nature that might be in the horizon. My colleague, Don Geesaman and I, have one which we wish to bring to your urgent attention now and it is the subject of this letter.

This problem concerns the biological hazard attendant upon the inhalation of plutonium oxide particles. Our analysis of this problem suggests that these particles may represent a unique carcinogenic risk--that, when the lung exposure occurs as a result of PuO_2 particles, the existing maximum permissible lung burden may be too high by orders of magnitude. If our suspicions are correct, the AEC could be confronted with a situation similar to the uranium miners in the plutonium industry. The enclosed report, UCRL-50387, ADDENDUM, is the basis for the above statements.

Our interest in this problem resulted from being requested to be members of the DBM Committee of Space Nuclear Systems Radiological Safety Matters. As you can see from the enclosed letters to Dr. Bruner, we disagreed with the Committee's conclusions beginning in August 1967. The more we studied the problem the more concerned we became as evidenced by the letter to Dr. Bruner of October 2, 1968. In this letter and the memo to Dr. Gofman we expressed our concern with respect to exposure of workmen in the very vital plutonium industry. We again expressed this concern at a briefing of the AEC Staff in Germantown on October 25, 1968 (copy enclosed).

We are calling this problem to your attention at this time because it appears that it will soon become a subject of public debate. As a result of the fire at Rocky Flats, Dr. E. A. Martell has been conducting an environmental survey to determine the levels of Pu-239 in the Colorado area. As we understand it, he will probably be releasing his results in December. His results will show evidence of contamination from the Rocky Flats plant. Our impression is that he will at that time raise the question of permissible exposure.

It is important to note that there is no official guidance concerning exposure to these hot-particles. ICRP publication #9, page 4, paragraph 20 states, "In the meantime there is no clear evidence to show whether, with a given mean absorbed dose, the biological risk associated with a non-homogeneous distribution is greater or less than the risk resulting from a more diffuse distribution of that dose in the lung."

Dr. John Totter November 26, 1969

Now, quite obviously, we do not feel that the Division of Biology and Medicine can adequately support the position taken by the Committee on Space Radiological Safety. Hopefully, the scientific community-at-large will be more receptive to their arguments but we doubt it. At any rate, we felt that we should call this problem to your attention.

Sincerely yours,

Arthur R. Tamplin
Bio-Medical Division

Donald P. Geesaman
Bio-Medical Division

ART:ml

Encls. as stated

cc: Dr. Seaborg

APPENDIX IV

"PLUTONIUM AND PUBLIC HEALTH"

(A talk given at the University of Colorado on April 19, 1970.)

(Printed with references added in Underground Uses of Nuclear Energy, Part 2, Hearings before the Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate, August 5, 1970.)

(Printed with Author's Note added in Electric Power Consumption and Human Welfare, AAAS Committee on Environmental Alterations, August 11, 1974.)

(To be published in Energy and the Environmental Crunch, eds. Firebaugh, et. al., Oxford University Press,* 1975; and in Energy and Human Welfare, eds. Commoner, et. al., Macmillan Publishing Company, 1975.)

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PLUTONIUM AND PUBLIC HEALTH

Donald P. Geesaman

Author's Note--June 1972.

On May 11, 1969 a major fire occurred at the large Rocky Flats plutonium facility located northwest of Denver, Colorado, and operated for the AEC by the Dow Chemical Company. For description of this fire see AEC press releases M-121, May 20, 1969, and M-257, November 18, 1969.

Consequent to this fire E.A. Martell and S.E. Poet conducted a pilot study on the plutonium contamination of surface soils in the Rocky Flats environs. Their results suggested an off site contamination that was orders of magnitude larger than that which would have been expected from the measured plutonium releases in the air effluent of the facility.

In a letter of January 13, 1970 to Glenn Seaborg, then chairman of the AEC, and in a press release of February 24, 1970 by the Colorado Committee on Environmental Information, Martell et al. called attention to this anomalous contamination and expressed concern over its uncertain origin and over its significance to public health. In response the AEC fixed the probable origin of the off site contamination as wind dispersal of plutonium leaking from rusted barrels of contaminated cutting oil, and denied that cause existed for concern over hazards to public health (see AEC press release N-22, February 18, 1970).

It was my conviction that the AEC response provided a distorted

and inadequate representation of the possible hazards associated with the observed off site contamination, and that the imminent large-scale commercial introduction of plutonium gave this situation a precedential significance much greater than the already considerable significance of the situation itself.

In April 1970 a representative of the AEC's Division of Biology and Medicine and myself were invited to present our views at the University of Colorado. "Plutonium and Public Health" derives from the preceding history and should be so interpreted. The presentation was to a lay audience and was made with that expectation. Adequate referencing was added to the written text prior to its inclusion in Underground Uses of Nuclear Energy, Part 2, Hearings before the Subcommittee on Air and Water Pollution of the Committee on Public Works United States Senate, August 5, 1970.

As it stands the paper still represents a legitimate critique, and the recent emphasis on plutonium as a major energy source increases the relevance of the discussion. An updating would involve only incremental changes, and would generally supplement rather than disturb the substantive arguments of the original paper. Hence while such an updating is desirable, it is also of sufficient marginal value that it can be properly deferred at my discretion.

For those who are interested in reading the traditional AEC position on the subject I would suggest "Appendix 24 - Safety Considerations in the Operations of the Rocky Flats Plutonium Processing Plant", from AEC Authorizing Legislation Fiscal Year 1971 - Hearings before the Joint

Committee on Atomic Energy, Part 4, March 19, 1970.

Times have changed since May 1969. Then plutonium was regarded as a military substance and was accordingly given little public attention. Now it is much publicized as the energy source of the not too distant future. April 1970 was a time of transition, and I felt the strong presence of the earlier tradition, and the decision to speak was not an easy one for me. I have had no regrets.

D. P. G.

Plutonium and Public Health

For the sake of completeness let me give you some background on plutonium. It is an element that is virtually non-existent in the earth's natural crust. In the early 1940's it was first produced and isolated by Dr. Seaborg and colleagues; --Dr. Seaborg is presently Chairman of the Atomic Energy Commission. Plutonium has several isotopes, the most important being plutonium-239, which, because of its fissionable properties and its ease of production, is potentially the best of the three fission fuels. That is why it is of interest. Aside from its fissionable properties, plutonium-239 is a radioactive isotope of relatively long half-life (24,000 years), hence its radioactivity is undiminished within human time scales. When it decays, it emits a helium nucleus of substantial energy. Because of its physical characteristics, a helium nucleus interacts strongly with the material along its path; and as a consequence deposits its energy in a relatively short distance, --about four-hundredths of a millimeter in solid tissue. For comparison, a typical cell dimension is about 1/4 to

1/10 of that. A cell whose nucleus is intercepted by the path of such a particle suffers sufficient injury that its capacity for cell division is usually lost (Bar endson, A.W., 1962 and Bloom, W., 1959).

The cancer inducing potential of plutonium is well known. One millionth of a gram injected intradermally in mice has caused cancer (lisco, H., et al., 1947); a similar amount injected into the blood system of dogs has induced a substantial incidence of bone cancer (Mays, C.W., et al., 1947), because of plutonium's tendency to seek bone tissue. Fortunately the body maintains a relatively effective barrier against the entry of plutonium into the blood system. Also, because of the short range of the emitted helium nuclei, the radiation from plutonium deposited on the surface of human skin does not usually reach any relevant tissue. Unfortunately the lung is more vulnerable.

Before I describe why this is, I'd like to say something about the characteristics of an aerosol. An aerosol is physically like cigarette smoke, or fog, or cement dust. Because of their small size, the particles comprising an aerosol remain suspended in air for long periods of time. If an aerosol is inhaled, then, depending on its physical characteristics, it may be deposited at different sites in the respiratory tree (Health Physics, 1966). Larger aerosol sizes are usually removed by turbulence in the nose, particles deposited in the bronchial tree are cleared upward in hours by the ciliated mucus blanket that covers the structure. This clearance system does not penetrate into the deep respiratory structures, the alveoli, where the basic oxygen-carbon dioxide exchange of the lung takes place. Smaller

particles tend to be deposited here by gravitational settling, and if they are insoluble they may reside in the alveoli for a considerable time. The problem is that, under a number of conditions (Anderson, B.V., et al., 1967; Fraser, D.C., 1967; Kirchner, R.A., 1966; Mann, J.R., et al., 1967; Stewart, K., 1963; Wilson, R.H. et al., 1967) plutonium tends to form aerosols of a size that are preferentially deposited in deep lung tissue. Plutonium dioxide, which is a principal offender, is insoluble and may be immobilized in the lung for hundreds of days before being cleared to the throat or to the lymph nodes around the lungs (Health Physics, 1966).

An aerosol is comprised of particles of many different sizes, and their radioactivity may differ by factors of thousands or even more. I will simplify the argument and say that there is a class of these particles, the largest ones deposited in the deep lung tissue, that can be expected to have a different potential of cancer induction than the particles of the smaller class. This is because they are sufficiently radioactive to disrupt cell populations in the volume of cell tissue which they expose (Geesaman, D.P., 1968a). An example might be a particle that emits 5000 helium nuclei per day. It would subject between 1 and 20 alveoli to intense radiation, sufficient to inflict substantial cell death and tissue disruption. For reference, the alveoli are the basic structural units of the deep lung. They are shaped and bunched roughly like hollow grapes 0.3 millimeter in diameter. Their walls are thin, a few thousandths of a millimeter, and they are a highly structured tissue with many cell types. Intense exposure of local tissue by a radioactive particle is referred to as the hot

particle problem. The question is: does such a particle have an enhanced potential for cancer ? No one knows. One can argue that cancer cannot evolve from dead cells, hence a depleted cell population must be less carcinogenic. This is believeable, and must be true on occasion. The facts are, though, that intense , local doses of radiation are extremely effective carcinogens, much more so than if the energy were averaged over a larger tissue mass (Geesaman, D.P., 1968b). Furthermore, this can take place at high doses of radiation where only one cell in ten thousand has retained its capacity to divide. The cancer susceptibility of lung tissue to radiation has been demonstrated in many species; one can say in general that the lung is more susceptible to inhomogeneous exposures from particles and implants than it is to diffuse uniform radiation. Some very careful skin experiments of Dr. Albert have indicated that tissue disruption is a very likely pathway of radioactive induction of cancer after intense exposure (Albert, R.E., et al., 1967a, 1967b, 1967c, 1969). The experiments show that the most severe tissue injury is not necessary, nor even optimal, for the induction of cancer. When these notions are applied to a hot particle in the lung, the possibility of one cancer from 10,000 disruptive particles is realistic. This is disturbing because an appreciable portion of the total radioactivity in a plutonium aerosol is usually in the large particle component.

Let me demonstrate what I mean. Suppose a man received a maximum permissible lung burden for plutonium, and suppose roughly 10% of the mass of the burden was associated with the most active class

of particles deposited (that is those emitting several thousand helium nuclei per day). This is reasonable. There would be something like a thousand of these particles and each would chronically expose 1 to 20 alveoli to intense radiation. If the risk of cancer is like 1 in 10,000 for one disruptive particle, then the total risk in this situation is one in ten, i.e., one man in ten would develop lung cancer.

Put another way, about 1 cubic centimeter of the lung is receiving high doses of radiation. It would not be surprising if intense exposure of such a localized volume led to a cancer one time in ten. The question is: if the individual volumes are separated from each other, is substantial protection afforded? No one knows. It is much easier to find two cancers using 50 exposures of 1 cubic centimeter each, than it is to find a couple of cancers in 50,000 single particle exposures. Certainly the length scales of injury are long enough that a disruptive carcinogenic pathway cannot be disregarded for isolated hot particles (Geesaman, D.P., 1968b).

One can look to the relevant experience for reassurance. In an experiment done at Hanford by Dr. Bair and his colleagues, beagle dogs were given $Pu^{239}O_2$ lung burdens of a few hundred thousandths of a gram (Bair, W.J., et al., 1966; Ross, D.M., 1967). At 9 years post exposure, or after roughly half of an adult beagle life span, 22 of 24 deaths involved lung cancer, usually of multiple origin. Five dogs remain alive. For comparison, these exposures are about 100 times larger than the present maximum permissible burdens in man.

There are two unsatisfactory aspects of this experiment. First,

because all of the dogs are developing cancer, it is impossible to infer what would happen at lower exposures: simple proportionality does, however, suggest that present human standards are too lax by at least a factor of ten. Second, because the radiation dose is large, with tissue injury almost killing the dogs; and because large numbers of particles are involved, often acting in conjunction; it is improbable that the risk from disruptive particles can be inferred. And after all, this is what we need to know, since almost all human exposures will involve hot particles acting independently, and if there is a risk from these particles, it will be additive throughout the population; --there will be no question of a threshold burden; and there will be a possibility that a man with an undetectable burden of a few particles will develop a cancer as a consequence. For the exposures of concern, 1000 people with 100 disruptive particles each will suffer as many total cancers as 10,000 people with 10 particles each, or as 100 people with 1000 particles each.

Human experience does not give us the answer either. Plutonium has been around for 25 years, and people have been exposed. In 1964 through 1966 contractors indicated an average total of 21 people per year with over 25% of a maximum permissible burden of plutonium (Ross, D.M., 1968). Three out of four of these exposures derived from inhalation. To be reasonably useful, the documentation of exposure must go back more than 15 years, because of the latent period for radiation induced cancer. In recent years documentation has improved greatly, but from early days there is pitifully little of relevance to the hot particle problem in the lung.

Since I have mentioned maximum permissible lung burdens, you are aware that there is official guidance. I would like to comment on it. The maximum permissible lung burden is established by equilibrating the exposure from the deposited radioactive aerosol with that of an acceptable uniform dose of x-rays. The International Commission on Radiological Protection indicates this may be greatly in error, and specifically states in its publication 9, "In the meantime there is no clear evidence to show whether, with a given mean absorbed dose, the biological risk associated with a non-homogeneous distribution is greater or less than the risk resulting from a more diffuse distribution of that dose in the lung." (ICRP, 1966). They are effectively saying that there is no guidance as to the risk for non-homogeneous exposure in the lung, hence the maximum permissible lung burden is meaningless for plutonium particles, as are the maximum permissible air concentrations which derive from it.

So there is a hot particle problem with plutonium in the lung, and the hot particle problem is not understood, and there is no guidance as to the risk. I don't think there is any controversy about that. Let me quote to you from Dr. K. Z Morgan's testimony in January of this year before the Joint Committee on Atomic Energy, U.S. Congress (Morgan, K.Z., 1960). Dr. K.Z. Morgan is one of the United States' two members to the main Committee of the International Commission on Radiological Protection: he has been a member of the committee longer than anyone and he is director of Health Physics Division at Oak Ridge National Laboratory. I quote: "There are many things about radiation exposure we do not

understand, and there will continue to be uncertainties until health physics can provide a coherent theory of radiation damage. This is why some of the basic research studies of the USAEC are so important. D.P. Geesaman and Tamplin have pointed out recently the problems of plutonium-239 particles and the uncertainty of the risk to a man who carries such a particle of high specific activity in his lungs." At the same hearing, in response to the committee's inquiry about priorities in basic research on the biological effects of radiation, Dr. M. Eisenbud, then Director of the New York City Environmental Protection Administration, in part replied, "For some reason or other the particle problem has not come upon us in quite a little while, but it probably will one of these days. We are not much further along on the basic question of whether a given amount of energy delivered to a progressively smaller and smaller volume of tissue is better or worse for the recipient. This is another way of asking the question of how you calculate the dose when you inhale a single particle." (Eisenbud, M., 1970). He was correct: the problem has come up again.

In the context of his comment it is interesting to refer to the National Academy of Sciences, National Research Council report of 1961 on the Effects of Inhaled Radioactive Particles (U.S. NAS.NRC.1961). The first sentence reads, "The potential hazard due to airborne radioactive particulates is probably the least understood of the hazards associated with atomic weapons tests, production of radioelements, and the expanding use of nuclear energy for power production." A decade later that statement is still valid. Finally let me quote Drs. Sanders, Thompson, and

Bair from a paper given by them last October (Sanders, C.L., 1970). Dr. Bair and his colleagues have done the most relevant plutonium oxide inhalation experiments. "Nonuniform irradiation of the lung from deposited radioactive particulates is clearly more carcinogenic than uniform exposure (on a total-lung dose basis), and alpha-irradiation is more carcinogenic than beta-irradiation. The doses required for a substantial tumor incidence, are very high, however, if measured in proximity to the particle; and, again, there are no data to establish the low-incidence end of a dose-effect curve. And there is no general theory, or data on which to base a theory, which would permit extrapolation of the high incidence portion of the curve into the low incidence region." I agree and I suggest that in such a circumstance it is appropriate to view the standards with extreme caution.

There is another hazardous aspect of the particulate problem in which substantial uncertainty exists. In case of an aerosol depositing on a surface, the material may be resuspended in the air. This process is crudely described by a quantity called a resuspension factor which is remarkable in that it seems generally known only to within a factor of billions (Kathren, R.L. 1968). Undoubtedly it can be pinpointed somewhat better than this for plutonium oxide, but the handiest way to dispatch the problem is to say there is some evidence that plutonium particles become attached to larger particles and are therefore no longer potential aerosols. Unfortunately there is also evidence that large particles generate aerodynamic turbulence, and are hence blown about more readily, and on

being redeposited tend to knock small particles free. In relation to this, I'd like to give you a little subjective feeling for the hazard. There is no official guidance on surface contamination by plutonium. Two years ago, in an effort to determine some indication of the opinions of knowledgeable persons with respect to environmental contamination by plutonium, a brief questionaire was administered to 38 selected LRL employees (Kathren, R.L., private communication). All were persons who were well acquainted with the hazards of plutonium. The group consisted of 16 Hazards Control personnel, primarily health physicists and senior radiation monitors. The remainder were professional personnel from Biomedical Division, Chemistry, and Military Applications, who had extensive experience with plutonium. I had nothing to do with the survey, nor was I one of the members who was queried. The conjectured situation was that their neighborhood had been contaminated by plutonium oxide to levels of 0.4 microcuries per square meter. For reference, this value is roughly ten times the highest concentration Dr. Martell found east of the Rocky Flast Dow Chemical facility (Martell, E.A., 1970), --and bear in mind that a factor of ten is a small difference relative to the large uncertainties associated with the hazards from plutonium contamination. Several questions were asked. One was, would you allow your children to play in it? 86% said No. Should these levels be decontaminated? 89% said Yes. And to what level should the area be cleaned? 50% said to background, zero, minimum, or by a reduction of at least a factor of 40. This has no profound scientific significance, but indicates that many people conversant of the hazard are not

blase about the levels of contamination encountered east of Rocky Flats.

Finally I would like to describe the problem in a larger context. By the year 2000, plutonium-239 has been conjectured to be a major energy source. Commercial production is projected at 30 tons per year by 1980, in excess of 100 tons per year by 2000. Plutonium contamination is not an academic question. Unless fusion reactor feasibility is demonstrated in the near future, the commitment will be made to liquid metal fast breeder reactors fueled byplutonium. Since fusion reactors are presently speculative, the decision for liquid metal fast breeders should be anticipated and plutonium should be considered as a major pollutant of remarkable toxicity and persistence. Considering the enormous economic inertia involved in the commitment it is imperative that public health aspects be carefully and honestly defined prior to active promotion of the industry. To live sanely with plutonium one must appreciate the potential magnitude of the risk, and be able to monitor against all significant hazards.

An indeterminate amount of plutonium has gone off site at a major facility 10 miles upwind from a metropolitan area. The loss was unnoticed. The origin is somewhat speculative as is the ultimate deposition.

The health and safety of public and workers are protected by a set of standards for plutonium acknowledged to be meaningless.

Such things make a travesty of public health, and raise serious questions about a hurried acceptance of nuclear energy.

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APPENDIX V

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July 8, 1971

Dr. Stanley M. Greenfield
Assistant Director
Environmental Protection Agency
5600 Fishers Lane
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Re: AEC's Draft Environmental Statement, Rocky Flats Plant
Plutonium Recovery Facility

Dear Doctor Greenfield:

By copy of his letter to you dated May 27, 1971, Dr. E. A. Martell invited my comment on the AEC's Draft Environmental Statement, Rocky Flats Plutonium Recovery Facility, April 1971. In response, I am submitting the following remarks for consideration in your review of that draft environmental statement.

A general comment: Plutonium is being projected as the primary energy source of the not-too-distant future. The gravity of this circumstance makes it appropriate that any environmental statement concerned with plutonium should give an informative representation of the associated hazards and uncertainties. The draft of April 1971 does not satisfy this criterion.

More specifically, the exposition in paragraph 4 of Section 2.0 is an inadequate and unrepresentative description of the uncertainties in human risk attendant to exposure by plutonium aerosols. Human lung tissue has a well known carcinogenic potential under a number of situations, including radiation exposure; the Hanford beagle study demonstrates induction of lung cancer by plutonium aerosols. These are sufficient basis to establish plutonium induced lung cancer as a legitimate concern for humans. Judged in this context the negative results of the cited mouse study have little public health relevance. In addition, it requires pathological optimism to find reassurance in the results of the Hanford beagle experiment. Dogs were given aerosol burdens of ~1-10 microcuries of $Pu^{239}O_2$. At nine years post exposure the lung cancer response was virtually saturated and multicentric origin were noted in some dogs. A correlation observed between initi burden and time to cancer death was used to infer the limit burden for no life shortening that was mentioned in the draft statement. The exclusive interpretation of this crude correlation to mean a practical threshhold of burden is no more than a promotional indulgence. The observations do not necessarily imply that a practical threshhold exists below which no plutonium induced cancer will occur. Moreover, the range of exposures above the inferred limit burden may in fact, be interpreted as a region of saturated response, that is a burden regime in which cancer induction in a population approaches 100% during a normal life span. The point here is that the time

to death may be related to the burden through population depletion, rather than through the latent period. In the former case, appreciable cancer incidence would be anticipated at lower burdens. To summarize a specivic concern with the plutonium problem: 1) under a number of probable circumstances plutonium forms aerosols; 2) the physical character of these aerosols is such that on inhalation by humans they are preferentially deposited in the deep respiratory tissue; 3) because of slow clearance and because of the insolubility of the aerosol, particles deposited in this tissue may experience long residence times (hundreds of days); 4) an appreciable mass fraction of the aerosol is associated with particles sufficiently large that significant ($\geq$1 alveolus) volumes of lung tissue will be exposed to intense radiation exposure ($\geq$1000 rem) within a meaningful physiological time; 5) studies of the effects of intense local radiation (Albert, Hulse (skin), Maldague (kidney), deposition hotspots in bone seeking alpha emitters) suggest that despite the near mitotic sterilization of the involved tissue an enhanced carcinogenic potential may exist, in the sense that energy dissipated in a limited volume may be far more carcinogenic than if the same radiation were to dissipate its energy over a larger volume. The question is then do the larger particulates in a plutonium aerosol lead to associated alveolar exposures that have enhanced carcinogenic potential. If they do, then present standards can be in error by 2-3 orders of magnitude. Notice that the emphasis here is on the anomalous risk that may be associated with a single particle; and that if any threshold is relevant, it is not the dose threshold since local exposures are large, but rather a structural or volumetric threshold that must be exceeded by the physical extent of the exposure; and finally that this is a very special case of the low exposure problem, a case that is peculiar to plutonium as an insoluble aerosol-forming, long lived alpha-emitter.

In relation to the preceding, the Hanford beagle study ($\sim$1-10 microcuries initial lung burden) showed cancers appearing in conjunction with radiation induced lesions. In addition, a dog having substantially less burden was prematurely sacrificed and no lesions or cencers were found. It would, however, be precarious to infer that absence of lesions implies no carcinogenic potential, or equivalently that radiation induced lesions are a necessary condition for high dose carcinogenesis. This point is illustrated by Albert's rat skin experiment, where carcinogenesis was optimal in a pre-ulcerative regime of less drastic radiation injury.

(I enclosed UCRL-50387 and GT-121 as sources of supplementary discussion).

It would be useful to have a formal documentation of past plutonium experience for humans, in order to judge the extent to which that experience can be used to quantify the hazards of plutonium. In the past 2 years the AEC has established a plutonium registry at Hanford. If any currently useful documentation is available from the registry, I am unaware of it.

Dr. Langham at LASL has for some 25 years followed 12 humans with burdens in excess of a MPL. It is my impression, perhaps erroneous, that these burdens largely derive from exposures experienced in a waste recovery area where the plutonium aerosol was in fact a dilute solution. If this is the case the relevance of this documentation to particulate exposure would be speculative.

Independent of the biological questions, there are substantial and significant uncertainties associated with the resuspension of plutonium surface contamination. The subject receives essentially no comment in the draft statement. In the case of accidental release of plutonium with consequent contamination of an uncontrolled area, resuspension phenomena along with carcinogenic injury will determine the hazard to inhabitants of the area. Uncertainties in these two factors will be important in the public determination of an acceptable level of surface contamination, especially in the absence of official guidance for this latter quantity. The acceptable level of contamination will in turn determine the costs of cleanup of property and long term displacement of people. I suggest that Dr. Martell is more competent than myself to discuss the physical basis of this topic.

By conjecturing essentially no releases and a substantial safety factor in present standards, the draft statement makes the facility appear unrealistically benign. I believe that it would be appropriate if the potential environmental impact were given realization by one or by both of the following examples.

1) By conjecturing an accident release, and using present knowledge of distribution, resuspension, deposition and lung cancer risks to estimate the magnitudes and uncertainties of the hazards to which contiguous Denver could be exposed. Something of this sort is done in "Theoretical Possibilities and Consequences of Major Accidents in U^{233} and Pu^{239} Fuel Fabrication and Radioisotope Processing Plants" ORNL-3441 (see attached excerpt); and the techniques of that study could be extended and refined for the specific case of the proposed Plutonium Recovery Facility. The study should be developed to the point of roughly estimating extent of human injury, scales of evacuation, costs of clean up and evacuation as a function of plutonium exposure standards and ground contamination criteria. Even though contamination from the May '69 fire at Rocky Flats was apparently contained, the magnitude of the fire was sufficient to demonstrate that a major release from such an occurrence was conceivable and hence should be considered.

2) By discussing the environmental implications, past and future, of the previous operating history of the Rocky Flats facility. In effect, this would mean considering the implications of the anomalous off site contamination discovered by Dr. Martell in 1969, since this total contamination was some orders of magnitude larger than the plutonium released in the plant's integrated air and water effluent. For this analysis, resuspensions would be related to an on site source of contamination. Uncertainties in associated human exposures and in the implications of these exposures would be described. Significance of future resuspension would also be defined. Such an evaluation would give a pragmatic measure of the level of environmental protection afforded by the facility in the past, as well as a sense of proportion for the hazard inherent in a plutonium handling facility.

I would appreciate hearing how the EPA chooses to deal with this environmental statement. If I can be of service to your organization, I will cooperate in any way that I can.

Sincerely yours,

Donald Geesaman

DG;dlp
cc: Dr. E. A. Martell NCAR Encs UCRL-50387, GT-121, ORNL-3441 excerpt

V.67-122

February 11, 1975

AMENDMENT TO:

Testimony Concerning the Acceptability
of Existing Public Health
Guidance for Plutonium

AND TO:

Responses to Comments and
Questions of the Panel

Donald P. Geesaman
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RE: Los Alamos Syrian Hamster Experiment

In para. 2, p. 24 of my written testimony, and in response #5 of my responses to comments and questions of the Panel, I commented on the nearly completed Los Alamos Syrian hamster experiment (2000 plutonium-loaded microspheres per animal, eight exposure levels, ∿ 70 animals per exposure level). There I stated:

> "virtually no lesions of any sort were observed in conjunction with the plutonium microspheres;"

and

> "The Los Alamos experiment resulted not only in virtually no cancers, but, as I read the literature, in very little evidence of injury in the tissue adjacent to the hot particles."

These statements were the basis for some of my subsequent discussion of this experiment. The statements were grounded specifically upon a recent summary of observed results taken from "A Radiobiological Assessment of the Spatial Distribution of Radiation Dose from Inhaled Plutonium" (WASH-1320), W. Bair, C. Richmond, and B. Wachholz (September 1974), which stated (emphasis added):

> "No aberrant clinical signs have been observed in any of the animals that have died or have been sacrificed to date. Blood samples have revealed no abnormalities even after long exposures and there have been no regional lymph node effects. Occasionally, small accumulations of macrophages are seen around spheres but the fibrous encapsulation previously described for the larger more radioactive (about 180 micron diameter) spheres (Richmond et. al., 1970, 1974) are not seen. Two rarely occurring tumors were observed among animals included in Table III-C. One hamster developed an angiosarcoma of the lung after 9.5 months exposure to 2000 microspheres each containing 0.42 picocurie alpha activity (level 2A). Another animal developed a lung sarcoma at the same exposure level after 12 months."
>
> (p. 19)

and

> "In a study of $^{239}PuO_2$ particles administered by intraperitoneal injection in rats, about 2% of the plutonium was found in the vasculature of the lung 300-500 days post-injection (Sanders, in press). The mean lung doses from these plutonium particles of > 0.3 μm diameter ranged from 10 to 600 rads for three treatment levels: 0.072, 0.360 and 2.900 μCi. Of 106 rats that survived longer than 200 days (life shortening occurred in the highest dose groups and was due to irradiation of the peritoneal cavity), one rat in the lowest dose group died with a bronchiolar-alveolar adenocarcinoma after 823 days. There was no other primary pulmonary neoplasia and little evidence of cellular reaction to the plutonium particles in the lung, even among those cells adjacent to the particles. Inflammation, fibrosis, and epithelial hyperplasia and metaplasia were not observed. In general these findings agree with the results from the current plutonium microsphere studies at Los Alamos (Richmond and Voelz, 1972, 1973; Richmond and Sullivan, 1974)."
>
> (p. 20)

While I had not seen the reference, (Richmond and Sullivan, 1974), I took the above description to be a proper representation of the experimental results.

In the past week it has come to my attention that the preceding description is at variance with the description given in the cited supporting reference, "Annual Report of the Biomedical and Environmental Research Program of the LASL Health Division," C. Richmond and E. Sullivan (May 1974). I have subsequently seen that reference and I quote here some observations on the Syrian hamster experiment taken from the section on Biological Results (emphasis added):

> "Most of the animals placed on study early in the program have reached the end of their normal life span without developing significant pulmonary lesions. During the past few months, we have observed some histological changes in the lungs of very long-term animals (15-20 months). In these animals, an extension of bronchiolar epithelium

> into the aveolar ducts and alveoli has occurred. In some cases, the alveoli are lined with cuboidal or columnar epithelial cells (Fig.1). This lesion has been observed almost entirely in the higher activity levels (levels 4-6) and in animals given relatively small numbers of spheres (2000-6000). An interesting recent observation has been the identification of a similar lesion in animals from a lower activity group (level 3) which had been given larger numbers of spheres of approximately 60,000 (Fig. 2). This group of animals has been exposed only about 6 months. A consistent observation of this lesion after drastically different induction times could lead to speculation that the amount of tissue irradiated is an important element in timing of the tumorigenic response. There has been no increase in frank tumors observed within the past year; however, the epithelial changes described above could be considered as precursors of peripheral adenomas."
>
> (p. 7)

Omitting these observations from the later report (WASH-1320) resulted in a defective representation of the experimental results of that experiment.

In particular, considering the short life-span of the hamster, the appearance of these late, potentially pre-cancerous, lesions implies a severe qualification on the observation that virtually no ($\sim 10^{-6}$/particle) tumors have occurred in the fixed particle burden Syrian hamster experiment. Moreover, the inclusion of these observations makes the results of the experiment less of an anomaly, and makes them much more compatible with an interpretation based upon tissue disruptive processes and the hot particle hypothesis.

V.67-126

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Donald P. Geesaman
Associate Professor
School of Public Affairs
University of Minnesota
Minneapolis, Minnesota 55455

Dear Mr. Geesaman:

Thank you for your letter of April 9, 1975 commenting on the Proposed Final Environmental Statement (PFES) on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Your comments indicate that you feel that responses to your comments on the Draft Environmental Statement on the LMFBR Program were often not adequate, in some cases because the Atomic Energy Commission apparently did not understand them. We trust that the present responses to your comments will further explain the previous responses and hope that you will find these to be adequate.

Responses to your specific comments and a copy of the Final Environmental Statement are enclosed. Thank you again for your comments.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Responses to Comments
by Mr. Donald P. Geesaman

The following ERDA responses are keyed to Mr. Geesaman's numbered comments. Mr. Geesaman chose to relate his comments on the PFES to ERDA responses to his comments on the DES. As he stated, "These comments are structured around the responses of AEC staff to my initial comments on the AEC Draft Environmental Statement, Liquid Metal Fast Breeder Reactor Program."

ERDA Responses:

The following 4 responses are to Mr. Geesaman's numbered comments on reactor accidents (pages 1-1 to 1-4 of his comments).

1. Referring back to the full five-page comment on the draft statement, it appears to confine itself to reactor safety. Nevertheless the AEC reply applied to other parts of the fuel cycle as well, as stated in the reply.

2. The suggested modification of the AEC paraphrase is noted.

3. As explained in Section 4.2.7 of the PFES and further elaborated upon in Section III B of the FES, the likelihood of occurrence can be made small with current technology (and is made small in current facilities). While it cannot be argued that no accidents will occur, it is the goal of the LMFBR safety program to not only minimize the frequency of occurence of accidents, but also to limit their consequences.

4. Although it might clearly be less expensive to disrupt a reactor or other fuel cycle component than to construct it, it cannot be categorically assumed it is easier to do substantial damage, without considering all of the protective capabilities of the systems involved.

   This comment appears to be based primarily on philosophical differences in evaluation of the ease of committing deliberate destructive acts. Acknowledging that specific conclusions are difficult to arrive at in this field, the position of the staff remains as stated in the PFES.

The following responses are to Mr. Geesaman's numbered comments on plutonium toxicity (pages 2-1 to 2-6 of his comments).

1. The commentor's opinion of the ICRP Task Group's Report is of interest. However, he provides no justification for ERDA to ignore the conclusions and opinions of members of the ICRP and its Task Groups.

2. Estimating human health risks from the environmental dispersal of plutonium requires extrapolation from relevant human data, which generally does not include exposure to the transuranic elements, and from experimental animal data involving plutonium. Problems involved in these extrapolations were discussed in Section II.G.5.5 of the PFES. Because neither approach is definitive, both methods were used and discussed in the PFES, and estimates of health consequences made by the two methods are mutually supportive, with no large variations in the estimates. ERDA agrees that the mechanisms underlying the origins of cancer are poorly understood. Relevant data is of greater importance than hypothesized mechanisms. Such data is normally obtained from observed effects in man or from observed effects in experimental animals. The relevance of animal studies is discussed in the PFES, pages VII.53-116 to VII.53-118.

6. The use of the word "suppose" implies assumptions which are then used to philosophically develop an argument based on the resulting logic. However, the purpose of the analogy remains unclear, and apparently is not substantive to the commentor's position, as is acknowledged in his comment 7.

9. Dr. Albert discussed the data from his laboratory and the "hot particle" hypothesis in a statement dated March 25, 1974, which has been published in WASH-1359, "Plutonium and Other Transuranium Elements: Sources, Environmental Distribution and Biomedical Effects," U.S. Atomic Energy Commission, December 1974, and in the "Proceedings of Public Hearings: Plutonium and the Other Transuranium Elements," Vol. 1, ORP/CSD-75-1, U.S. Environmental Protection Agency, 1974.

10. The commentor argues against this conclusion by means of an analogous "nonsense example." Data or references to support such an argument are not identified.

11. The inference, nevertheless, is present, and the comment does not address the falling part of the curve.

12. The reference paragraph 2, page 10 states only that "this is not pertinent to previous arguments" and must be considered the commentor's opinion.

13. The possible relationship between cancer induction and cell viability or mitotic competence is not denied. However, this relationship is not well understood for any type of radiation or any tissue. It is even less understood for alpha irradiation of lung tissue. The studies of Barendson and Albert involve rat skins; the reference to the studies of Withers is not specified.

14. This implication would be dependent upon the relevance, conclusiveness and extent of the omitted experiments.

15. The relevance of the Albert and the Maldague data to inhaled particles of plutonium dioxide is not clear. Albert irradiated large areas of the skin with low or high LET radiation. The applicability of this data has been discussed in WASH-1359 by Dr. Albert (see response to comment 9) and in other publications (e.g., WASH-1320, LA-5810-MS). Maldague uniformly irradiated the left kidney of rats and of mice with X-rays. In both experiments the irradiated areas are extremely large in comparison to the point at issue.

17. Since the primary basis for the commentor's hypothesis is the Albert data, it is not surprising that the commentor finds the fact that the same data can be used to challenge the hypothesis "hardly dispositive." See also response to comment 9.

19. Few health issues in the public domain are resolvable by simplistic solutions which find no acceptance from knowledgeable scientific organizations.

20. ERDA agrees that the relationship of these processes to radiation carcinogenesis is inadequately understood, although their effectiveness is not denied by the commentor. The opinion is noted as that of the commentor.

21. ERDA agrees that the role of the body's defense mechanism, the immune system, in suppression of the growth of transformed cells is inadequately understood. However, sufficient information is known to justify consideration of the immune system with regard to carcinogenic processes.

22. ERDA fully agrees. For this reason reliable relevant data are used where available, and conservative assumptions are made where data is not available. However, prudence does not require that the most conservative approach, regardless of its scientific foundation or acceptance, or lack thereof, be used. Until additional scientifically valid evidence suggests that the approach taken by ICRP, NCRP, and ERDA is not appropriate, it is considered a conservative answer. Since the publication of the LMFBR PFES, a number of other organizations have expressed themselves on the "hot particle" issue. All of these organizations conclude either that (1) the hypothesis upon which the "hot particle" argument is based is not a valid one, or (2) that averaging the dose throughout the lung is proper and conservative or both. These organizations include the Medical

Research Council of the United Kingdom, the National Radiological Protection Board of the United Kingdom, the Los Alamos Scientific Laboratory, the Science and Technology Advice and Information Service of the Biophysical Society, and the National Council on Radiation Protection and Measurements. Where matters of the public health are concerned, it would be inappropriate for ERDA to base assessment of health risk on a method which is contrary to the overwhelming weight of scientific opinion.

23. In the referenced paragraph the commentor suggests caution in discussing the experiments of Little et. al. and of Passonneau et. al.; he does not present data or references to refute the conclusions referred to.

24. The applicability of the Albert data to inhaled particles of plutonium and the validity of the "hot particle" hypothesis have been discussed by Dr. Albert (see response to comment 9) and in other publications (e.g., WASH-1320; LA-5810-MS).

25. While the algebraic sign is not identified and may reflect a degree of uncertainty in either direction, the remainder of the comment is speculation and the commentor's opinion.

26. The statement means that the bases of the author's hypothesis tell us little or nothing about actual tumor probability.

27. ERDA does not see where the language of the citations states that the NCRP and the ICRP explicitly offer no guidance.

28. It is also the opinion of numerous individuals, committees and boards which review and/or approve the documents of the NCRP and the ICRP prior to publication. If the commentor wishes to take issue with the philosophy of the ICRP and NCRP, we suggest that he should address those organizations directly.

30. The point of the quoted passage is relevant to whether or not the lung, the lymph nodes or both should be considered the critical tissue, and, correspondingly, whether the dose should be averaged over the lung, lymph nodes, or both. NCRP opinion on this issue can be found in NCRP Report No. 46 (in press).

31. The comment states, "...consensus in error may provide amiable agreement amongst federal agencies, but seems hardly a desirable basis for decisions involving the public health and safety." That the commentor finds that two federal agencies independently have

arrived at similar results apparently is disagreeable to him but no evidence is presented that the calculations are in error. The point and context of the comment is not clear since no comment was addressed to the AEC response to the discussion of the Hanford Beagle data on pages 15 and 16 of the commentor's original comment.

32. ERDA appreciates the caution expressed by the commentor, but restates that the concept of a "threshold burden" was not used in the Draft Statement or in the PFES to estimate risks, but was introduced by other persons.

33. ERDA does not find reference to the term "reassurance" either in Appendix 24, AEC Authorizing Legislation-Fiscal Year 1971, Part 4, or in the AEC Draft Environmental Impact Statement, Rocky Flats Plant Plutonium Recovery Facility, WASH-1507, April 1971. The Hanford beagle studies are discussed briefly in both documents with respect to the data available from those studies at the time the statements were made; 1970 and 1971, respectively. In both cases the results available at that time are discussed with respect to standards, but the statement regarding "reassurance" is the commentor's.

34. See response to comment 15.

35. Again, reference is made to Albert's comments on the interpretation of his own data as used to support the "hot particle" hypothesis. ERDA fully recognizes the elegance and intelligence of the conception of the referenced studies and that the results are useful for reasonable hypotheses, but this does not include extrapolation of this data to inhaled particles of alpha-emitting radionuclides.

36. See response to comment 22.

37. See response to comment 23.

38. While the "comment" argues to the contrary, relevant data are not provided to support the argument, as indicated in the AEC response.

39. ERDA agrees that it would be desirable to have had "an extensive epidemiological program" in place for "decades" from which "dispositive" conclusions could be drawn which would have eliminated "uncertainties... of hazard or safety...". While "an extensive epidemiological program" has not been in place for "decades," a limited program has been conducted for nearly 30 years; moreover, detailed exposure records have been maintained

and are available for every person who ever worked with or in proximity to plutonium. The U.S. Transuranium Registry was established in 1968. It will take many years before significant information from current prospective epidemiological studies will become available (e.g., a defined and significant portion of the potentially exposed population, and appropriate control populations, must die before meaningful morbidity/mortality patterns and/or relationships can be determined). Since the earlier plutonium workers in this population are only now in middle age, it will be a number of years, perhaps decades, before morbidity and mortality patterns become apparent. Even though records have been kept, it is not possible to "age" the population any more rapidly than time permits, and the establishment of such studies "decades" ago would have done little to accelerate the passage of time.

40. The potential involvements of legal procedures of any kind, even those that might favor the individual, are often a deterrant to voluntary participation by some people in surveys, registers, epidemiological studies, etc. On the other hand, it could stimulate the participation of others. Whichever, the result could be a biased study.

41. ERDA does not see where the quoted statement negates the significance of the data presented. As the commentor knows, research continually progresses, results are presented as they become available, and conclusions are made and modified as justified by the data.

42. The reference of McInroy, et al., is not clear. While his data may modify somewhat the numerical values referred to in the PFES, reference 102 of Section II.G, Volume II, the statements and positions are not invalidated. In other words, the McInroy, et al., data contradicts the Geesaman hypothesis but by a smaller number than that derived in WASH-1320 using assumed, but very nearly accurate, values. However, the limitations of McInroy's data should not be ignored, his data are from limited amounts of tissue from a single person.

43. ERDA agrees, but in the absence of fundamental theories scientific observations and facts are of greater use than are debatable or unsupported hypotheses or theories, considering the present state of knowledge.

44. Principles derived from the sum of past experiences are more valid indicators than are unsupported or ill-defined theories in the formulation of extrapolations. It is more reassuring to extrapolate from experience--human or experimental--than it is from conflicting theories.

45. The implication is the commentor's opinion.

46. The referenced enclosure is an expanded version of the previous comments submitted and provides little clarification and no scientific justification for the commentor's views. The issue remains as before. Although ERDA specifically is referred to the Summary and Conclusions of the document, only the Summary was included; there is no section identified as the Conclusions. However, the Summary concludes with the commentor suggesting "that a proper basis for establishing plutonium standards is the most conservative hypothesis consistent with scientific experience." ERDA agrees with that statement and has followed this judgment in the preparation of the PFES. That the procedure followed in the PFES is the "most conservative" method of analysis, and that the "hot particle" hypothesis is neither "most conservative" nor "consistent with scientific experience", has been supported by the National Council on Radiation Protection and Measurements, the Medical Research Council of the United Kingdom, the National Radiological Protection Board of the United Kingdom, the Los Alamos Scientific Laboratory, and the Science and Technology Advice and Information Service of the Biophysical Society.

In the commentor's "Amendment to Testimony Concerning the Acceptability of Existing Public Health Guidance for Plutonium," he accuses the authors of WASH-1320 of "a defective representation of the experimental results of that (the Los Alamos microsphere studies) experiment." The text of WASH-1320 in question, page 20, discusses the findings of Sanders:

> "In a study of $^{239}PuO_2$ particles administered by intraperitoneal injection in rats, about 2% of the plutonium was found in the vasculature of the lungs 300-500 days post-injection (Sanders, in press). The mean lung doses from these plutonium particles of >0.3 μm in diameter ranged from 10 to 600 rads for three treatment levels: 0.072, 0.360 and 2.900 μCi. Of 106 rats that survived longer than 200 days (life shortening occurred in the highest dose groups and was due to irradiation of the peritoneal cavity), one rat in the lowest dose group died with a bronchiolar-alveolar adenocarcinoma after 823 days. There was no other primary pulmonary neoplasia and little evidence of cellular reaction to the plutonium particles in the lung, even among those cells adjacent to the particles. Inflammation, fibrosis, and epithelial hyperplasia and metaplasia were not observed. In general

these findings agree with the results from the current plutonium microsphere studies at Los Alamos (Richmond and Voelz, 1972, 1973; Richmond and Sullivan, 1974)."

This last quoted sentence purportedly is misleading when compared to the description of the study as described in the Los Alamos Annual Report for 1973:

"Most of the animals placed on study early in the program have reached the end of their normal life span without developing significant pulmonary lesions. During the past few months, we have observed some histological changes in the lungs of very long-term animals (15-20 months). In these animals, an extension of bronchiolar epithelium into the alveolar ducts and alveoli has occurred. In some cases, the alveoli are lined with cuboidal or columnar epithelial cells. This lesion has been observed almost entirely in the higher activity levels (levels 4-6) and in animals given relatively small numbers of spheres (2000-6000). An interesting recent observation has been the identification of a similar lesion in animals from a lower activity group (level 3) which had been given larger numbers of spheres, approximately 60,000. This group of animals has been exposed only about 6 months. A consistent observation of this lesion after drastically different induction times could lead to speculation that the amount of tissue irradiated is an important element in timing of the tumorigenic response. There has been no increase in frank tumors observed within the past year; however, the epithelial changes described above could be considered as precursors of peripheral adenomas."

The referral to Sander's data in WASH-1320 addresses inflammation, fibrosis, epithelial hyperplasia, metaplasia, and a single bronchiolar-alveolar adenocarcinoma. The reference then states that "in general these findings agree with the results...at Los Alamos" (emphasis added). ERDA does not find the sentence in the Los Alamos Annual Report referring to the "extension of bronchiolar epithelium into the alveolar ducts and alveoli" to be contrary to the opinions as stated in WASH-1320; in general, the findings agree.

It should be clarified also that the last part of the last sentence of the Los Alamos Annual Report is speculative and conditional. It was stated that "the epithelial changes described...could be considered as precursors of peripheral adenomas." Whether the changes were or were not precursors is an unresolved matter, and whether or not adenomas would develop is speculative. (An adenoma is a benign, not malignant, epithelial tumor).

The Los Alamos Annual Report for 1974 provides additional information on this subject:

> "As reported last year, epithelial changes (metaplasia) have been observed at late times (1-2 years) with specific activities above 4 pCi/sphere and lung burdens above 8 nCi. There was an indication that a similar effect might occur after 6 months exposure to a lung burden of 55 nCi from 0.9 pCi per sphere particles. Continued observation of hamsters from these and similar groups have failed to identify any development of this lesion into a tumor."

The commentor states that "...considering the short life-span of the hamsters, the appearance of these late, potentially precancerous, lesions implies a severe qualification on the observation that virtually no (10^{-6}/particle) tumors have occurred in the...hamster experiment."

Lung cancer has been reported to occur in hamsters following exposure to alpha-emitting radionuclides. This has been reported by Little, Grossman, et al. (and referred to in WASH-1320) and has been confirmed at the Los Alamos Scientific Laboratory. Therefore the life-span of the hamster should be adequate for testing the hypothesis that non-uniformly distributed hot particles result in a higher lung cancer incidence than more uniformly distributed alpha-emitting radionuclides and result in a lung cancer probability of 1 in 2,000. The commentor apparently interprets the epithelial changes described in the Los Alamos Annual Report for 1973 as being "potentially pre-cancerous." The changes are described in the report as perhaps being "considered as precursors of peripheral adenomas." The reference to "pre-cancerous" is neither supported not referenced. No suggestion has ever been made that cellular changes, as well as other changes, could not be expected from particulate plutonium in the lung. However, the test of the hypothesis is to determine whether or not the probability of cancer induction is as claimed.

It is unfortunate that the argumentation serves to dilute, diffuse and divert attention from the primary issue; namely, the only numerical conclusion subject to experimental verification: that a single "hot particle" has a probability of 1 in 2000 of producing a tumor in rat skin. On this basis the "hot particle" hypothesis was formulated. This number is a well-defined quantitative value which can be tested with minimal possibilities for subjective judgments and misinterpretations; i.e., do "hot particles" in fact produce tumors with a probability of 1 in 2000?

The hypothesis rests upon data obtained from the skin of a rodent; therefore the minimal extrapolation, which would favor the hypothesis to the maximum degree, would be to test the hypothesis in the lungs of a rodent demonstrated to be sensitive to the induction of lung cancer by alpha-irradiation.

Hamsters exposed to "uniform" lung irradiation with alpha radioactivity establish the nature, time scale and intensity of this tumorigenic response. It is precisely this comparison of uniform irradiation with particulate irradiation that is at issue.

The criteria are definitively posed by the hypothesis and the experimental results with uniform lung irradiation. If this cancer risk is 1 in 2000 hot particles, then one malignant tumor must appear within the observationally established time scale for each 2,000 particles. If this does not occur, the hypothesis is not a valid one. The question is not that marginal effects observed in connection with high levels of particulate exposure might suggest that "hot particles" could lead to cancer. That conclusion has never been at issue. The issue is the relative production of tumors by diffuse vs. particulate exposure and the specific claim of 1 in 2000 probability for the latter.

The results of the directly relevant experimental data to date are compelling: 44,000 tumors predicted, 3 tumors observed. Such striking discrepancies argue strongly that the probability of lung cancer is considerably less than 1 in 2000; therefore, at the present time the "hot particle" hypothesis cannot be considered a valid one.

The following 2 responses are to Mr. Geesaman's numbered comments on diversion and safeguards (pages 3-1 and 3-2 of his comments).

1. Concerning the lack of a sensitivity study of the economic effects of a disruptive plutonium diversion, the PFES cited inability to predict the risk to society of potential future anti-social acts as the reason for not specifically including them in the cost-benefit analysis (Volume V, page V.12-23). The thrust of the present comment appears to be that dollar costs associated with anti-social acts should be postulated and factored into the cost-benefit analysis even if there is little or no basis for their prediction because this factor is important to policy analysis. To accept this recommendation would confuse rather than illuminate the issue. Cost-benefit analyses should consider factors which are known to exist (e.g. extent of uranium resources, demand for electric power), and whose future variation can be projected (not necessarily without argument) from current observation of real situations. Other effects which have bearing on

policy issues, but which cannot be predicted quantitatively, should be discussed to the extent practicable, but cannot be specifically included in the quantitative statement of cost-benefit analysis. Catastrophic anti-social acts do not meet the quantifiability test. To postulate purely artificial data for purposes of exercising an analysis would only confuse the results, and would not serve to illuminate policy issues or guide policy decisions. In summary, staff position on this matter is unchanged.

2. For ERDA to formulate a specific policy position on the "rate of occurrence of nuclear calamity" that ERDA considers to be acceptable would be inconsistent with our intention and determination to prevent the occurrence of such events, and would imply insensitivity to their consequences and abdication of our legal responsibility to protect the public. The PFES made our position on these matters quite clear. Regarding the technological and institutional means of assuring protection in the future, Section 7.4.8 of the PFES and Section III C of the Supplemental Material in the Final Environmental Statement provide a substantial amount of information on measures which might be used. It is not possible at this time, however, to predict the exact mix of safeguards measures which will be found appropriate for the LMFBR fuel cycle. As stated in Section III C, this information will be developed during the course of the ERDA safeguards research and development program.

COMMENTS ON PROPOSED FINAL ENVIRONMENTAL STATEMENT FOR THE LIQUID METAL FAST BREEDER REACTOR PROGRAM

Dear Mr. Pennington:

I am sending my comments on the LMFBR program to you-as requested.

As you know, I presented oral comments at the public hearing regarding the LMFBR program on April 25, 1974. I prefaced my oral remarks by stating that they would be a shortened version of my longer written comments on the LMFBR program. I then handed my written comments to the appropriate person. I am therefore puzzled regarding the lack of inclusion of my written remarks in the proposed final EIS for the LMFBR. Although the AEC letter to me assured me that my views were considered in the preparation of the Proposed Final Environmental Statement for the LMFBR I did not receive any direct response to my comments/questions.

During my presentation on April 25th, I requested that a public document room be established for all Westinghouse nuclear facilities within 50 miles of Greensburg. My request(in writing) was handed to the appropriate person during my oral comments. AEC letters on August 26thandOctober 9th reassuringly stated that "We are establishing a local public document room in the greater Pittsburgh area for licensing information related to Westinghouse Electric Corporations activities in that area." This is April 1975 and I am still waiting for that document room to be established. The citizens in this area have little information about local nuclear facilities. WE HAVE A RIGHT TO SUCH INFORMATION.

The Nuclear Regulatory Commission is well aware of the recent adverse publicity regarding plutonium oxide shipments from Italy via New York city to Cheswick, Pa. I do not believe that current methods of safeguarding special nuclear materials are adequate to prevent theft by a determined group of persons. The Westinghouse facility at Cheswick is to use the plutonium oxide in the fabrication of fuel rods? WHEN did the NRC license the facility at Cheswick to fabricate fuel rods containing plutonium oxide for use in a nuclear reactor in Italy? WHEN did the NRC license the facility at Cheswick to fabricate mixed oxide fuel rods for the New York Ginna reactor? How much plutonium does Cheswick handle? Are there special nuclear materials "unacoounted for" at 1)Cheswick 2)Bettis 3) NUMEC(Nuclear fuels division of Babcock and Wilcox)?What kind of special nuclear materials are "unaccounted for" and how much is "unaccounted for"? Are the safeguards in effect at the nuclear fuel cycle facilities in this area adequate?

What responsibility does NRC have in regard to radioactive monitoring in and around nuclear fuel cycle facilities? Is plutonium monitoring done outside of each facility handling plutonium in this area?(i.e. NUMEC, Bettis, Large, Waltz Mills, and Cheswick) I believe the "as low as practicable" guidlines for radiation emissions is somewhat flexible for nuclear fuel cycle facilities. How do the current fuel cycle facility radiation emiss ion standards compare with the 5 mrm at boundary site standard for a nuclear power facility?

"Additional waste treatment systems could be used to further reduce the small

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amounts of radioactive material expected to be released from the fuel fabrication plant"(Proposed Final Environmental Statement LMFBR-Vol I-Dec 74-page 1.6-9) What kind of waste treatment systems are in effect at The nuclear facilities in this area-especially Cheswick, Bettis, and NUMEC? Are any additional waste treatment systems planned for those facilities?

The Colorado Public Interest Research Group "litigated the question of the Environmental Protection Agency's nondiscretionary duty to control discharges of radioactive materials from the Rocky Flats Plant. EPA had, prior to the suit, deferred to AEC for the purposes of such regulations. The issue was resolved in favor of EPA's jurisdiction under the Federal Water Pollution Control Act. Since the states have concurrent jurisdiction with EPA to promulgate regulations under the Act, it would appear under this decision that Colorado has the authority, if not the obligation, to monitor discharge into navigable waters for radioactive wastes."(Preliminary Report -LAMM-WIRTH-Task Force On Rocky Flats-Chapter on Price -Anderson Amendments-page 13) I believe there is an ongoing effort to lessen EPA effectiveness by lessening EPA funding. In region III EPA has one person assigned to the radiation area. I doubt that he will be able to do much monitoring of radioactive discharges into the waters of Pennsylvania.

I am aware that the radiation monitoring program by the Pennsylvania Department of Environmental Resources-Bureau of Radiological Health is"totally inadequate".(The) "bureau is supposed to independently monitor nuclear power plants, prepare emergency plans in case of accidents and find out what happens to low level radiation released into the environment....with current manpower and budget(the bureau) cannot accomplish any of those tasks, and no one else, including the federal government and the utilities, is doingthat kind of work."(UPI-3-6-Harrisburg-by David Milne) The Lamm-Wirth Task Force On Rocky Flats-Preliminary Report is an admirable effort on the part of the scientific community and the citizens of Colorado. It is not likely such an effort will ever be made in Western Pennsylvania. Dr. Morris DeGroot was a member of the Shippingport panel. At the conclusion of their fact finding assignment he suggested "I propose a full scale interdisciplinary study of low-level radiation and health, to be carried out by an independent commission appointed at the federal level." (Shippingport Nuclear power Station-Alleged Health Effects-Report to the Governor-1974-page 106)

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Dixon has estimated that residents of Wisconsin receive far more radiation from nuclear fission than the nuclear industry would have us believe.(Statement To Radiation Protection Council, Wisconsin Department Of Health Concerning Radiation Monitoring-January 3, 1975-by Gertrude Dixon, Chairperson for Research, League Against Nuclear Dangers) Dixon called for a thorough nuclear radiation dose assessment program tailored to actual living people in Wisconsin. I'm sure the results of such a program in Pennsylvania would be most interesting!

Numec is now officially the "Nuclear Materials Division of the Babcock and Wilcox Company....AEC regulations....do not require holding of a public hearing for the issuance or renewal of a materials license unless a public hearings is requested by a person whose interest may be affected....B&W has indicated that a totally revised renewal application will be submitted early this year for license SNM-414 to be followed in about three months by a revised application for license SNM 145. ....both of the license renewal actions...require an evaluation by AEC to determine if an environmental impact statement should be prepared. If it is determined that an environmental impact statement need not be prepared, a negative, declaration and an environmental appraisal will be prepared."Numec licenses were originally issued prior to time(1969) that National Environmental Policy Act became effective. "Thus no environmental impact statements have been prepared by AEC covering these activities." (quotes from January 17th, 1975 letter from AEC) I am aware that the licenses in question deal with both plutonium and uranium. Another previously (and?currently) held license of interest is SMB-502 for depleted uranium and thorium with no limitation on quantities. I HEREBY REQUEST THAT A COMPREHENSIVE ENVIRONMENTAL IMPACT STATEMENT BE PREPARED TO INCLUDE ALL OF THE NUCLEAR ACTIVITIES CONDUCTED BY BABCOCK AND WILCOX IN APOLLO AND LEECHBURG. MY LIFE AND HEALTH, AND THOSE OF MY FAMILY MAY BE AFFECTED BY THE NUCLEAR ACTIVITIES AT APOLLO AND LEECHBURG*THEREFORE I REQUEST THAT PUBLIC HEARINGS BE HELD BEFORE ANY ISSUANCE OR RENEWAL OF ANY NUCLEAR LICENSE TO THE ABOVE MENTIONED FACILITIES. Have Environmental Impact Statements ever been written for Bettis, Cheswick, Large, and Waltz Mill? If not, I ask that this be done immediately and that such information be made public. I question continuing the operation of nuclear fuel cycle facilities in this area that handle plutonium(and other SNM) until all of the environmental impacts are assessed and discussions about such are held in the public arena. I believe that those of us who live here are being subjected to great risks. For many of us there are no corresponding benefits.

One of the alternative technology options to the LMFBR is the Light Water Breeder Reactor. The LWBR is discussed in Volume III. As a preface to discussing the LWBR-I note that it seems that Admiral Rickover, in his own inimitable style, has succeeded in getting the LWBR excluded from the regular licensing process. ERDA- rather than NRC is to assure safe operation of this reactor. "Thus the double standard of promotion and regulation will continue at Shippingport"(Beaver County Times- December 27, 1974)

(4)

The breeding core and associated hardware needed to install it in the Shippingport reactor vessel are being manufactured. Installation of the breeding core in the Shippingport reactor plant is expected to begin in late 1975 with start up in 1976." (Wash 1535-Vol III-Page 6a.1-113) "This system also has the potential that it can be backfit into existing PWR plants, thus converting them to breeders with higher fuel utilization."(Wash 1535-Vol III-page 6A.1-122) The LWBR work at Shippingport is proceeding although an Environmental Impact Statement has not yet been filed. If the precedent being set at Shippingport is followed in case of conversion of other PWR's to LWBR's it will certainly help to "streamline the licensing process"! "The fuel elements in the LWBR consist of pelletized nuclear fuel materials encapsulated in high integrity ziracloy rods....The ability of the LWBR fuel systems to withstand the effects of irradiation has been confirmed from PWR operations and extensive irradiation testing. Hence, any release of fission product activity that might occur is expected to be about the same for an LWBR as that experienced in PWRs."(Vol III-page 6A.1-120) A brief discussion of the chemical and metallurgical behavior of zirconium alloys would have helped to clarify the above statement. "The Shippingport core will normally be fueled and defueled by removing complete modules after the vessel closure is removed."(VOL III page 6A1-117) How frequently will this need to occur? "In the fuel reprocessing plant, the thorium, uranium, and fission products are chemically separated. The reprocessed uranium is sent back to the fuel element fabrication plant to be refabricated into fuel elements while the fission products and radioactive wastes are placed in appropriate long-term storage....Refabrication is complicated by the fact that the recycled fuel is radioactive."(Volume III-pages 1-118 and 119) Where are the fuel fabrication plant and the fuel reprocessing plant for the Shippingport LWBR to be located? or where are they located? Has the problem of the formation of U-232 with its daughter products that give off penetrating gamma radiation been solved?

I object to a nuclear experiment , such as the LWBR being conducted in an area as densely populated as the Pittsburgh area. However, I also object to such an experiment being conducted in an area at least 5 miles from a population center of 25,000 or less and in an area with less then 400 persons per square mile.

I am aware-and distressed-that Pennsylvania is one of the States that has been chosen in which to push the energy park concept. "We don't even know the background radiation levels in many areas of Pennsylvania-we have to know this so we can tell if new plants that come on line are adding to the radiation"(UPI 3-6-Harrisburg by David Milne) Western Pennsylvania has more than one facility handling special nuclear materials-including plutonium. Dr. Bernard Cohen has called the Pittsburgh area "The world center of the nuclear industry". The Shippingport reactor was the first commercial nuclear reactor in the United States.-it started operation in 1957. WHY is the radiation monitoring so inadequate in Pennsylvania?

(5)

If one does not know background radiation levels it will be difficult or impossible to state with accuracy how much radiation a large nuclear complex adds.

I believe that the objectives I raised and the questions I asked regarding the LMFBR program in April, 1974 are still valid. The writing of more volumes about the LMFBR program(Wash 1535) does not answer the questions and objections-even though "opposing views" are recognized. WHEN are adjudicatory hearings going to be held on the entire plutonium question?

I suggest an additional chapter in the Environmental Statement on the LMFBR Title? The military implications of nuclear power". The decisions being made today regarding nuclear power will determine whether life will be allowed to continue on this planet. Beyond that-will man be free to become truly human -fully and completely human? Man today is at a crossroads in history-he must opt for life or death. As Sir George Porter stated "If sunbeams were weapons of war, we would have had solar energy centuries ago."

Pat Hoffman
RD#4
Greensburg, Pennsylvania
15601

4-8-75

CC: NRDC & Senator Richard Schweiker

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mrs. Pat Hoffman
R.D. #4
Greensburg, Pennsylvania 15601

Dear Mrs. Hoffman:

Thank you for your letter of April 8, 1975, in which you provided comments on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Responses to your specific comments are enclosed. After consideration of all comments received on the PFES as well as the testimony received at the Public Hearing held on May 27-28, 1975, the Statement has been issued in final form. A copy of the Final Environmental Statement is enclosed for your information.

Your letter makes two comments on agency action taken on written material which you submitted during the April 1974 Public Hearing on the LMFBR Program. Regarding your first comment, the fact that the written version of your oral statement was not included in the PFES is consistent with the ground rules established for all submissions relative to the LMFBR environmental review. We believe that the Federal Register notice requesting comments on the Draft Statement (39 FR 9692, March 13, 1975) and the subsequent Federal Register notice inviting submissions for the Public Hearing (39 FR 11641, March 24, 1974) were sufficiently specific regarding the separate procedures by which comments on the Statement and documents relative to the hearing record were to be handled. Specifically, the former notice requested that comments be sent to my office. Since you followed procedures pertinent to the hearing, and since the document in question was titled, "Limited Appearance Testimony of Pat Hoffman...," we believe the handling of the document as hearing record material supportive to your oral testimony was appropriate and in compliance with the aforementioned Federal Register notices. All hearing testimony (both oral and written) was treated in the same manner as formal comments on the Draft Statement, and information responding to substantive views expressed in the hearing record was incorporated into the text of the Proposed Final Statement. This was the case with regard to the document you submitted. The difference that exists from the treatment of comments received on the Draft Statement in accordance with provisions of the March 13 Federal Register notice is that hearing record submittals were not appended to the Proposal Final Statement and formal detailed responses to those submittals were not prepared.

In your second comment, you express concern that the new public document room you requested during the April 1974 hearing has not been established. The Nuclear Regulatory Commission (NRC) has advised us that the new document room has been established at the Carnegie Library of Pittsburgh, and that you have been informed of this action by copy of their April 17, 1975 letter from Hanna D. Bristow, NRC, to Mr. Anthony Martin, Carnegie Library.

You also ask when adjudicatory hearings are going to be held on the entire plutonium question. It is believed that the review of plutonium issues which has taken place during the two-year period leading up to the publication of the LMFBR Final Statement has been comprehensive. It has included AEC's solicitation of written comments and the holding of public hearings by both AEC and ERDA. During this review comments from other government agencies, public interest groups, and private citizens such as yourself have been carefully considered. Also, two public hearings on the LMFBR Program, not required under NEPA, were conducted in order to provide additional opportunity for expression of views on plutonium and other issues. Taking this history into account, it does not appear likely that adjudicatory hearings on plutonium would produce new information of value.

Thank you again for your expression of interest in the LMFBR Program.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Comments
2. Final Environment Statement,
   LMFBR Program

Enclosure 1

ERDA Staff Responses to Comments by Mrs. Pat Hoffman

Comment (page 1):

"WHEN did the NRC license the facility at Cheswick to fabricate fuel rods containing plutonium oxide for use in a nuclear reactor in Italy? WHEN did the NRC license the facility at Cheswick to fabricate mixed oxide fuel rods for the New York Ginna reactor? How much plutonium does Cheswick handle"?

ERDA Response:

The Westinghouse Electric Corporation was licensed on May 16, 1969 to use special nuclear material at its Cheswick facilities for the fabrication of nuclear reactor fuels. Licenses authorizing fuel fabrication do not specify the reactors for which fuel may be manufactured. A licensee authorized to fabricate fuel may transfer it to any other Nuclear Regulatory Commission (NRC) licensee authorized to receive it. If the fuel is intended for a foreign reactor, an NRC export license must be obtained before the fuel can leave the country.

Westinghouse is authorized to possess a total of 395 kilograms of plutonium at Cheswick. Of this, 275 kilograms is limited to storage only of clad mixed oxide pellets in sealed fuel rods contained in approved shipping packages.

Comment (page 1):

"Are there special nuclear materials 'unaccounted for' at 1) Cheswick 2) Bettis 3) NUMEC (Nuclear fuels division of Babcock and Wilcox)? What kind of special nuclear materials are 'unaccounted for' and how much is 'unaccounted for'?"

ERDA Response:

As is explained in the attached news release, the Atomic Energy Commission (AEC) requested a study through the National Security Council of the national security and international implications of releasing data on "material unaccounted for." It is expected that the study will be completed in the next few months. Pending the completion of the study it would be inappropriate for us to release such data.

Comment (page 1):

"What responsibility does NRC have in regard to radioactive monitoring in and around nuclear fuel cycle facilities? Is

plutonium monitoring done outside of each facility handling plutonium in this area? (i.e. NUMEC, Bettis, Large, Waltz Mills, and Cheswick)"

ERDA Response:

The NRC requires that each licensee establish and maintain a program of monitoring for radioactivity to protect his workers and the general public. The adequacy of this program is evaluated before a license is issued and the results of the monitoring program are examined periodically by NRC inspectors.

A general description of the types of monitoring performed by fuel cycle licensees and descriptions of the environmental monitoring programs of the Nuclear Materials Division of the Babcock and Wilcox Company (formerly NUMEC) and of Westinghouse Electric Company at Waltz Mill are described in the enclosure to the attached copy of a letter from the AEC to you dated August 26, 1974.

The environmental monitoring program at Cheswick is similar to those discussed above. Air samples are taken both on- and off-site. Water samples are collected at six locations, including the Allegheny River. In addition, sediment, fish, soil and vegetation samples are collected. Analyses of these samples include evaluation of plutonium content.

The possession of plutonium at Large is limited to 160 grams in the form of an encapsulated heat source. Because of the containment of the plutonium within a sealed source, environmental sampling for plutonium is unnecessary.

In addition to the monitoring programs performed by the licensees, both NRC and the Environmental Protection Agency (EPA) conduct special studies and independent monitoring programs at selected licensed facilities to determine the impact of these facilities on the environment. With the cooperation of the Babcock and Wilcox Company and NRC, the EPA has recently initiated a special study at the B&W plutonium fabrication plant in Leechburg. The study will include collection and evaluation of air exhaust stack samples, environmental air samples at three locations outside the plant, and local soil and vegetation samples at sites both upwind and downwind of the plant.

The Bettis Laboratory does not fabricate plutonium fuels. The environment around Bettis is routinely monitored for radiation levels and the presence of radioactive material. The Bettis Laboratory emissions have always been well below Federal standards. Estimated exposure due to effluents from Bettis is less than the 5 millirem value (See next Comment and Response).

Comment (page 1):

"How do the current fuel cycle facility radiation emission standards compare with the 5 mrm at boundary site standard for a nuclear power facility"?

ERDA Response:

It is important to distinguish between radiation protection standards and numerical guides for design objectives. All NRC licensees are subject to the same radiation protection standards, which are contained in Part 20 of Title 10 of the Code of Federal Regulations. Part 20 includes limits on concentrations of radioactive material in effluents to an unrestricted area to protect the health and safety of the general public. In addition, Part 20 requires that licensees make every reasonable effort to maintain releases of radioactive material to unrestricted areas as far below the specified Part 20 standards as practicable. Numerical guides for design objectives are being developed for specific types of licensed activities to provide a quantitative expression of the meaning of "as low as practicable."

The 5 mrem exposure guide referenced above was a numerical guide for design objectives developed specifically for light-water-cooled nuclear power reactors (LWR's). A public hearing on the proposed design objectives for LWR's was held and on April 30, 1975, the Nuclear Regulatory Commission rendered a decision in this matter. The Commission decision revised the design objective for limiting the annual dose or dose commitment to any organ of an individual at or beyond the site boundary to 15 mrem. The Commission decision emphasizes that the numerical guides for design objectives which the Commission adopted are not radiation protection standards.

The NRC is in the process of developing numerical guides for design objectives for fuel cycle plants. Pending the establishment of such guidance, these plants are evaluated on a case-by-case basis to determine that appropriate effluent treatment systems are employed to reduce emissions to a level that is "as low as practicable," considering available technology.

Comment (page 1):

"I do not believe that current methods of safeguarding special nuclear materials are adequate to prevent theft by a determined group of persons."

ERDA Response:

Current safeguards standards, their implications, and their adequacy are thoroughly reviewed in the PFES (Volume IV, Section 7.4.7. and Appendix IV.A). It is stated therein that, while current safeguards are acceptable and adequate for the present, the anticipated introduction and expansion of fuel cycle modifications, along with the continued threat of anti-social acts, will require increasingly stringent safeguards. The currently expanding safeguards R&D program has supplied and will continue to supply the techniques necessary to implement these safeguards improvements.

Comment (page 2):

> "What kind of waste treatment systems are in effect at the nuclear facilities in this area-especially Cheswick, Bettis, and NUMEC? Are any additional waste treatment systems planned for those facilities"?

ERDA Response:

At Cheswick, process liquid wastes are collected in containers, solidified, and shipped to licensed waste burial grounds. Nonprocess liquid wastes (which have a low probability of contamination) are collected in holding tanks and analyzed for radioactivity. If the concentration of alpha radioactivity is no greater than 5% of the standard contained in 10 CFR Part 20 for release to a sanitary sewage system, the liquid is pumped through a filter designed to remove very small particles and is released into the sanitary sewage system. All air exhausts from the fuel fabrication area are filtered by at least two stages of high efficiency particulate air (HEPA) filters in series to remove airborne particulates.

The waste treatment systems at the B&W (formerly NUMEC) plutonium plant are similar. Process liquids are solidified and shipped to waste burial grounds. Nonprocess liquid wastes are collected in holding tanks and monitored. If the concentration of radioactivity is not excessive the liquid is released to the Kiskiminetas River. Air exhausts from the fuel fabrication area are filtered by at least two stages of HEPA filters.

Safety and environmental reviews will be conducted in connection with the renewal of licenses for use of special nuclear material at these plants. These reviews will include an evaluation of waste treatment systems to determine whether effluents are being maintained "as low as practicable" or whether additional waste treatment systems are warranted.

The Bettis Laboratory processes liquid wastes through treatment systems which include filters, activated charcoal beds, ion exchange beds and by

evaporation. In some instances, processed water is recycled back to the operating area eliminating liquid release to the environment. The quantity of radioactive material in water released from Bettis has been too small to have a significant effect on the environment.

Comment (page 3):

> "I HEREBY REQUEST THAT A COMPREHENSIVE ENVIRONMENTAL IMPACT STATEMENT BE PREPARED TO INCLUDE ALL OF THE NUCLEAR ACTIVITIES CONDUCTED BY BABCOCK AND WILCOX IN APOLLO AND LEECHBURG. MY LIFE AND HEALTH, AND THOSE OF MY FAMILY MAY BE AFFECTED BY THE NUCLEAR ACTIVITIES AT APOLLO AND LEECHBURG* THEREFORE I REQUEST THAT PUBLIC HEARINGS BE HELD BEFORE ANY ISSUANCE OR RENEWAL OF ANY NUCLEAR LICENSE TO THE ABOVE MENTIONED FACILITIES. Have Environmental Impact Statements ever been written for Bettis, Cheswick, Large, and Waltz Mill? If not, I ask that this be done immediately and that such information be made public."

ERDA Response:

NRC rules and regulations regarding implementation of the National Environmental Policy Act of 1969 (NEPA), the provisions for public hearings, and the procedures and requirements for requests for a hearing in any licensing action were described in the letter from the AEC to you dated January 17, 1975, a copy of which is attached. There have been no significant changes in any of this information. With respect to the B&W plants, a decision of the appropriate course of action in implementation of NEPA cannot be made until receipt of the applicant's environmental information and review of this information by the NRC staff.

The Westinghouse Electric Company has submitted environmental information regarding their Cheswick plant in connection with an application for license renewal. This information will be evaluated in accordance with the procedures described in the January 17 letter.

The licenses issued to Westinghouse for use of special nuclear material at Large and Waltz Mill were issued prior to NEPA and environmental impact statements have not been prepared for these plants. The present uses of special nuclear material at both Large and Waltz Mill are very limited in scope and renewal of such licenses are not necessarily subject to the requirements of 10 CFR Part 51.

Annual effluent and environmental monitoring reports prepared for the Bettis Laboratory have been issued which assess the effect of Laboratory operation. As mentioned earlier the Bettis Laboratory does not fabricate plutonium fuel.

Evaluation of the radiological, chemical, and biological environmental data indicate that operation of the Bettis Laboratory continues to have no measurable effect on the quality of the human environment.

Comment (page 3):

> "One of the alternative technology options to the LMFBR is the Light Water Breeder Reactor. The LWBR is discussed in Volume III. As a preface to discussing the LWBR-I note that it seems that Admiral Rickover, in his own inimitable style, has succeeded in getting the LWBR excluded from the regular licensing process. ERDA rather than NRC is to assure safe operation of this reactor. 'Thus the double standard of promotion and regulation will continue at Shippingport' (Beaver County Times - December 27, 1974)"

ERDA Response:

As has been previously stated by the Atomic Energy Commission, the LWBR conversion is being treated in a manner consistent in all significant respects with that of a licensed commercial plant.

A Safety Analysis Report will be available to the public this year, covering operation of the LWBR core in Shippingport. This report will receive the same NRC review that would be made for a commercial licensed facility under similar circumstances, including a review by the Advisory Committee on Reactor Safeguards.

Comment (page 4):

> "The LWBR work at Shippingport is proceeding although an Environmental Impact Statement has not yet been filed. If the precedent being set at Shippingport is followed in case of conversion of other PWR's to LWBR's it will certainly help to 'streamline the licensing process'."

ERDA Response:

The draft LWBR Environmental Statement was issued in August of this year. Public hearings will be conducted in Pittsburgh starting in December of 1975.

Because the Shippingport Atomic Power Station is essentially a facility for developing and testing reactor core concepts, a precedent will not be set in cases involving conversion of commercial Light Water Reactors for the use of LWBR cores.

Comment (page 4):

"The fuel elements in the LWBR consist of pelletized nuclear fuel materials encapsulated in high integrity ziracloy rods.... A brief discussion of the chemical and metallurgical behavior of zirconium alloys would have helped...."

ERDA Response:

Zircaloy has been used for many years as cladding material for both naval and commercial fuels with complete success. This alloy is composed principally of zirconium with small amounts of other metals such as iron, tin, and chromium. Zircaloy has good nuclear characteristics and at the same time maintains its strength and corrosion resistance under reactor operating conditions.

Comment (page 4):

"The Shippingport core will normally be fueled and defueled by removing complete modules after the vessel closure is removed." (VOL III page 6A1-117) How frequently will this need to occur?

ERDA Response:

The LWBR core will be installed and operated approximately three years without any intermediate refueling.

Comment (page 4):

"Where are the fuel fabrication plant and the fuel reprocessing plant for the Shippingport LWBR to be located? or where are they located? Has the problem of the formation of U-232 with its daughter products that give off penetrating gamma radiation been solved"?

ERDA Response:

At present, there are no plans for permanent LWBR fuel fabrication or fuel processing plants. After about three years operation in the Shippingport Plant, the entire core will be shipped to the expended core facilities at the Idaho National Engineering Laboratories.

The fuel for the LWBR core to be installed at Shippingport was fabricated at Bettis.

The radiation present from the uranium-232 daughter products requires that fuel fabrication take place within shielded facilities. A great deal of practical experience exists within the nuclear industry in handling radioactive materials within shielded facilities. Shielded facilities were used during fabrication of the LWBR core.

Comment (pages 4-5):

> "I object to a nuclear experiment, such as the LWBR being conducted in an area as densely populated as the Pittsburgh area....I am aware- and distressed-that Pennsylvania is one of the States that has been chosen in which to push the energy park concept....The Shippingport reactor was the first commercial nuclear reactor in the United States. It started operation in 1957. WHY is the radiation monitoring so inadequate in Pennsylvania?
>
> "If one does not know background radiation levels it will be difficult or impossible to state with accuracy how much radiation a large nuclear complex adds."

ERDA Response:

The LWBR core will operate in the existing Shippingport plant, which is not part of a nuclear park. The safety aspects of such operation are well proven and it does not constitute an "experiment".

Natural background levels in the Pittsburgh area are accurately known and continually monitored. Background levels have been determined over wide areas by aerial surveys as well as by sensitive ground level monitoring in regions around nuclear facilities. Monitoring of background radiation levels has been conducted by the Commonwealth of Pennsylvania, the U.S. Environmental Protection Agency, the U.S. Energy Research and Development Administration (formerly AEC) as well as the nuclear facilities. Monitoring around the Shippingport Plant by the Duquesne Light Company has not detected any increase above natural background radiation levels as a result of operations within the facility. Details of this monitoring are reported in annually published Duquesne Light Company environmental monitoring reports. Questions pertaining to the monitoring performed by the Commonwealth of Pennsylvania should be referred to Pennsylvania.

The proposal for an energy park in Pennsylvania was initiated by a group of utilities in that state as an alternative to locating new plants at a large number of dispersed sites. Whether it be for a single reactor or the 4 to 8 reactors in an energy center, radiation monitoring is an

important part of nuclear plant planning. For several years prior to operation of a reactor a utility is required to conduct measurements to establish background radiation levels in the vicinity of the nuclear plant. The earliest startup date for a reactor in an energy park in Pennsylvania would be 1987, and thus there would be adequate time to establish background radiation levels. Further, if an energy park is built in Pennsylvania, it will most likely be in an area which does not now have nuclear facilities.

Attachments: (1) United States Atomic Energy Commission News Release No. U-3, January 2, 1975.
(2) Letter to Ms. Pat Hoffman from S. H. Smiley dated August 26, 1974, with enclosure.
(3) Letter to Ms. Pat Hoffman from Howard J. Larson dated January 17, 1975, without enclosures.



No. U-3
Contact: Joseph J. Fouchard
Tel. 301/973-4538

FOR IMMEDIATE RELEASE
(Thursday, January 2, 1975)

NOTE TO EDITORS AND CORRESPONDENTS:

The Atomic Energy Commission has received a number of inquiries concerning the amount of plutonium and highly enriched uranium which is unaccounted for in the nuclear industry.

Consistent with its national security responsibilities the Commission wants to be as responsive as possible to these requests. It is therefore requesting that a short-term study be conducted through the National Security Council to consider the national security and international implications of releasing data on "material unaccounted for" and to make recommendations on the manner in which this information should be handled.

"Material unaccounted for" usually results from measurement instrument inaccuracies. It also could result from the physical inventory not reflecting those quantities of materials that adhere to process equipment (pipes, filters). Further, it could be due to measurement and reporting errors by employees.

The Commission wishes to emphasize that strict security procedures are in force at all plants which handle significant quantities of plutonium and highly enriched uranium. Measures are in force to prevent theft or diversion. Security measures include personnel monitoring devices, checking of packages entering or leaving a facility, guards and barriers such as fences, and alarms. In recognition of the increase in acts of sabotage and terrorism in society today, and the fact that the uses of nuclear material are growing, the AEC has had a major effort underway to strengthen future procedures for protecting nuclear material in the fuel cycle, nuclear power program and transportation.

Recent news reports have contained several unverified statements concerning "material unaccounted for" at specific facilities.

(Continued on Reverse)

One report said that there were two known instances where Government employees were discovered to have smuggled out enough special nuclear material to make a nuclear weapon. No such instances have occurred.

Another report involves material at the AEC's gaseous diffusion plants. These plants have been operating for more than 20 years. During that span of time substantial quantities of material have collected on equipment and on filters in the plants. This is considered to be "material unaccounted for." Whenever equipment is removed and replaced, the enriched uranium has been recovered. It should be noted that a major fraction of this material is low enriched uranium which could not be used for weapons purposes.

Press stories also have discussed "material unaccounted for" at the Kerr-McGee Corporation plant at Crescent, Oklahoma. The most recent inventory of plutonium at that facility shows that only a small amount of material is unaccounted for. Whenever it appears that the total of "material unaccounted for" at a licensee facility exceeds a limit imposed by AEC, the plant shuts down and makes an immediate inventory. On two occasions in the last year Kerr-McGee has done this. The quantity of "material unaccounted for" was determined to be small and well within normal levels.

JAN 17 1975

Ms. Pat Hoffman
24 Salem Drive, RD #4
Greensburg, Pennsylvania 15601

Dear Ms. Hoffman:

This is in reply to your letter of December 13, 1974 to Mr. S. H. Smiley regarding the NUMEC operations conducted at Apollo, Pennsylvania and near Leechburg, Pennsylvania, under authority of AEC materials licenses. For your information, effective January 1, 1975, the official name of the licensee was changed from Nuclear Materials and Equipment Corporation (NUMEC) to the Nuclear Materials Division of the Babcock and Wilcox Company (B&W).

You requested information regarding the provisions for public hearings as related to renewal of these licenses. AEC regulations implementing the Atomic Energy Act of 1954, as amended, do not require holding of a public hearing for the issuance or renewal of a materials license unless a public hearing is requested by a person whose interest may be affected. AEC materials licenses, the type held by B&W, are licenses issued under the provisions of AEC regulations 10 CFR Parts 30, 40 and 70. (Licenses for production and utilization facilities, for example nuclear reactors and fuel reprocessing facilities, are issued pursuant to 10 CFR Part 50.) The procedures and requirements for a petition for leave to intervene and requests for a hearing in any licensing action are set forth in Section 2.714, 10 CFR Part 2 of the AEC regulations. A copy of 10 CFR Part 2 is enclosed for your information. Also, please note the discussion concerning petitions for leave to intervene in Appendix A to 10 CFR Part 2. Provisions for limited appearances at a hearing are specified in Section 2.715 of Part 2 and also are discussed in Appendix A.

As you indicated in your letter, the AEC Regulatory staff has been reviewing applications submitted by NUMEC in connection with renewal of Materials Licenses No. SNM-145 (Docket 70-135) and SNM-414 (Docket 70-364). These licenses cover the majority of the activities at the Apollo and Parks Township (Leechburg) sites, respectively. The subject renewal applications were submitted May 31, 1972 for License No. SNM-414 and October 31, 1972 for License No. SNM-145. The staff's review of these applications was delayed and questions were not transmitted to the licensee until August 20, 1974 for SNM-414 and October 11, 1974 for SNM-145. Because of the extent and nature of the questions and because of changes in the licensee's organization and administration, the staff has agreed with the licensee

that a complete revision of the renewal applications is appropriate. Accordingly, B&W has indicated that a totally revised renewal application will be submitted early this year for License No. SNM-414 to be followed in about three months by a revised application for License No. SNM-145.

The renewal applications are for the purpose of updating and consolidating descriptions and safety requirements of previously authorized activities and are not expected to add new operations. In accordance with AEC regulations, the existing licenses, as amended, continue in effect until a final determination is made by the AEC on the requests for renewal.

Copies of the revised renewal applications, when submitted by B&W, will be placed in the local public document file at the Apollo library. We also are placing copies of the staff's letters of August 20 and October 11, 1974 in this file. As noted above, these letters reflect the staff's reviews of the earlier renewal applications. We do not have spare copies of the 1972 renewal applications for the Apollo library file nor, as we understand, does the licensee. However, in view of the fact that these documents are soon to be superseded, we hope that the above arrangements are satisfactory. Copies of the applications, as well as other licensee correspondence, are available for public inspection at the AEC Public Document Room located at 1717 H Street, N. W., Washington, D. C.

The NUMEC licenses were issued a number of years ago, prior to the time that the National Environmental Policy Act of 1969 became effective. Thus, no environmental impact statements have been prepared by the AEC covering these activities. However, in accordance with 10 CFR Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," both of the license renewal actions discussed above require an evaluation by the AEC to determine if an environmental impact statement should be prepared. If it is determined that an environmental statement need not be prepared, a negative declaration and an environmental appraisal will be prepared. A copy of 10 CFR Part 51 is enclosed; your attention is directed to §51.5(b) (3) and §51.5(c). To provide a basis for the staff's evaluation and subsequent determination, B&W has indicated that it will submit by June 1975 appropriate environmental information for the activities conducted under Licenses No. SNM-145 and SNM-414. Copies of these submittals and any related correspondence will be placed in the document file at the Apollo library for public inspection.

Ms. Pat Hoffman

If you have any further questions regarding these matters, please let me know.

Sincerely,

Original Signed by
Howard J. Larson

Howard J. Larson
Acting Deputy Director
for Fuels and Materials
Directorate of Licensing

Enclosure:
10 CFR, Part 2
10 CFR, Part 51

cc: Mr. W. A. Cameron
Nuclear Materials Division
Babcock and Wilcox Company
609 N. Warren Avenue
Apollo, Pennsylvania 15613

V.68-22

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

AUG 2 6 1974

Ms. Pat Hoffman
24 Salem Drive, R.D. 4
Greensburg, Pennsylvania 15601

Dear Ms. Hoffman:

I am pleased to reply to your letter of July 10 to Dr. Ray.

With respect to your request for a file of safety related information for all nuclear facilities within a 50-mile radius of Greensburg, Pennsylvania, we recently sent Senator Schweiker a letter concerning the local public document rooms that have been established in Pennsylvania. These local files of documents pertaining to a particular facility are set up in the vicinity of the facility. There are two near Pittsburgh: the Beaver Area Memorial Library, Beaver, Pennsylvania (Duquesne Light Company); and the Apollo Memorial Library, Apollo, Pennsylvania (Nuclear Materials and Equipment Corporation). Since we wrote Senator Schweiker, we have taken action to establish a local public document room for the activities of the Westinghouse Electric Company in the greater Pittsburgh area. We will notify you of the location when it has been chosen.

Your questions about the activities, monitoring, and emergency planning for Nuclear Materials and Equipment Corporation (NUMEC) and the Westinghouse operations at Waltz Mill are answered in the enclosure to this letter.

Sincerely,

S. H. Smiley, Deputy Director
for Fuels and Materials
Directorate of Licensing

Enclosure:
Answers to Questions

Answers to the Questions asked by Pat Hoffman, letter dated July 10, 1974

NUMEC - Apollo and Leechburg, Pa.

1. What amounts and kinds of radioactive materials does NUMEC handle? What form is the material in?

NUMEC has three licenses for the possession and processing of radioactive materials: SMB-502, Docket No. 40-1193; SNM-145, Docket No. 70-135; and SNM-414, Docket No. 70-364. Their possession limits for the various materials are as follows:

SMB-502: Natural or depleted uranium or thorium - no limit

SNM-145: Total U-235 isotope in uranium - 7850 kilograms, distributed as:

UF_6 and scrap with more than 5% U-235 - 2100 kg uranium

UF_6 and scrap with less than 5% U-235 - 115,000 kg uranium

SNM-414: Total plutonium and/or uranium containing greater than 5% U-235 isotope - 2000 kilograms;

Plutonium-238 isotope - 120 grams;

Uranium-233 isotope - 4000 grams; and

Uranium containing not more than 5% U-235 - 223,000 kg.

The radioactive materials are generally received as metal, UF_6, or oxides in approved shipping containers. They are possessed and used in various chemical, ceramic, or metallurgical forms, and generally leave the plants as encapsulated fuel forms such as oxides, ceramics or metal alloys.

2. What kind of monitoring of radioactive material is done at NUMEC? What kind of monitoring of radioactive material is done in the area surrounding NUMEC? What is the size of the area monitored around NUMEC?

In general, the AEC requires that each licensee establish and maintain a program of monitoring for radioactivity to protect

his workers and the general public, as well as to show compliance with our regulations. The adequacy of this program is evaluated before a license is issued, and the results of the monitoring program are examined periodically by AEC inspectors.

The inplant monitoring generally includes air sampling to determine concentrations of airborne radioactive particulates in the work areas, radiation dosimetry to measure the dose to individuals from external radiations such as beta, gamma, and neutrons, and radiation surveys with instruments to determine the presence of radiation in work areas. In addition to radiation monitoring, those plant features which contribute to radiation safety, such as ventilation systems, air filters, etc., are periodically monitored for satisfactory performance.

All effluents from a plant must be measured for radioactivity before being released. In the case of effluent air from the plant, samples are taken, usually at the point of discharge. Liquid effluents are also measured, most commonly by collecting in a holding tank, taking a sample and analyzing the sample before the contents of the holding tank are released. In some instances, liquid wastes are not released from a plant but are solidified and handled as a solid waste. Solid wastes are not released to the plant environs. After measurement to determine the amount of radioactivity present, solid wastes are transferred to a licensed disposal site where they are buried.

Additional samples may be taken outside the plant to assess the impact on the environment of the plant effluents.

NUMEC has an environmental monitoring program which includes the sampling of the Kiskiminetas River, both above and below the plant. They maintain a meteorological station and take air samples at several selected locations at the plant site and in the unrestricted area around the plant. Periodic soil and vegetation samples are taken to confirm and augment the other samples in the unrestricted area, and special sampling programs would be initiated whenever there is any evidence that any loss of control may have occurred. Most off-site samples are taken within a mile of the plant, with others taken up to 5 miles from the plant.

The AEC periodically inspects the plants and reviews the operations and records to assure that NUMEC is operating within the established limits.

3. What is the largest credible accident that could occur at NUMEC and what would be the possible/probable effects on people in the surrounding area?

A principal objective in the design and operation of fuel processing and fabrication facilities is the prevention of accidents which could result in the uncontrolled release of radioactive material. In addition, safety systems and procedures are utilized to mitigate the consequences of an accident in the unlikely event that one should occur. For example, the ventilation systems contain highly efficient filters that have protective fire screens ahead of them.

In assessing the adequacy of the design of a plant such as NUMEC's, no single maximum credible accident is considered; rather, certain accidents of concern for the type of operations conducted are postulated. The three accidents considered for NUMEC are fire, chemical explosion, and nuclear criticality.

In the case of fire, the emphasis is on prevention, early detection, and prompt corrective action. Wherever possible, noncombustible or difficult-to-ignite materials of construction are used, and the presence of other combustible materials in the processing areas is strictly controlled and kept to a minimum. Heat sensitive instruments are installed to automatically activate an alarm in the event of fire. A manually activated fire alarm system is also provided. Powder type fire extinguishers and inert gas systems are provided in the glove boxes to extinguish fires. Fires outside of the glove boxes are controlled with fire extinguishers and conventional fire fighting systems that are used by the plant fire brigade or the local firefighting companies.

In the case of chemical explosion, the emphasis is on preventing conditions which could result in explosions and the detection of such conditions so that corrective action can be taken. Solvents and flammable gases are stored outside the buildings and are used in limited and controlled quantities in the buildings. Inspections and sample analyses are also used to help minimize the potential for explosion conditions.

In the case of nuclear criticality, the emphasis in on prevention, through the design of equipment and its spacing, and through rigorously enforced rules which assure that the nuclear safety parameters are not violated.

It is possible to postulate accidents that would be more severe than those considered in the design of the plant which, if they occurred, could cause off-site effects; however, if the probability of such accidents happening is sufficiently low, the resulting risk is judged to be acceptable when compared to other public risks.

Safety reliance is not placed on just the plant design. To assure that licensees are prepared to cope with emergencies, the AEC requires that they have an emergency plan of action that is designed to protect the health and safety of the public. This plan requires that prearrangements be made with the local policemen, firemen, hospitals, public health officials, and others necessary to provide assistance. The license plan is backed up by AEC response teams, consisting of trained and equipped radiation safety personnel. These teams are strategically located around the United States and can go into action on short notice. As may be necessary, the radiological assistance plans of the AEC could involve the full resources of the Federal government.

Almost all accident possibilities that might be postulated at NUMEC would be contained within the plant and would not affect people in the surrounding area. In the highly unlikely event that an accident breached the confinement systems and allowed airborne materials to be released, NUMEC has developed plans for the evacuation of people downwind from the plant and the subsequent stabilization and decontamination of the areas, thus minimizing the effects on people in the surrounding area.

4. How would people of the area be notified if NUMEC had a large scale accident involving radioactivity? If such an event should occur, what kind of actions are recommended for people of area surrounding NUMEC?

NUMEC's emergency plan involves coordination with the local and state police to control the movement of people in any area that might be affected by a plant accident involving the release of radioactive material. A member of NUMEC management is responsible for contacting the local radio, television, and newspaper offices and keeping the public informed of any emergency control areas established. NUMEC has the responsibility for regaining control of the plant problems, of stabilizing the radioactive materials in the off-plant areas, and for decontaminating the plant and off-site areas. The nearest AEC Radiological Assistance Team to provide assistance in such an

emergency is located at the AEC's Pittsburgh Naval Reactors Office. Further information on the Radiological Assistance Program can be obtained from the Brookhaven Area Office, USAEC, Upton, New York 11973.

People in the area should cooperate with the parties responsible for attaining the above objectives, following directions from the local law enforcement agencies and staying away from the plant areas or any off-plant areas that have been placed under restrictions.

Westinghouse Electric Company - Waltz Mill, Pa.

1. What kind of monitoring of radioactive material is done at Waltz Mills? What kind of monitoring of radioactive material is done in the area surrounding Waltz Mills? What is the size of the area monitored around Waltz Mills?

   Westinghouse monitors, by means of air samples, radiation surveys, and personnel dosimetry, all radioactive materials at their plant. For example, all personnel working in restricted areas wear film badges or pocket dosimeters to record their radiation exposure, a practice that is common to licensed activities. These devices are supplemented by radiation surveys using sensitive instruments. Both in-plant air and effluent air leaving the buildings are monitored and the radioactivity measured to assure that employees and the public are not exposed to concentrations of radioactivity in excess of that permitted by the regulations. All liquids which might contain radioactivity are collected in retention tanks for sampling and measurement. If the liquids are found to contain radioactivity in excess of release limits, they are processed to remove the radioactivity to an acceptable level.

   Air samples are collected on-site at distances up to one mile from the central operations area, in order to provide data to supplement the measurements made on the air as it is discharged from the plant. Similarly, water samples are taken at two locations on-site from Calleys Creek and at two locations off-site from Sewickley Creek. Silt samples are collected from Calleys Creek above and below the point where liquids are discharged.

2. What is the largest credible accident that could occur at Waltz Mills and what would be the possible/probable effects on the people in the surrounding area?

Since the Westinghouse Test Reactor and the hot cells formerly used for work on irradiated fuel and irradiated reactor components have been shut down, the inventory of radioactive material at the site has been reduced considerably. The principal activity at Waltz Mill is in the analytical laboratories. Accidents in these operations would not be expected to release radioactivity from the confines of the buildings and therefore, would not affect the public.

3. How would people of the area be notified if Waltz Mills had a large scale accident involving radioactivity? If such an event should occur, what kind of actions are recommended for people of area surrounding Waltz Mills?

Westinghouse maintains emergency plans to deal with the consequences of an accidental release of radioactivity. This plan has provisions for notifying civil authorities and disseminating information to the public. As with all emergency plans for licensed facilities, the plan is coordinated with local law enforcement authorities and public health agencies. The Westinghouse emergency plan has the same basic characteristics as the NUMEC plan (see question 4 above).

1233 Gloria Drive
Santa Rosa, California 95401
April 7, 1975

Mr. W.H. Pennington
Assessment and Coordination Officer
Division of Biomedical and Environmental Research
Energy Research and Development Administration
Washington D.C.

Dear Sir:

I have perused the environmental impact report recently issued by the AEC relative to its proposal to develope the Liquid Metal Fast Breeder Reactor. After some deliberation it is my sincere opinion that the LMFBR program would be for our nation an extremely unwise decision. The benefits promise to be great, almost invaluable. But the risks, the dangers of such a course, are commensurately high. These risks do not seem to be fully realized by the AEC report.

As regards the security of LMFBR fuel, for instance, the AEC report is dreamily reassuring. The report states in its section dealing with Waste Management Facilities, "The technology and facilities required for management and disposal of radioactive waste from the LWR fuel cycle will be directly applicable to the management of radioactive waste generated by the LMFBR fuel cycle."" Due to the introduction of plutonium waste such an assumption is questionable. Can, for instance, the Energy Resources and Development Administration guarantee the security of LMFBR waste should the LMFBR be made available to foreign governments? Can the ERDA guarantee the security of LMFBR wastes for the complete duration of their fertile and fissile lives? Particularly in light of today's rapidly changing conditions. Can the ERDA guarantee the stability of any government for the fertile or fissile life of Plutonium 239? The seriousness of LMFBR technology dictates that it must. The lives and health of too many people, too many generations, weigh in the balance.

One has to ask oneself when thoughtfully considering risks as high as these, is not there some other way to achieve the same ends. I believe there is. In fact there appear to be several, a combination of which could satisfy our legitimate needs. First of all the ERDA should join with HUD, HEW, Transportation, EPA, and Congress in the development of a comprehensive national land-use, transportation, and energy policy aimed at the conservation of energy and other resources. The thrust of such a policy should be to bring the other bounding paramenters of the American way of life in line with its bounded, limited resources. We know the bounds of our resources. And "deficit spending" in this area is clearly unacceptable. Such a policy should be our top priority.

In addition to this, we as a nation should invest in the development of less-polluting, lower-cost, lower-risk solutions to out energy problem. These solutions should include solar power, geothermal power, and as a more valid justification for extravagant spending, nuclear fussion. Man has lived before on a lower energy diet than he does today. If necessary he can learn to do so again. Given LMFBR technology, however, it is quite possible that he may be deprived of that option.

Respectfully submitted,

Douglas W. Scott

cc. Senator Alan Cranston
Environmental Protection Agency
Natural Resources Defense Council
Task Force Against Nuclear Pollution

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Douglas W. Scott
1233 Gloria Drive
Santa Rosa, California 95401

Dear Mr. Scott:

Thank you for the comments in your letter of April 7, 1975 on the impact of the Liquid Metal Fast Breeder Reactor (LMFBR).

We appreciate your concerns about the security of plutonium wastes generated in the LMFBR fuel cycle. As shown in Table 9.1-4 of the Proposed Final Environmental Statement (PFES) for the LMFBR Program, wastes containing plutonium are produced in the Light Water Reactor (LWR) and High Temperature Gas Cooled Reactor fuel cycles as well as in the LMFBR fuel cycle. Plutonium is produced by neutron capture primarily in uranium-238 which is present in varying amounts in all nuclear power reactor fuel. Plutonium will be present in the radioactive wastes from all spent fuel processing. Thus, the technology for radioactive waste management for the LMFBR fuel cycle will be nearly the same as that for the LWR fuel cycle, and the waste management problem exists whether or not LMFBR development proceeds.

Quite obviously, ERDA cannot guarantee the security of LMFBR wastes nor the stability of any government for even one half-life of plutonium (24,000 years). However, such a guarantee should not be necessary. As discussed in Sections 4.6 and 7.3.5 of the PFES, the near-term management program for high-level waste assumed retrievable surface storage for safekeeping only until a safe and acceptable ultimate disposal method has been selected and tested. Surface storage, if used, is considered to be a safe method for all credible occurrences. It does, however, impose the requirement of human surveillance while it is in use. Thus a substantial program of analyses of potential disposal alternatives is going forward as is a development program on disposal in geological formations, one of the possible ultimate disposal alternatives. Further information on the waste management program can be found in Section III D of the Final Environmental Statement.

Regarding the management of LMFBR wastes by foreign governments, it is important to recognize that intensive development of the LMFBR is underway in a number of countries, France, Russia, and Great Britain among others, and that some of these programs are further advanced than ours. Thus, any decision on our part to not proceed with development of the LMFBR may not have any effect on the proliferation of LMFBR waste.

It is true, as you state, that "Man has lived before on a lower energy diet than he does today. If necessary he can learn to do so again." Many individuals feel this way and have voluntarily elected to adopt a more simple lifestyle. However, attractive as this may appear to be, it is not believed to be a viable alternative for the Nation as a whole when one considers the dependence of the great majority of the population on the industrial economy for their existence. The most optimistic projection of reduction in energy usage through maximum energy conservation efforts is no more than a 30% reduction by the year 2000 from energy projections that vary between doubling or tripling our current energy usage by the year 2000. Thus it can be seen that extensive new energy sources must be found even under the most favorable energy conservation projections. This is made especially urgent when one considers the dwindling oil and gas reserves available to the Nation.

In your letter you suggested that the Nation should invest in alternative sources for power generation such as solar and geothermal energy. ERDA agrees and is actively engaged in developing alternative energy systems. Although the environmental review of the LMFBR Program has led ERDA to conclude that continuation of research, development and demonstration of the LMFBR concept is needed, continuation of the LMFBR Program will not be at the expense of alternative power generation and conservation concepts, which must be developed on a priority basis. Indeed, these other technology options, which are examined in Section II of the Final Environmental Statement, are receiving substantially increased appropriations in the current fiscal year and are proceeding at a pace limited only by the need to build up the new programs efficiently and effectively.

We are sending you a copy of the LMFBR Program Final Environmental Statement. We suggest particularly that you read Section II, 6A of the Statement where, "lower-cost, lower-risk solutions to our energy problem," such as solar and geothermal, among others, are examined. We also suggest that you read Section II, 6C which evaluates conservation as an alternative to the LMFBR Program.

It is hoped that your review of the enclosed Final Environmental Statement will alleviate your concerns. We appreciate your comments and your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

April 8, 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental
Research
Energy Research and Development
Administration
Washington, D. C. 20545

Dear Mr. Pennington:

This is in response to your request for comments on the AEC's proposed Final Environmental Impact Statement for the Liquid Metal Fast Breeder Reactor Program (WASH-1535). This final statement is basically an updating of information, estimates, and commentary on the proposed new technologies contained in the draft statement. Therefore our review was conducted from the standpoint of our suggestions and views provided to AEC on April 29, 1974 and June 4, 1974.

We note that additional studies have been initiated for some of the technologies required by the LMFBR program as it advances to the operational stage. These studies include: the fabrication of mixed oxide fuel elements; the temporary storage of and ultimate disposal of high level and transuranic wastes produced by the reactor industry as a whole; and safeguards for plutonium, including security within the nuclear power industry.

Information in the draft statement regarding the estimates of potential health consequences has been updated in this proposed final, and utilizes health effects parameters contained in the BEIR Committee Report. However, these estimates are still within the same order of magnitude as those which appeared in the original draft statement and have been found acceptable. We find that estimated uranium production has been increased for the time span covered by the EIS. This in turn increases the potential for health impacts on persons employed in the uranium mining industry.

In conclusion, we view this environmental statement to be an improvement over the earlier draft. We note the incorporation, on pages 3 and 4 of Volume I, of our recommendation that future environmental statements be prepared

by ERDA on the significant additions and modifications to the program as they relate to plant sites, designs, new technologies, interactions with other parts of the fuel cycle, and on the entire LMFBR program as it develops.

Thank you for the opportunity to review this statement.

Sincerely,

Charles Custard

Charles Custard
Director
Office of Environmental Affairs

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Charles Custard
Director
Office of Environmental Affairs
Department of Health, Education
and Welfare
Washington, D. C. 20201

Dear Mr. Custard:

Thank you for your letter of April 8, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. It is not surprising that you found the PFES to be an improvement over the Draft Statement since it took into effect the extensive written comments received on the Draft Statement as well as the views expressed during the Public Hearing held in April 1974. Similarly, we believe you will note continued upgrading in the Final Environmental Statement (FES). The Energy Research and Development Administration (ERDA) has carefully considered all written comments received on the PFES and the testimony given at the Public Hearing held on May 27-28, 1975 in preparing the FES. A copy of the Statement is enclosed for your information.

Thank you for your review of the LMFBR Program.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program



GENERAL ATOMIC

GENERAL ATOMIC COMPANY
P.O. BOX 81608
SAN DIEGO, CALIFORNIA 92138
(714) 453-1000

April 8, 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental Research
U.S. Energy Research and Development Administration
Washington, D.C. 20545

Dear Mr. Pennington:

General Atomic Company has reviewed the proposed final environmental statement for the Liquid Metal Fast Breeder Reactor Program (WASH-1535) and the brief comments attached to this letter were prepared from that review.

We appreciate that the statement recognized the significant benefits of the HTGR, in particular the low thermal discharge and low uranium resource requirements. In addition, we appreciate the recognition of the potential benefits of the direct cycle HTGR with its potentially very high thermal efficiency.

General Atomic Company has supported LMFBR development as an important ingredient in the nation's energy R&D program. While we will continue to support the development of the LMFBR system, we are very concerned about the assertion presented in WASH-1535 that governmental support for the Gas Cooled Fast Breeder Reactor (GCFR) will terminate in 1982-83, when a decision will be made to rely solely on LMFBR technology.

At this stage in breeder reactor development, such a statement is premature and fails to recognize that two or more breeder development programs leading to eventual commercialization are in the national interest. Most of the nation's investor-owned and public electric utilities continue to actively support two or more breeder development programs, including the GCFR program at General Atomic Company. Since it is the utilities who must make the final decision on which breeder reactor system or systems will best fit their needs, it is entirely too early to predict the total success, or the ultimate choice, of one approach over all others. The governmental support policy proposed in WASH-1535 will serve to discourage private investment in the GCFR and other reactor concepts. Therefore, we recommend that the final statement be modified to reflect these considerations and serve as a stimulus rather than a deterrent to the development of reactor technology.

We also disagree with the general assumptions and conclusions presented in the cost-benefit section of the statement that helium cooled fission energy systems will play a minor role in the future national energy supply picture. For many reasons, some of which are elaborated upon in the attached comments, we expect that gas cooled technology (both HTGR and GCFR) will play a role of increasing significance.

General Atomic Company's comments are based upon the premise that WASH-1535 is intended as an assessment of the maximum environmental impact of the LMFBR program. We do not assume that this proposed final statement represents a statement of AEC reactor development policy or strategy nor that it represents AEC policy regarding the development of alternative energy sources or nuclear options. Rather, our comments are presented on the assumption that as these options are developed and become viable, the energy production mix will undoubtedly be significantly different than that presented in the "LMFBR maximum impact statement" covered in WASH-1535. We believe the report would be improved if this point was made clear in the preface.

We would be pleased to meet with you or other ERDA representatives should there be questions on our letter or attached comments.

Sincerely,

Norval E. Carey
Vice President

Enclosure

COMMENTS OF GENERAL ATOMIC COMPANY ON THE PROPOSED FINAL ENVIRONMENTAL STATEMENT FOR THE LIQUID METAL FAST BREEDER REACTOR PROGRAM (WASH-1535)

With commercial operation of HTGRs in the 1980s, the industrial base for the GCFR will be available in the late 1980s. The current development schedule calls for the construction and operation of a GCFR demonstration plant in the later half of the 1980s and construction of a commercial-sized GCFR by the mid-1990s. This schedule is not tied directly to LMFBR developments in that much of the relevant fuel technology base is currently available, and the principal commonality of future development between the LMFBR and GCFR is in the fuel cycle areas, such as reprocessing.

GCFR Development Costs

The current industrial-government program for developing the GCFR as an alternative fast breeder reactor is reviewed in the Alternatives section of WASH-1535. However, in the cost-benefit analysis section, government costs for developing a parallel breeder option, such as GCFR, are estimated as $\$5.7 \times 10^9$ (Table 11.2-2). Work on the GCFR program has reached the stage where estimates of development costs to commercialization are being made with some confidence. General Atomic Company projections indicate that only 10-20% of the amount quoted above for government costs will be required. This is based on the fact that only an incremental amount of development is required because so much of GCFR technology is common with HTGR and LWR plant technology and LMFBR fuel cycle technology. Because of the development and existence of this technology base, we believe that the assertion on pages 11.1-16 and 11.1-17 (Volume IV) that: "The AEC believes the approach recommended by GAC to be one having higher risks than the usual approach that the AEC has followed in its reactor development programs..." should note that this development approach has been used successfully for other reactor types, and that the risks are not high while the benefits are substantial.

Nuclear Fuel Resource Utilization

The analyses presented in WASH-1535 document the important environmental benefits which accrue from the utilization of our nuclear fuel resources in partnership with our fossil resources to supply the nation's energy needs. The nuclear fission development scenario assumed in WASH-1535 is one possible way in which these benefits could be obtained. However, it is widely recognized that there is another nuclear fission development approach which would also result in similar and perhaps greater environmental benefits. This approach is also being developed and involves helium-cooled advanced thermal converters (HTGRs) and helium-cooled fast breeder reactors (GCFRs). Although these are discussed under alternatives, the assumptions made about LMFBR introduction are allowed to obscure the significant role which is possible for these systems in the U.S. energy economy.

Breeder reactors can be used as fuel factories to breed uranium-233 for use in LWRs and HTGRs. In the long range, this indeed may be one prime role that

2.

the fast breeders can play, i.e., as a source of low-cost fissile material. If the breeders are high-gain breeders, they could provide a lower cost source of fissile material (U-233) than the U-235 obtained from higher cost uranium ore.

If this role for the breeder develops, then a limited number of breeders (one breeder for two or three advanced thermal reactors) would be required to satisfy the fuel requirements of advanced thermal reactors, such as LWRs using the U-233/thorium fuel cycle, and HTGRs. Nuclear fuel resources used in a power economy consisting of advanced thermal reactors and breeders would be sufficient for many centuries. The use of thorium along with uranium more than doubles the amount of economically recoverable nuclear fuel resources.

Recent changes in fossil fuel economics due to the rapid rise in oil prices and recent increased estimates of economically recoverable U.S. uranium resources should be considered by ERDA in evaluation of commercial breeder reactor scheduling. The U.S. energy resource base in economically recoverable uranium and thorium, when used in current generation LWRs and HTGRs, can be comparable to the U.S. resource of coal which is economically recoverable today. In the current fuel supply situation, use of uranium and thorium at even $100/lb is expected to be economically viable. With higher U_3O_8 costs, there would be an increasingly large incentive to favor fuel utilization in overall energy economics. The conversion ratio can be increased and fuel costs decreased in the HTGR by decreasing power density and increasing refueling frequency. The "resource optimized" HTGR assumes a power density decrease from 8.4 to 6.0 kw/liter and a change from annual to semi-annual refueling. These changes, which are within the bounds of current technology, increase the average conversion ratio of the HTGR from 0.66 to a value of 0.82. At this conversion ratio, the relative ore requirement for a plant is reduced by 47% over a 30-year lifetime.

HTGR Cost-Benefit Considerations

The benefit analyses in Section 11.2.4.2, Figures 11.2-27 and 11.2-28, show that the HTGR achieves only a modest fraction of the total nuclear power economy, even when it has an unrestrained allowable growth. This picture results from the assumption that the HTGR does not burn plutonium. In fact, the HTGR is a very efficient burner of plutonium should the need arise to it in that manner. However, as mentioned earlier, we believe that a more likely and cost effective scenario is to utilize thorium blankets in breeders and the resultant uranium-233 in LWRs and HTGRs.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Norval E. Carey
Vice President
General Atomic Company
P.O. Box 81608
San Diego, California 92138

Dear Mr. Carey:

Thank you for your letter of April 8, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. As you note, the Energy Research and Development Administration (ERDA) is well aware of the benefits that could accrue from a successful High Temperature Gas Cooled Reactor (HTGR) program leading to widespread deployment of the HTGR in the electric power economy and has been and is continuing to support programs leading to development of the full nuclear fuel cycle for the HTGR.

Your remarks regarding termination of government support of the Gas Cooled Fast Reactor (GCFR) in 1982-83 indicate that you may have misinterpreted a statement which appears on page 11.2-37 of Volume IV where the assumptions that went into constructing the Base Case for the cost-benefit analysis are laid out. In this case it is assumed that there would be no parallel breeder program so that it follows logically that the other breeder programs would be phased out once the decision had been made to proceed with only the LMFBR. This was not intended to be construed as a policy decision nor to reflect what decisions actually will be made in the mid-1980s as to whether one or more breeder reactor concepts will continue to be pursued. It should be viewed as an assumption of that particular cost-benefit case and nothing further should be construed.

With regard to the extent of the future role of helium cooled fission energy systems, the cost-benefit analyses presented in the PFES indicate that helium cooled fission energy systems (HTGRs) can play a significant role in the future national energy supply picture should the LMFBR not be commercially available or if it is greatly delayed beyond about 1990. It also notes that there is a possible role for HTGRs in a breeder economy by having the breeders provide U-233 for use in HTGRs. Regarding GCFRs the PFES notes that its economic and environmental characteristics are similar to those of the advanced LMFBRs. There is no substitution of GCFRs for advanced LMFBRs in the

analysis as there would be no change in breeder benefits. At the time when both LMFBRs and GCFRs are commercially available and economically competitive, selection of which breeder to build will be made by individual utilities based upon their specific situation in a manner analogous to the selections being made among Boiling Water Reactors, Pressurized Water Reactors and HTGRs today.

You are correct in your assessment that the PFES does not represent ERDA policy on LMFBR development or development of alternative energy sources. ERDA policy, to the extent that it appears in the Final Environmental Statement (FES), is reflected in Sections I and IV A of the FES.

ERDA responses to your specific comments are enclosed herewith as is a copy of the Final Environmental Statement for your information. Thank you for your considered comments on the Proposed Final Environmental Statement, and we hope this letter and the responses to your specific comments will clarify the points you have raised.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Responses to Comments by General Atomic Company

Comment (p. 1):

> "GCFR Development Costs
> ...in the cost-benefit analysis section, government costs for developing a parallel breeder option, such as GCFR, are estimated at $\$5.7 \times 10^9$ ...Company predictions indicate that only 10-20% of the amount...will be required..."

ERDA Response:

This comment was made in essentially the same terms in the General Atomic Company response to the Draft Environmental Statement. Response was provided in the PFES in Volume III, pages 6A.1-141 and -142. Experience since preparation of the PFES has not led ERDA to believe that any change in that response is warranted.

Comment (pp. 1 and 2):

> Nuclear Fuel Resource Utilization
> This comment related to the resource utilization benefits that can accrue from the use of high-gain GCFRs to supply HTGRs with U-233 fuel.

ERDA Response:

This approach to using the GCFR in symbiotic relationship with the HTGR is acknowledged to be worthy of consideration and is discussed in Volume III, page 6A.1-138 of the PFES. Further amplification of the details is not believed warranted in an environmental statement.

Comment (pp. 1 and 2):

> "Nuclear Fuel Resource Utilization
> ...assumptions made about LMFBR introduction are allowed to obscure the significant role which is possible for gas-cooled reactors in the U.S. energy economy.... Breeder reactors can be used as fuel factories to breed uranium-233 for use in LWRs and HTGRs. In the long range, this may be one prime role the fast breeders can play..."

ERDA Response

The PFES does not obscure the significant role that gas-cooled reactors can play in the U.S. energy economy. The PFES emphasizes that any fast breeder with a simple fuel doubling time of 15 years or less can in about 25 years after its availability, if built in large numbers, make the U.S.

nuclear power economy independent of mined uranium. It also indicated that there are large economic benefits for early introduction of the breeder. The PFES also provides in Section 11.1.2.1.4, Alternative Fission Breeder Systems, the following information on design characteristics and availability of the GCFR in comparison to the LMFBR.

> "The gas-cooled fast breeder reactor (GCFR) as an alternative fast breeder option will have utilization incentives similar to those of the LMFBR. The economic, resource, and environmental costs of the GCFR are expected to be comparable with those of the LMFBR. However, the GCFR is in the early stages of development, and it is expected to reach commercial introduction later than the LMFBR.
>
> "The GCFR will use the same mixed uranium-plutonium-oxide fuel cycle as the LMFBR. Therefore, the GCFR will produce the same benefits accruing to the very efficient use of uranium resource as the LMFBR.
>
> "The GCFR is expected to have a higher breeding ratio than the LMFBR, but the LMFBR is expected to have a higher specific power because of the lower heat removal capability of the GCFRs helium coolant."

The General Atomic Company is correct in stating that breeders could provide low cost fissile material (U-233) which could be used to fuel LWRs and HTGRs. Both the LMFBR and the GCFR can operate either on the uranium-plutonium cycle, the thorium-U-233 cycle, or cycles involving other combinations of these materials. The optimum use of the fissile material generated in breeders is as fuel for other breeders. Further, it would be best to generate plutonium for the breeders since its superior neutron breeding characteristics provide the fastest route to system fuel self-sufficiency. Once system fuel self-sufficiency is attained and there is low cost fissile material excess to breeder requirements, it probably would make little difference in total power costs whether U-233 or plutonium would be generated in the breeders for use in LWRs or HTGRs. The economic and safety factors that would indicate the preferred fissile material probably cannot be defined in sufficient detail at this time to make a choice.

Comment (p. 2):

> "Nuclear Fuel Resource Utilization
> Recent changes in fossil fuel economics due to the rapid rise in oil prices and recent increased estimates of economically recoverable U.S. uranium resources should be considered by ERDA in evaluation of commercial breeder reactor scheduling.... With higher U_3O_8 costs, there would be an increasingly large incentive to favor fuel utilization in overall energy economics. The conversion ratio can be increased and fuel costs decreased in the HTGR..."

ERDA Response:

Regarding recent increased estimates of economically recoverable U.S. uranium resources, the cost-benefit analysis presented in the PFES assumed that 4 million tons of uranium ore were available before utilizing the low grade shale ores. This is conservative with regard to the recent estimate of 3.6 million tons of higher grade ores projected by ERDA.

The new estimate of uranium resources is not comparable to the earlier estimates. The increase in U.S. estimated resources from 2.4 to 3.6 million tons U_3O_8 at the $30 level resulted largely from revision of definitions to allow inclusion of potential resources estimated for geological areas which did not meet the previous criteria such as speculative resources in new formations or in new geologic provinces. (See Section III E of the Final Environmental Statement for additional information on uranium resource availability).

Recent changes in fossil fuel prices would probably have little impact on the results of the cost-benefit analysis. The nuclear power build-up was not constrained due to price competition from fossil plants in the PFES, but was constrained due to other considerations. In fact, when nuclear was allowed to compete economically with fossil, nuclear power captured a larger fraction of the market than the fixed fraction assigned to it for the analysis.

HTGRs with improved conversion ratio due in part to semi-annual refueling were utilized in the PFES analysis. They had a large impact on uranium requirements for the no-breeder situation. However, their impact on the cases where the breeder was available was small. The model of the U.S. power economy in its optimization of costs selects nuclear power plants that minimize mined fuel requirements.

Comment (p. 2):

> "HTGR Cost-Benefit Considerations
> The benefit analysis in Section 11.2.4.2, Figures 11.2-27 and 11.2-28, show that the HTGR achieves only a modest fraction of the total nuclear power economy, even when it has an unrestrained allowable growth. This picture results from the assumption that the HTGR does not burn plutonium."

ERDA Response:

Figures 11.2-27 and 11.2-28 in the PFES indicate the composition of the nuclear power economy with the LMFBR available. Due to the availability

of the LMFBR by the year 1987 there is little requirement for new HTGRs after the mid-1990's. About the year 2010 plutonium burners are built to utilize the bred plutonium which exceeds breeder requirements.

The General Atomic Company is incorrect in assuming that a Pu-fueled HTGR was not available to the model. The model has available Pu fueled LWRs and HTGRs to utilize Pu burners as an option during the period of system full self sufficiency. The model selected LWR Pu burners because information on hand indicates that they have lower fuel cycle costs than HTGRs as noted on page 11.2-136 of the PFES.

TELEDYNE
BROWN ENGINEERING

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April 9, 1975

Mr. W. H. Pennington
Assessment and Coordination Officer
Division of Biomedical and Environmental Research
U. S. Energy Research and Development Administration
Washington, D. C. 20545

Dear Mr. Pennington:

We have reviewed the proposed Final Environmental Statement for the Liquid Metal Fast Breeder Program, WASH-1535, with the view of assessing the reliability requirements for a low risk commercial breeder plant. In this regard, we have focused our attention on the reliability requirements for plant protection systems and the safety requirements for limitation of public risk.

We have found the document to be an admirable, extensive compilation. Although we note with interest the comments of prior reviewers and the response of ERDA concerning the technical problems associated with the plant protection system, we find it necessary to readdress certain reliability and safety issues.

The attachment relates our major concerns for development of a low risk commercial breeder.

F. O. Leopard
Nuclear Effects Branch

for H. M. Barnard
Vice President
Military Systems Division

Attachment: a/s

TELEDYNE BROWN ENGINEERING REVIEW COMMENTS

Environmental Impacts and Public Risks (Section 4.2 through 4.6)

The environmental effects of plant construction, low level plant effluents, fuel fabrication, reprocessing and transportations accidents are discussed in sufficient detail to identify potential impacts on the environment and to assess the resulting public risks. By contrast, the discussion of LMFBR plant accidents in Section 4.2.7 is not sufficient to establish the magnitude or number of potential impacts nor to support the assumption that the plant design will incorporate the reliability requirements for achievement of low public risk. The proposed demonstration plant is intended to demonstrate the low-power performance of the reactor and the heat transport systems using materials, components and protection systems that are being developed and tested concurrently with the application for a construction permit. The operational characteristics of the reactor system are not yet finalized and the reliability characteristics are not yet determined. The demonstration plant by its nature involves an iterative development of reliability characteristics throughout the design and construction process. Therefore, it is evident that the safeguards and protection requirements for the demonstration plant must rely on regulatory policies and management procedures developed, executed and verified by competent technical personnel. The risk associated with this stage of development will depend to a larger extent upon personnel performance and strict adherence to safe construction and operation procedures. Since a specific consideration of special requirements in this area is not presented in the proposed final environmental impact statement, we desire that the subject be adequately addressed in the application for a construction permit and the preliminary safety analysis report for the demonstration plant.

Accident Classification and Design Basis Considerations (Section 4.2 and Appendices B.4.2.2 through B.4.2.4

The designation of fault types included in the three fault frequency categories, (1) anticipated faults, (2) unlikely faults, and (3) extremely unlikely faults, reflects a very optimistic prognosis of

reliability achievement and safety performance. It seems reasonable to expect that plant conditions will be discovered as the design progresses which will lead to the reclassification of some of these fault types and the incorporation of other faults not yet identified. The exclusion of core disruptive accidents from consideration in the design basis for the demonstration plant is not justified. The assumption that core disruptive accidents can be excluded from consideration in the demonstration phase places an unreasonable burden on the prediction methodology employed to assess its omission. The present experimental data base regarding transient behavior and power burst shutdown characteristics of liquid metal fast reactors is wholly inadequate to establish the existence of positive shutdown mechanisms that will ultimately limit repeated burst outputs. There is a need to generate additional experimental data regarding liquid metal fast reactor transient behavior in the vein of the SPERT and BORAX experiments for light water reactors. The present status of component development for the demonstration reactor system and the popular requirements for excellent safety performance at this stage of LMFBR development argue for incorporation of special protection features in the design basis concept. We contend that design provisions should be made for local retention of molten core components in the vicinity of the pressure vessel and that additional engineered safeguards should be provided to assure the termination of repetitious power burst outputs.

Reliability Goals and Prediction Methodology

The development of adequate reliability levels in the demonstration systems selected for use in the commercial breeder plant requires a continual appraisal of reliability performance and a confident prediction methodology. The prediction methodology must be adequate to identify the failures which are significant for public risk assessment and must be timely enough to provide guidance for design modifications needed to improve the reliability of the protection system. Because of the developmental nature of the demonstration reactor, a confident assessment of public risk cannot be made for the commercial plant until a significant performance level has been attained in the demonstration

model. Nevertheless, the designer must develop a comprehensive reliability prediction model relating component and subsystem failures to the overall reliability of the plant. We recommend that the method of setting reliability goals and allocating reliability budgets to the plant protection and safety system should include a conservative allowance for common mode failures and potential threats from anticipated transients without scrams.

By way of example, the reliability goal designated in Appendix B.5.3 of Section 4.2 for the reactor shutdown system says:

> "Based on guidance from the Regulatory assessment of Anticipated Transients Without Scram in water reactors, the need to assume scram failure in accident analyses is negated if the failure rate is less than about 10^{-7} per reactor year."

Our first comment on this manner of goal setting is that regulatory policies and design philosophy adopted for LWR systems are not proper guidelines for LMFBR systems. Whatever the reliability requirements of the LMFBR system might be, the goals should be based on the intrinsic safety and risk characteristics of LMFBR's. Our second comment on the designated goal of 10^{-7} failures per reactor year is that neither a probability of 10^{-7} accidents per year nor a probability of 10^{-7} shutdown failures per year are acceptable per se for the commercial plant. The designated failure rate says nothing with regard to the spectrum of consequences flowing from potential accidents at this rate. The risk associated with a 10^{-7}, 10^{-8}, etc. shutdown failure rate should be stated. The philosophy implicit in the adoption of numerical values for acceptable failure probabilities without risk quantification could become constrainful to the NRC in future assessments of risks and benefits. Our third comment refers to the treatment in WASH-1353 of common mode failures, where common mode failures include unexpected common events. The discussion on page VI.38-416 still begs the issue of how common mode failures in the shutdown system will be considered. The AEC states "Current LMFBR design approaches take full cognizance of this Regulatory position, and accounts for the unknown likelihood of

common mode failures by use of diverse and independent redundant shutdown systems." This implies to us that two diverse and independent shutdown systems reduces common mode failures to a negligible value. However, it is likely that in two diverse and independent shutdown systems, each with independent failures rates of 10^{-4} reactor years, common mode failures will dominate the total shutdown system reliability. We suggest a statement showing the analytical treatment of common mode failures. For example, an equation should be given of the following form and the "desired" quanitative values for each variable should be stated.

$$P_{SDS} = P_{SDS}' \pm P_{AU} = P_{SD1} * P_{SD2} + P_{CM} \pm P_{AU}$$

where

P_{SDS} = True Probability of Shutdown System Failure

P_{SDS}' = Predicted Probability of Shutdown System Failure

P_{AU} = Probability Associated with Analytical Uncertainties

P_{SD1} = Probability of Primary Shutdown System Failure

P_{SD2} = Probability of Secondary Shutdown System Failure

P_{CM} = Probability of Common Mode Failure

and

P_{CM} = (Largest Probability of Failure in Common Set)^{CMF} = $(P_{SDX})^{CMF}$

where

CMF = Common Mode Failure Factor.

Typically, if $P_{SD1} = P_{SD2} = 10^{-5}$, CMF = $\sqrt{2}$, and $P_{AU} = 10^{-8}$; then,

$$P_{SDS} = P_{SD1} * P_{SD2} + P_{CM} \pm P_{AU}$$

$$P_{SDS} = 10^{-5} * 10^{-5} + (10^{-5})^{\sqrt{2}} \pm 10^{-8}$$

$$P_{SDS} = 10^{-10} + 10^{-7} \pm 10^{-8}$$

$$P_{SDS} \cong 10^{-7}$$

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. H. M. Barnard
Vice President
Military Systems Division
Teledyne Brown Engineering
Research Park
Huntsville, Alabama 35807

Dear Mr. Barnard:

Thank you for your letter of April 9, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Energy Research and Development Administration (ERDA) has reviewed all written comments received on the PFES as well as the testimony received during the Public Hearing held on May 27-28, 1975, and has taken these views into account in the preparation of the Final Environmental Statement on the LMFBR Program.

We hope you will find satisfactory answers to most of your concerns in the enclosure to this letter. Thank you for your constructive comments and for your interest in the Energy Research and Development Administration's programs. A copy of the Final Environmental Statement is enclosed for your information.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

cc: Mr. F. O. Leopard w/encl.

ERDA Staff Responses to Comments by Teledyne Brown Engineering

Comment (page 1):

" ... The operational characteristics of the reactor system are not yet finalized and the reliability characteristics are not yet determined. The demonstration plant by its nature involves an iterative development of reliability characteristics throughout the design and construction process. Therefore, it is evident that the safeguards and protection requirements for the demonstration plant must rely on regulatory policies and management procedures developed, executed and verified by competent technical personnel. The risk associated with this stage of development will depend to a larger extent upon personnel performance and strict adherence to safe construction and operation procedures. Since a specific consideration of special requirements in this area is not presented in the proposed final environmental impact statement, we desire that the subject be adequately addressed in the application for a construction permit and the preliminary safety analysis report for the demonstration plant."

ERDA Response:

It is true that reliability characteristics of the LMFBR demonstration plant (CRBR) have not been established to a degree comparable to that associated with light water reactors, though for many areas the technology is transferable between the two types of systems. As noted, the dependence on personnel performance and strict adherence to safe construction and operating procedures is emphasized in the case of demonstration plants. Such was the case also with early light water reactors. Efforts are, of course, being made to minimize this dependence by extensive testing of individual components and systems, by the use of redundancy, and by specific design features (for example, by placing primary coolant system components in inerted vaults). Quality assurance and management policy programs are now being developed specifically for the demonstration plant. It is expected many of these points will be adequately addressed in the preliminary safety analysis report for the CRBR.

Comment (pages 1 and 2):

"The designation of fault types included in the three fault frequency categories, (1) anticipated faults, (2) unlikely faults, and (3) extremely unlikely faults, reflects a very optimistic prognosis of reliability achievement and safety performance. It seems reasonable to expect that plant conditions will be discovered as the design progresses which will lead to the reclassification of some of these fault types and the incorporation of other faults not yet identified. The exclusion of core disruptive accidents from consideration in the design basis for the demonstration plant is not justified. The assumption that core disruptive accidents can be excluded from consideration in the demonstration phase places an unreasonable burden on the prediction methodology employed to assess its omission. The present experimental

data base regarding transient behavior and power burst shutdown characteristics of liquid metal fast reactors is wholly inadequate to establish the existence of positive shutdown mechanisms that will ultimately limit repeated burst outputs. There is a need to generate additional experimental data regarding liquid metal fast reactor transient behavior in the vein of the SPERT and BORAX experiments for light water reactors. The present status of component development for the demonstration reactor system and the popular requirements for excellent safety performance at this stage of LMFBR development argue for incorporation of special protection features in the design basis concept. We contend that design provisions should be made for local retention of molten core components in the vicinity of the pressure vessel and that additional engineered safeguards should be provided to assure the termination of repetitious power burst outputs."

ERDA Response:

Designation of fault types included in the three frequency categories is based primarily on experience with equipment and components of reactors which have been built and operated, both water-cooled and sodium-cooled. Although some additional fault types may be discovered, we believe the lists contained in the PFES to be representative and reasonably comprehensive. Considerable discussion of core disruptive accidents is contained in the PFES. As indicated there, substantial capability to accommodate core disruptive accidents is provided by currently conceived LMFBR designs. We expect that R&D efforts will, in the not-very-distant future, provide a basis for the conclusion that core disruptive accidents resulting in the generation of significant amounts of mechanical energy are physically unrealizable. Nevertheless, the safety and licensability of LMFBRs do not have to await the R&D result since it is possible to contain significant amounts of energy from a disruptive accident (e.g., the FFTF design). Once the anticipated R&D confirmation is obtained, design features of subsequent plants may change significantly (most probably with attendant cost savings). The questions of repeated criticality and post-accident heat removal are also being addressed in the LMFBR safety R&D program. It is anticipated that an increased understanding of these phenomena will, in the future, show them not to require accommodation by special design features. Nevertheless, in the near term, the capability to accommodate these phenomena by suitable design features exists and will be retained in the demonstration plant unless and until shown to be unnecessary.

Comment (page 3):

"Our first comment on this manner of goal setting is that regulatory policies and design philosophy adopted for LWR systems are not proper guidelines for LMFBR systems. Whatever the reliability requirements of

the LMFBR system might be, the goals should be based on the intrinsic safety and risk characteristics of LMFBRs. Our second comment on the designated goal of 10^{-7} failures per reactor year is that neither a probability of 10^{-7} accidents per year nor a probability of 10^{-7} shutdown failures per year are acceptable per se for the commercial plant. The designated failure rate says nothing with regard to the spectrum of consequences flowing from potential accidents at this rate. The risk associated with a 10^{-7}, 10^{-8}, etc., shutdown failure rate should be stated. The philosophy implicit in the adoption of numerical values for acceptable failure probabilities without risk quantification could become constrainful to the NRC in future assessments of risks and benefits."

ERDA Response:

We agree that Regulatory policies and design philosophies will not be and should not be entirely the same for LMFBRs as for LWRs with regard to reliability requirements, although many of the same considerations apply equally to both types of systems. We also agree that probabilities of accidents, considered by themselves, are not meaningful guides to acceptability, without a consideration of the consequences of the accidents involved.

As noted in the footnote on the first page of Annex B to Section 4.2.7 of the PFES, from which the 10^{-7} figure for scram failure was taken, the CRBR design and safety approach are still under development and are expected to differ in specifics from that presented in Annex B (a paper presented on April 2, 1974). Specific reliability goals will be proposed and worked out with NRC in the process of licensing review and will of necessity include consideration of consequences. Meanwhile, pending the development of applicable Risk Acceptance Criteria by NRC, we are proceeding with a conservative design.

We are funding some exploratory and investigatory work in the development or risk methodology for LMFBRs. If successful, it is believed that such methods, properly utilized, will aid in establishment of priorities for safety R&D efforts. It will also help identify the relative contributions to overall plant risk of various systems, subsystems, and components as well as the effect of design variations of those components. It is believed that this kind of effort can be useful in the early stages of the development of the LMFBR program. With the buildup of a sufficient data base the methods can be quantified and the uncertainty bands reduced. This will assist even more the decision making process concerning safety options in the LMFBR program. Present limitations rest primarily with the lack of a specific methodology tailored to LMFBRs and a detailed understanding of in-core phenomena and the lack of a large data base. Early analyses should be completed in the next few years; a tentative goal of the development of an acceptable risk

assessment methodology by mid 1985 has been established. In addition, risk assessments specific to the CRBR plant design will be performed as part of the CRBR development program.

Comment (pages 3 and 4):

> "Our third comment refers to the treatment in WASH-1353 of common mode failures, where common mode failures include unexpected common events. The discussion on page VI.38-416 still begs the issue of how common mode failures in the shutdown system will be considered. The ERDA states 'Current LMFBR design approaches take full cognizance of this Regulatory position, and accounts for the unknown likelihood of common mode failures by use of diverse and independent redundant shutdown systems.' This implies to us that two diverse and independent shutdown systems reduces the common mode failures to a negligible value. However, it is likely that in two diverse and independent shutdown systems, each with independent failures rates of 10^{-4} reactor years, common mode failures will dominate the total shutdown system reliability. We suggest a statement showing the analytical treatment of common mode failures."

ERDA Response:

It is recognized that the use of diverse and independent redundant shutdown systems cannot totally eliminate the possibility of common mode failures, and that common mode failures represent a problem requiring attention, particularly in instances in which common mode failures could significantly change total system reliability. The risk methodology studies referred to in the previous response will include consideration of means of clarifying the methods to be used to quantify and evaluate the effects of common mode failures. Additionally, special procedures are being developed in the CRBR Project for identifying, quantifying if possible, and treating common mode failures.

V.73-1

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April 9, 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental
Research
U.S. Energy Research and Development
Administration
Washington, D.C. 20545

Dear Mr. Pennington:

Enclosed is a copy of NRDC's comments on the sections of the Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program (WASH-1535), December 1974, concerning the management of radioactive wastes. These comments are in addition to the comments on other portions of the statement which you have received under separate cover from NRDC's office in Washington, D.C.

If you have any questions regarding these comments, do not hesitate to contact Mr. J. G. Speth in our Washington, D.C. office or me.

Sincerely yours,

Terry R. Lash

Terry R. Lash, Ph.D.
Staff Scientist

TRL/ak
Enclosure

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NRDC COMMENTS ON WASH-1535

Proposed Final Environmental Statement

Liquid Metal Fast Breeder Reactor Program

Re: Management of Radioactive Wastes

Terry R. Lash
April 9, 1975

INTRODUCTION AND SUMMARY

The severe potential environmental and safety hazards posed by the radioactive wastes generated in nuclear power plants are widely recognized. The toxicity of the high-level and transuranic wastes requires that they be kept out of possible human exposure pathways for the hundreds to hundreds of thousands of years required for various radionuclides to decay naturally to innocuous levels. The proposed final environmental statement (PFES) on the liquid metal fast breeder reactor (LMFBR) Program presents no detailed plan of action for achieving this necessary goal to develop a safe, permanent disposal means. For this reason alone, the AEC's proposed final statement should be substantially revised and reissued by ERDA as a new draft environmental impact statement.

Additional reasons pertaining to radioactive waste management that the proposed final statement should be rewritten and circulated as a draft statement for agency and public comment are (1) the

virtual lack of any consideration of the special implications of the LMFBR Program to the overall plan for the safe disposal of radioactive wastes, (2) the failure of the statement's Summary (Volume I) to discuss fairly and fully the environmental and health problems posed by radioactive wastes, and (3) the inadequate response of the AEC to public and agency criticisms of the draft statement's treatment of the storage and disposal of radioactive wastes.

In our opinion, these deficiencies cannot be satisfactorily corrected simply by the issuance of a final statement, or an appendix to the proposed final, without the provision of another round of comment and review of the LMFBR Program by ERDA. Therefore, we believe that ERDA should undertake to prepare and circulate its own draft environmental impact statement on the LMFBR Program which carefully analyzes the proposed detailed plan, and all reasonable alternatives to it, for the safe storage and disposal of radioactive wastes generated by large numbers of LMFBR's.

I. The Proposed Final Environmental Statement Does Not Adequately Consider The Ultimate Disposal Of High-Level and Transuranic Radioactive Wastes

The PFES states that " . . . the AEC has, from its beginning, recognized the full implications of high-level wastes to present and future generations and has conducted a continuous development effort in the matter of ultimate disposal methods that will not burden mankind with caretaker functions." (p. 4.6-7)[1/] In other

---

1/ Unless otherwise indicated, page numbers refer to pages in the PFES.

words, the AEC claims that for the past 30 years a determined attempt has been made to establish a safe ultimate disposal means for high-level wastes. Yet, admittedly, no such ultimate disposal means exists. (p. 4.6-2) Furthermore, such means evidently will not even exist within the next few years because the AEC proposed to construct a near-surface engineered structure, the so-called Retrievable Surface Storage Facility (RSSF), to store the high-level wastes for as long as a century while potential ultimate disposal means are investigated further. (p. 4.6-6) The hope of the AEC, as expressed in the PFES, however, is to have a geological disposal facility available within two or three decades. (p. 4.6-6)

However, while this may have been the AEC's goal, there is virtually no detailed evidence presented in either the PFES or the cited references (last footnote, p. 4.6-7) that the goal can or will, in fact, be achieved. Indeed, the failure to develop an ultimate disposal means during the past 30 years strongly suggests that the PFES is overly optimistic in this regard. What is needed for an adequate discussion on radioactive waste disposal in the environmental statement is a detailed plan, including specification of the amounts of money to be spent on particular means and sites within clearly defined time frames, for achieving safe, ultimate disposal of the high-level and transuranic wastes that would be produced by a commercial LMFBR industry. The procedures that will be followed in the next few years should be clearly explained in order to distinguish meaningfully between the past 30 years of experience, which did not result in the establishment of an ultimate disposal means, and the AEC's proposed course of action. The PFES

fails entirely to do this.

Furthermore, the three references (numbers 9, 10 and 12, p. 7.4-94) cited as providing this type of information simply do not do so. Reference 9 (WASH-1297) is only the summary for reference 10 (BNWL-1900). The Battelle study (BNWL-1900), while a useful compendium of most of the suggested ultimate disposal means, is not itself the plan action for achieving the safe disposal of high-level wastes. The third reference is the draft environmental statement, Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste (WASH-1539), which has been widely criticized because it does not set forth a detailed program plan for developing an ultimate disposal means. For instance, the U.S. Environmental Protection Agency, which rated the draft statement "Inadequate" (the lowest category), commented on the draft statement as follows:

> "In particular, the AEC's program for the development of final disposal methods is not presented in the detail necessary for an independent decision on this important alternative course of action. The current level of funding for the geological disposal evaluation program for fiscal year 1975, according to the AEC, is 2.5 million dollars. It is not apparent from the draft statement that this funding level is consistent with the importance or priority of achieving an environmentally acceptable long-term management method, especially when compared to the large commitment inherent in the total waste management program. We believe that the AEC should present, in the final statement, a more complete description of their program plan for the development of geological disposal techniques, including funding levels required through the period in which assessment of the concept is carried out. In this description, the AEC should present detailed work schedules and their existing

> plans for the development of a geologic disposal site (including target completion dates for the completion of exploration, construction, and beginning operations) so that reviews and comments may be obtained from other qualified or interested government and private sources. Since one of the stated purposes of the draft environmental statement is to assess the environmental consequences of evaluating geological formations and sites for the purpose of developing a repository for permanent disposal, the program plan for such development, as mentioned above, would appear to be a necessary part of that assessment."2/

Similar criticisms of WASH-1539 were made by other governmental agencies and public interest groups. NRDC's comments, which are appended to and by this reference incorporated in these comments on the PFES, detail the major deficiencies of WASH-1539.3/ The issues raised by our comments on WASH-1539 should be thoroughly addressed in a new draft environmental statement on the LMFBR Program. The importance of incorporating a detailed discussion of ultimate disposal in a new draft statement on the LMFBR Program is substantially increased, if, as has been suggested, WASH-1539 is scrapped by ERDA.

II. The Proposed Final Environmental Statement Does Not Adequately Consider The Special Problems Posed By The Radioactive Wastes Generated By The LMFBR Program

There are two principle ways in which the proposed LMFBR

2/ U.S. EPA, November 1974, Environmental Impact Statement Comments D-AEC-A00107-00, Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste (WASH-1539), p. 6.

3/ The appendices to NRDC's comments on WASH-1539 are not attached, because those discussions were submitted previously in connection with NRDC's comments on the draft version of WASH-1535.

Program could significantly affect the management of commercial radioactive wastes. First, implementation of the Program will require the reprocessing of spent fuels, which will eliminate the possible alternative of disposing of spent fuel rods in a geological formation without such reprocessing. This waste management procedure could be adopted for spent fuel from light water reactors.[4/] Commitment to plutonium economy inherent in the LMFBR Program, on the other hand, would eliminate disposing of spent fuel as a permanent option. The PFES should have, but did not, address this issue.

Second, the impact of the radiological and chemical properties of high-level wastes from LMFBR's as compared to light water and high temperature gas reactors and other types of breeder reactors, on the criteria for a safe ultimate disposal means, should have been, but were not, thoroughly assessed. For instance, the relative amount of americium in LMFBR spent fuel is roughly 10 times that in light water reactor spent fuel. (BNWL-1900, p. 2.10) Because americium is the principal controlling potential hazard in drinking water between 350 and 2X 10^4 years (BNWL-1900, p. 2.13), it may be that high-level radioactive wastes from LMFBR's should be disposed of in a more secure geological formation than wastes from LWR's. In any event, a new draft environmental statement on the LMFBR Program should thoroughly consider this and related issues.

4/ See, for instance, "Is Reprocessing Cost-Justified?" by Dr. Marvin Resnikoff, Rachel Carson College, Amherst, New York, and "The Back End of the Fuel Cycle" by Bertram Wolfe and Ray W. Lambert, General Electric Company, San Jose, California.

III. The Discussion Of Radioactive Waste Management In The Summary (Volume I) Does Not Accurately Reflect The Material In The Body Of The Proposed Final Environmental Statement And Does Not Adequately Present The Potential Hazards Posed By Radioactive Wastes

The Summary in Volume I will undoubtedly be the most widely read section of the PFES. Perhaps more importantly, busy decision-makers may substantially rely upon the discussion in the Summary to assess the LMFBR Program. Therefore, the Summary should carefully reflect the material in the body of the PFES and should fairly present an evaluation of both the benefits and hazards associated with the Program. Uncertainties, possible problems and potential hazards should not be omitted or glossed over.

However, the approach in the Summary appears to be just the opposite of a fair appraisal of the problems and uncertainties with the AEC's radioactive waste management program. The so-called "maximum credible accident" at the RSSF is, in fact, incredibly small and gives an unrealistic impression of the degree of potential harm resulting from a serious accident.[5/] (p. 1.4-7) The description of the vulnerability of the RSSF to successful attack by a small band of well-trained terrorists is grossly misleading and does not address the central issue.[6/] (p. 1.4-12)

5/ See, for instance, John Holdren and Lee Schipper, Comments on WASH-1539, October 25, 1974, pp. 3-5.

6/ See, for instance, Thomas Cochran, NRDC, Comments on WASH-1539, September 23, 1974.

Although the principal focus of the analysis of the potential environmental effects of radioactive waste storage and disposal is the RSSF, there is some mention of ultimate disposal of high-level wastes. (p. 1.5-2) But the discussion clouds the issue more than it sheds any light on it. For instance, while the PFES states that "[t]here are several options for permanent disposal of high-level wastes open to contemporary society . . ." (p. 1.5-2), there is neither a description of the particular options believed to be available nor a reference to the body of the statement where the options are analyzed. Furthermore, questions are raised concerning ultimate disposal options, but there is no discussion about how the AEC plans to make a choice among the options. Reference is made to section 7.3.5 in the Summary (p. 1.6-10), but that section contains only short, general descriptions of concepts that have been in the literature for years. There is no detailed procedure described for choosing among these hypothetical alternatives and no clear description of the AEC's research and development program to demonstrate the acceptability of an ultimate disposal means. Furthermore, the general description seems to be misleading. For instance, the discussion of the transmutation concept fails to mention that the AEC omitted funds from its FY 1976 budget for research on partitioning, a necessary first step in the transmutation of the actinides. Without independent knowledge of the AEC's submitted budget, the reader might mistakenly believe that research on the transmutation concept -- in principle, a superior waste management option -- was progressing a pace.

IV. The AEC's Responses To NRDC's Comments On The Discussion Of Radioactive Waste Management In The Draft Statement Is Inadequate

A. NRDC Comment # 1 (p. VI.38-379)

The AEC staff is apparently unwilling to accept the detailed criticisms leveled at the RSSF concept, which is the focus of the discussion on radioactive waste management in both the draft and the proposed final environmental statements on the LMFBR Program. We believe that the analyses in the draft and proposed final statements are even more superficial and inadequate than the presentation in WASH-1539. Our detailed review of WASH-1539, which is attached as an appendix to these comments, demonstrates the inadequacy of the waste management sections of the PFES.

B. NRDC Comment # 2 (p. VI.38-380)

To the extent that an assertion of the inadequacy of the AEC's waste management program is "primarily a matter of interpretation", then the program has been found to be inadequate by virtually all of the commentators on WASH-1539, including the U.S. Environmental Protection Agency, U.S. Department of the Interior and the Western Interstate Nuclear Board.

Indeed, it is our understanding that ERDA, in light of these criticisms and its own review of the statement, is seriously considering withdrawing WASH-1539 and preparing an entirely new, and more detailed and comprehensive, draft statement on ERDA's waste management program. If WASH-1539 is withdrawn, then this would be sufficient reason for the sections on radioactive waste management in the PFES to be completely rewritten and resubmitted in a new

draft statement on the LMFBR Program.

C. NRDC Comment # 3 (p. VI.38-381)

The AEC staff missed our central point in discussing past failures in the handling of radioactive wastes. While we believe that inadequate resources have been committed to establishing an ultimate disposal means -- as evidenced by the simple fact that large amounts of high-level and transuranic wastes are being produced without an ultimate disposal means at hand -- we recognize that a significant effort has been made to store radioactive wastes safely. But that, in essence, is the point. Even though there was this care taken, bad judgments were unwittingly made in the past, leading to the release of large amounts of high-level wastes at Hanford and the preliminary selection of an unsuitable repository for commercial high-level wastes at Lyons, Kansas. The history of radioactive waste storage shows rather clearly, we believe, that good intentions do not ensure that the wastes will be safely stored.

D. NRDC Comment # 4 (p. VI.38-382)

The AEC staff states that regarding the partitioning of actinides, "there are serious questions about the overall hazard involved in the repeated handling of these materials as well as the effectiveness of disposal that must be resolved before a final decision can be made." Yet there is no detailed description of those "questions" or how they will be resolved. Furthermore, the AEC staff does not explain how the final decision can ever be rationally made if no money is spent on the research to obtain the basic data that is required for a fair analysis of this potential

option. A full explanation of the reason the AEC terminated funding for research of partitioning in the proposed FY 1976 budget should have been presented in the PFES.

V.73-13

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Comments of the

Natural Resources Defense Council, Inc.

and the Sierra Club

on the

Atomic Energy Commission's

Draft Environmental Statement

MANAGEMENT OF COMMERCIAL HIGH-LEVEL

AND TRANSURANIUM-CONTAMINATED

RADIOACTIVE WASTE

(WASH-1539)

Submitted by:

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I

INTRODUCTION

The Natural Resources Defense Council, Inc. (NRDC) and the Sierra Club submit these comments on the draft programmatic environmental impact statement, Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste (WASH-1539), prepared by the Atomic Energy Commission (AEC).[1/] The statement concerns the proposed construction of a temporary national storage facility for the hazardous radioactive waste materials that are produced principally at irradiated ("spent") fuel reprocessing and mixed-oxide fuel fabrication plants. For the reasons stated in detail below, we believe that the draft statement and the course of inquiry reflected therein do not satisfy the requirements of the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. §§ 4321-4347 (1970).

Most importantly, NRDC and the Sierra Club submit that the AEC, in preparing this impact statement, is required to consider and evaluate fully the unavoidable necessity, once high-level and transuranic wastes are produced, of containing them perpetually. This is the fundamental issue of radioactive waste

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1/ These comments supplement Dr. Thomas B. Cochran's September 23, 1974 letter and enclosure, concerning the omission of important national security considerations in the draft statement's analysis of the safety of storing the nation's high-level radioactive wastes in vulnerable facilities on the earth's surface.

management. By narrowly restricting the focus and scope of the draft statement to an incomplete analysis of the environmental effects of facilities that are intended to store the long-lived wastes for at most the next two or three decades, instead of the million years that some of the wastes remain hazardous, the AEC has improperly substituted an extremely short-term and more manageable problem for the real one. The draft statement never seriously considers the environmental implications of the central fact that the proposed decision to produce and store radioactive wastes temporarily irrevocably commits the nation to finding a means to store them for thousands of generations into the future.

This draft statement provides no detailed analytical basis for the critical conclusion that, in fact, a satisfactory permanent means of disposal of long-lived high-level radioactive wastes will be found in the foreseeable future. The grave hazards posed by the extremely long-lived toxicity of these wastes have too often been described to require a restatement here.[2/] This programmatic impact statement provides uniquely the opportunity for the AEC to justify, if it can, its conclusion that the nation should proceed to generate vast amounts of wastes in advance of an assured means of permanently containing them. No question is more fundamental. Inexcusably, in this draft, the AEC does little more than assert that an answer will be found.

2/ For an overview of the long-term hazards posed by radioactive wastes, see inter alia, Citizens' Guide: The National Debate on the Handling of Radioactive Wastes from Nuclear Power Plants, August 1974. (Available from NRDC, 664 Hamilton Avenue, Palo Alto, California 94301.)

At the risk of belaboring the obvious, the answer to that question must be the predicate of waste generation and the solution cannot -- at the peril of unprecedented environmental contamination -- be assumed. The very existence of this draft environmental statement -- focused as it is on a temporary storage facility for radioactive wastes -- after years of scientific research and searching for a permanent solution suggests the great difficulty in finding a means for ultimate disposal.

To cite just one expression of doubt, the Continuing Committee of the Pugwash Conferences on Science and World Affairs, a body of renowned international scientists, adopted last year the following statement:

> "No general solution for the isolation of long-lived radioactive wastes from the biosphere, for the necessary many thousands of years, is yet in hand; that is, despite a wide variety of proposals, 'experts' still disagree on whether any of them will suffice. Disposal in deep salt beds is perhaps the most thoroughly investigated possibility, but the viability of this approach depends on the geological details of the particular salt deposit. New and larger research programmes should be initiated in search of a solution. It is impossible to be complacent about expansion in the use of nuclear power without having a solution in hand."3/ (emphasis added)

The failure to present step-by-step the detailed basis for its conclusion that a solution will be found before disastrous management mistakes or accidents occur, in itself, is sufficient grounds for our conclusion that the AEC should scrap the present

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3/ Pugwash Newsletter 11, July & October 1973, p. 23. (Available from Pugwash Conferences on Science and World Affairs, 9 Great Russell Mansions, 60 Great Russell Street, London WC1B 3BE, England.)

draft and start again, with a new determination to disclose candidly and analyze fairly the basic questions at stake and alternative actions available. Even beyond this most fundamental failure, however, the statement suffers from such serious omissions and lack of essential detail that it should not qualify as an acceptable draft on even the subsidiary issues -- to which the draft principally devotes itself -- regarding short-term storage.

To compare for decision-making purposes alternative means of processing and storing radioactive wastes, it is necessary to view the waste management process in toto, starting with removal of spent fuel from reactors through transportation, reprocessing, and management and on to the point at which the radioactivity will have decreased to innocuous levels. The statement fails to do this.

The following major deficiencies exist in the draft statement:

1. There is virtually no consideration given either to the storage of spent fuels at power plant sites or to their transportation to reprocessing facilities.

2. The reprocessing step and short-term storage are not discussed at all.

3. The possibility of storing noble gases and tritium at a Federal Repository instead of releasing them to the environment is not analyzed.

4. There is inadequate review of the physical and chemical forms in which the high-level wastes should be stored.

5. The cost analysis of the proposed engineered surface storage facility and subsequent geological disposal is virtually non-existent, consisting solely of bottom-line figures.

6. The discussion of possible geological formations for a permanent radioactive waste repository is only cursory.

7. The evaluation of the processing and storage of transuranium-contaminated wastes is much too abbreviated.

8. There is no discussion of the final disposition of large equipment and buildings that will become heavily contaminated during spent fuel reprocessing and mixed-oxide fuel fabrication.

9. Major alternatives to the proposed program, such as permanently storing spent fuel assemblies, establishing nuclear parks, and recycling all transuranic elements are either ignored entirely or simply dismissed out of hand as impractical at this time.

10. The issue of safeguarding facilities and radioactive waste-related materials from acts of terrorism, sabotage, and theft was improperly postponed to the final statement.

11. There is no mention of the possibility of having to reprocess spent fuels from abroad and/or storing high-level and transuranium-contaminated radioactive wastes that are produced in foreign nuclear reactors.

12. The storage time considered in the draft statement is effectively limited to only a few decades instead of the thousands of years during which the wastes will have to be separated from the human environment.[4/]

In addition, this draft statement is not, as it should be, explicitly coordinated with other "programmatic" environmental

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4/ Each of these points is discussed in greater detail below.

impact statements that recently have been or soon will be released by the Commission. Such coordination is necessary in order to assist the reader and ensure that no vital questions and interrelationships are overlooked and to provide useful background and fill gaps in any one statement. The new draft statement on radioactive waste management should be carefully cross-referenced with the following other NEPA statements: (a) the existing draft statements on the Liquid Metal Fast Breeder Reactor Program (WASH-1538), the recycling of plutonium in nuclear fuel (WASH-1327) and Waste Management Operations at the Hanford Reservation (WASH-1538); (b) the proposed draft statements on waste management operations at the Idaho National Engineering Laboratory (formerly the National Reactor Testing Station) and at the Savannah River Plant;[5/] and (c) the draft statement on the International Nuclear Power Program which is in preparation.[6/]

While underscoring at the outset our gravest concern at the omission of adequate justification for proceeding with waste generation at all, we attempt in these comments to indicate specifically why the treatment in this draft of the subsidiary issues is itself unacceptably incomplete and to suggest which subjects, for what reasons, should be covered in the new draft that should be prepared.

In our view, a new draft programmatic environmental impact statement must be prepared and circulated for comment before any contractual commitments are made or Congressional appropriations sought for the construction of an engineered surface storage

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5/ 38 Fed. Reg. 29155; August 14, 1973.

6/ 39 Fed. Reg. 20835; June 14, 1974.

facility or any other type of national waste management repository. To take any definitive action toward implementing a proposed radioactive waste management plan prior to preparing an entirely new draft statement would thwart the public's right to know in advance the potentially adverse consequences and full costs of a large nuclear power industry and would thereby violate the National Environmental Policy Act and the case law and agency regulations established under it.

II

GENERAL REQUIREMENTS FOR PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENTS

In order to disclose fully for the public and governmental decision-makers the potentially significant adverse environmental effects of proposed actions and all reasonable alternatives thereto, draft environmental statements on major national policies and programs should be issued in a sequential process, progressing from the initial general policy considerations to subsequent implementing decisions on individual activities. One observer put it this way:

> "Rather than a final plan or project with an accompanying assessment, there should instead be a series of increasingly specific evaluations. When undertaken properly, this is the essence of a realistic comprehensive planning process." 7/ (emphasis added)

The President's Council on Environmental Quality (CEQ) has offered some guidance here:

> "In many cases, broad program statements will be required in order to assess the environmental effects of a number of individual actions on a given geographical area . . . or environmental impacts that are generic or common to a series of agency actions (e.g., maintenance or waste handling practices), or the overall impact of a large-scale program or chain of contemplated projects. . . ." 8/

The scope of statements and their timing depend on the circumstances in each case. As the CEQ has observed:

> "An agency must time its preparation of program and individual statements to accomplish NEPA's ends in the light of its other program

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7/ P. H. Sedway, "Time For An Overhaul: The Environmental Impact Report," Cry California, Summer 1974, pp. 10-15.

8/ CEQ Guidelines, § 1500.6(d)(1).

> objectives. When a new program is just beginning, the obvious course is for the agency to prepare an environmental statement before the program is launched."9/

The classic example of the programmatic type of statement is the one on the Commission's Liquid Metal Fast Breeder Reactor (LMFBR) Program, wherein the AEC controls the funding for research and development and will closely regulate construction and operation of breeder nuclear power plants. Under court order10/ the AEC has now issued a draft programmatic environmental statement.11/ It is clear from the language of the court opinion, and from the strong adverse reaction to the draft statement itself12/ that very high standards are being established for programmatic environmental statements.

The general purposes of programmatic statements have been identified by the CEQ as follows:

> "The program 102 statement affords an occasion for a more comprehensive consideration of effects and alternatives than is practicable in a statement on an individual action. It tends to ensure that cumulative impacts likely to be slighted in a case-by-case analysis are considered. And it avoids duplicative discussion of basic policy questions. A program statement can be supplemented or updated as necessary to account for changes in circumstances or public policy and to measure cumulative impacts over time."13/

9/ CEQ Third Annual Report, p. 234.

10/ Scientists' Institute for Public Information v. Atomic Energy Commission, 481 F.2d 1079 (D.C. Cir. 1973).

11/ AEC, Draft Environmental Statement, Liquid Metal Fast Breeder Reactor Program, WASH-1535, March 1974.

12/ See, for instance, R. Gillette, "Low Marks for AEC's Breeder Reactor Study," Science, p. 877 (May 24, 1974).

13/ CEQ, Environmental Quality: The Third Annual Report of the Council on Environmental Quality, p. 233 (August 1972) (hereinafter, "Third Annual Report"). Essentially identical language is contained in CEQ Recommendations for Improving Agency NEPA Procedures, 3 Environment Reporter Current Developments 82,85 (May 1972).

More recently, the CEQ has reemphasized as follows the importance of programmatic statements in improving the NEPA review process, thereby improving decision making to protect the environment:

> "The [new, revised] guidelines encourage the use of program or generic statements to cover a number of related individual actions when comprehensive analysis is more useful and efficient than separate analyses of several related projects. If sufficiently comprehensive and informative, such program statements eliminate or reduce the need for further individual project statements. Program statements cut redundancy and unnecessary paperwork and make the environmental analysis more meaningful."14/

The revised AEC guidelines15/ for the preparation of NEPA statements explicitly provide for programmatic statements on research and development programs, such as the Commission's plan to regulate, develop, construct and maintain facilities for the handling of high-level and transuranium-contaminated radioactive wastes.

It should be emphasized that programmatic statements are not to be vague discussions of environmental impact. The consideration of adverse effects of the program must be detailed and comprehensive. To the extent that it is impossible or unwieldly to be specific in assessing potential adverse impacts, then subsequent environmental statements should be prepared on more narrow "actions". The CEQ has specifically addressed this issue as follows:

> "[A] program statement would not satisfy section 102(2)(C) if it were superficial or limited to generalities. The very rationale for a program statement requires that environmental considerations be analyzed fully. When all significant

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14/ Fourth Annual Report, p. 235.

15/ 10 C.F.R. § 11.5(a)(4); 39 Fed. Reg. 5620, February 14, 1974 .

> issues cannot be treated adequately in connection with the program as a whole, statements of more limited scope will be necessary on some or all individual actions to complete the analysis."16/

Thus, in order to satisfy at once the goals of assessing overall, cumulative impacts and achieving specificity in descriptions of potentially adverse environmental effects, it is necessary to estimate in detail, and insofar as possible quantitatively, the total primary and secondary impacts of an entire series of related individual actions during a specified period of time.

It is also important to recognize that the concept of the broader, programmatic EIS is firmly rooted in, and logically flows from, the fundamental considerations that prompted Congress to enact NEPA in the first place. That body clearly perceived the great need for overall environmental assessments of the long-range consequences of federal actions. Indeed, the need to consider the cumulative and diverse environmental effects of major federal actions provided much of the impetus to establish a strong national policy on the environment. Thus, the Senate Committee Report on NEPA stated:

> "[NEPA] is also designed to deal with the long-range implications of many of the critical environmental problems which have caused great public concern in recent years. . .."17/

16/ Third Annual Report, p. 234. See also CEQ Guidelines § 1500.6(d)(1) and Fourth Annual Report, p. 235.

17/ S. Rep. No. 91-296, 91st Cong., 1st Sess. (1969), p. 8. It is also worth noting that radiation hazards were a specific problem noted in NEPA's legislative history. Id. at 4.

In the following sections we discuss the omission of major topics and the lack of sufficient detail in this draft statement that render it incomplete and inadequate as a programmatic impact statement by the standards that have been established pursuant to NEPA.

III

THE DISCUSSION OF POSSIBLE ENVIRONMENTAL EFFECTS IN THE DRAFT ENVIRONMENTAL IMPACT STATEMENT IS TOO NARROW, INCOMPLETE AND DOES NOT ADEQUATELY CONSIDER CUMULATIVE EFFECTS

The Commission has too narrowly focused the draft statement. The result is a significant understatement of potential adverse environmental effects and costs.

Programmatic environmental statements, as discussed in the previous section, are intended to be comprehensive analyses of the cumulative effects of an entire proposed program and its reasonable alternatives. Thus, this draft statement should have considered all major steps in the handling of commercially-generated high-level and transuranium-contaminated radioactive wastes, starting at the time that spent fuel assemblies are removed from the cores of power reactors and ending at the time -- thousands of years in the future -- when the radioactivity of the wastes has decayed to innocuous levels. The best available evidence should have been presented that each step in the handling of the wastes can be carried out at acceptable costs for as long as the country may utilize the nuclear fission process for the generation of electricity and the wastes remain hazardous. The total cost in financial, social and environmental terms should have been compared to the benefits of nuclear power, and the full cost of each step should have been compared with the costs of alternatives.

The principal deficiencies in this draft with respect to the analysis of possible environmental effects are the

following: (a) the lack of a detailed discussion of the steps in the fuel cycle -- storage at nuclear power plant sites, shipment to reprocessing facilities, treatment at spent fuel reprocessing plants and temporary storage at such plants -- that precede the time they are placed in federal custody; (b) the failure to analyze fully the detailed criteria for an acceptable design and site for an engineered surface storage facility and compare accurately the relative merits of the three specific designs and sites that are discussed; and (c) the failure to analyze the likely suitability of various geological formations and sites and explain the detailed procedures that will be followed in selecting a particular formation and site for a permanent national radioactive waste repository. Each of these omissions is sufficiently serious to render the draft inadequate under NEPA. Collectively, they are an indication of the Commission's apparent hesitancy to act "to the fullest extent possible" on the Congressional mandate to

> ". . .utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment. . .." (NEPA, § 102(2)(A))

A. The Environmental Statement Must Fully Consider All Significant Potential Environmental Effects Of Managing Radioactive Wastes

As discussed in section II above, the principal thrust of the programmatic statement is to evaluate the possible

overall environmental effects of a proposed series of actions which may be only incompletely considered in a piecemeal approach. The programmatic environmental statement on high-level and transuranic wastes should analyze the overall, cumulative environmental effects in the handling of commercially-generated wastes from the time of their creation in nuclear power plants through their ultimate decay to innocuous levels. The draft statement, however, omits the important transportation, handling and reprocessing steps, explicitly leaving them to facility-by-facility analysis. (pp. 2.2-6, -7; C-23; C-36; C-70; C-78) To start the analysis of the management of commercially-generated radioactive wastes, as the draft does, at a point when the high-level wastes may have already been in storage for 10 years at spent fuel reprocessing plants and the transuranium-contaminated wastes may have been stored for 5 years, frustrates the purpose of the programmatic statement and violates NEPA by systematically underestimating costs.

The U.S. Court of Appeal's opinion in Scientists' Institute for Public Information v. Atomic Energy Commission, 5 ERC 1418, 1422 (D.C. Cir. 1973), applies equally here.

> "The Commission takes an unnecessarily crabbed approach to NEPA in assuming that the impact statement process was designed only for particular facilities rather than for analysis of the overall effects of broad agency programs. Indeed, quite the contrary is true."18/

18/ The court also went on to observe that "[t]he issues discussed in an analysis of the overall program would be quite different from those discussed in an analysis of a particular facility, and the relevant audiences, both in government and outside, would vary for each analysis." Id. at 1426.

1. The Definitions And Amounts Of Wastes Must Be Presented In Greater Detail And Under Varying Assumptions Of Nuclear Power Development

a. High-Level Wastes

Rather than including all of the highly radioactive wastes that may be handled and finally stored at a federal repository as part of the national radioactive waste management program, this draft employs the restrictive definition of "high-level liquid radioactive wastes" from Appendix F of 10 C.F.R. Part 50:

> "For the purpose of this statement of policy, 'high-level liquid radioactive waste' means those aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels." (p. 1.2-2)

Taking this narrow view of what constitutes "high-level radioactive wastes" for the purposes of this environmental statement excludes from consideration all the handling, shipping and processing steps that always are associated with the production of the first cycle aqueous wastes and their concentrated equivalents. As we have stated previously, such a restrictive definition does not comport with the requirements of a programmatic statement under NEPA.

Further, the Appendix F definition is not even precise within the context of a spent fuel reprocessing plant, as indicated in the following footnote in the draft statement:

> "Since the issuance of this regulation, a number of questions have been raised by industry as to the degree, if any,

> to which subsequent extraction cycle wastes might be concentrated without requiring their treatment as first cycle waste. This point has not been resolved." (p. 2.3-1) 19/

Thus, because the draft statement uses a narrow and imprecise definition of the wastes under consideration in the draft statement, the scope of the statement is too limited, and there is significant uncertainty about the amounts and characteristics of the wastes which may be shipped to a federal repository. This throws a shadow over the entire analysis.

The definition of wastes is not a trivial or easy matter. The new draft statement should devote sufficient attention to defining what wastes will have to be sent to a federal repository so that any remaining ambiguities are not of great consequence. As we requested earlier,20/ serious consideration should be given to the groupings of wastes that are recommended by the International Atomic Energy Agency.21/ The advantage of the IAEA classifications for liquid wastes is that they are based solely upon specific concentrations of gross radioactivity. While this clearly does not solve all problems, such classifications are an improvement in precision. We also urge the Commission

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19/ The new draft statement should provide a clear explanation of the unresolved issues, including a discussion of the implications for the radioactive waste management program and the steps that are underway to eliminate uncertainties.

20/ Letter from Terry R. Lash and John E. Bryson, NRDC, to Dr. James L. Liverman, AEC, dated June 7, 1974.

21/ IAEA, Standardization of Radioactive Waste Categories, Technical Reports Series, No. 101 (1970)

to consider adopting, at least for the purpose of defining waste categories in the new draft statement, the concept of "inventory commitment," which unfortunately is discussed only briefly in an appendix of the draft (p. A.2-8). Similarly, we urge the AEC to consider using the EPA's "environmental dose commitment"[22/] criteria as a rationale for defining and categorizing radioactive wastes. We also call attention to the classifications of wastes to be found in other recent AEC documents.[23/]

b. Transuranium-Contaminated Wastes

In contrast to the vague and overly restrictive definition of high-level wastes, the definition of transuranium-contaminated wastes in the draft is precise, being a simple numerical concentration (10 nanocuries per gram), and meaningful because it is comparable to the potential for radiological damage of natural radioactivity from radium in the earth's crust. Unfortunately, however, it is evidently impractical to measure such low alpha activity from the outside of a package. (pp. 6-67, -74) While the draft statement asserts that there are practical "administrative means" available for identifying wastes containing more than the 10 nanocuries per gram limit, these guidelines are not reproduced in the statement. In order for the discussion of transuranium-contaminated waste management to be whole, these guidelines should be reproduced and discussed in the new draft statement.

22/ Office of Radiation Programs, Environmental Protection Agency, Environmental Radiation Dose Commitment: An Application To The Nuclear Power Industry, EPA-520/4-73-002 (February 1974).

23/ Blomeke, Kee and Nichols, Projections of Radioactive Wastes To Be Generated By The U.S. Nuclear Power Industry, ORNL-TM-3969, p. 1 (February 1974).

Furthermore, consideration should be given to uranium alpha wastes from the thorium fuel cycle of the High Temperature Gas Reactor. These wastes undoubtedly will also be shipped to a federal repository before the end of the century.[24]

c. Projections of Waste Generation

Clearly defining what wastes will have to be delivered to a federal repository in the future is a necessary prerequisite to accurately estimating the magnitude and nature of the problem of providing perpetual containment of the wastes. Staff at the AEC's Oak Ridge National Laboratory (ORNL) has recognized the importance of accurately forecasting the build-up of nuclear wastes:

> "Projections of the industrial radioactive wastes from the nuclear fuel cycle are useful in the planning and design of methods and facilities that will be needed for their future management, and for the assessment of potential environmental effects."[25]

The draft statement does contain estimates for the amounts of high-level (pp. 2.3-5 through 2.3-11)[26] and transuranium-contaminated (pp. 2.4-14 through 2.4-16) wastes through the year 2000.[27] Estimates of waste production into the next century

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24/ Id. at 91. (From hereinafter our comments regarding transuranium-contaminated wastes are also to apply to future uranium alpha wastes.)

25/ Id. at 1.

26/ The projections of the high-level wastes for some unexplained reason are taken from an older study, by Blomeke and Nichols, (Commercial High-Level Waste Projections, ORNL-TM-4224, May 1973), than were the projections for transuranium-contaminated wastes (Blomeke, et al., op. cit.) See pp. 2.3-36 and 2.4-17.

27/ The projections of transuranium-contaminated wastes should be expanded to include uranium alpha wastes. See Blomeke, et al., op. cit. Furthermore, it should be made clear that the tables in Blomeke et al. explicitly assume that the wastes will be compacted.

are not presented because "projections of reactor growth beyond the year 2000 are not considered firm enough. . . ." (p. C-27) While this stance may be appropriate for some situations, we believe that this limitation unduly restricts the assessment of costs and potentially adverse environmental effects of the radioactive waste management program. In our view, the Commission must attempt now to project the waste management problems which will arise in the 21st century as a result of heavy reliance on nuclear fission. Only in this way will the complete size and potential hazards and costs of a national repository be appreciated.

While it is true that the longer the extrapolations, the greater the potential error, even rough calculations will be useful in setting guiding parameters for engineered and geological repositories. We suggest that different scenarios of nuclear development be constructed that would bracket any actual development. In any event, projections beyond the year 2000 can be made and such longer term projections should be used in the new draft. For instance, the ORNL study[28/] that was relied upon for projections to the year 2000 also contains estimates for the amounts of radioactive wastes generated out to the year 2005. Further, the ORNL study refers to a "sophisticated systems analysis computer program"[29/] that presumably could be run to generate waste accumulation values well into the next century.

28/ Blomeke, et al., op. cit.

29/ Id. at 1.

Additionally, we call attention to the projection of cumulative environmental effects in section 9.1 of the LMFBR draft programmatic environmental impact statement (WASH-1535), wherein the amounts of radioactive wastes from LMFBR's are projected through the year 2020. It would seem reasonable that the new draft statement on the radioactive waste management program could include similar projections for all reactor types that may be in commercial operation at that time.

Extending projections out even only 20 years would be useful in assessing the overall magnitude of the waste storage problem because the nuclear industry is projected to be in a period of very rapid growth at the turn of the century. For instance, in the 5-year period between the year 2000 and 2005, the amount (in cubic feet) of accumulated high-level radioactive waste is expected to increase by more than 60%, with the annual rate of addition still increasing.30/ Thus, the real crunch -- particularly for a surface storage facility -- for space to store the commercially-generated wastes may begin to occur shortly after the time the draft statement's analysis ends. For this reason we believe that the new draft statement will be seriously deficient if projections of waste generation are not extended well beyond the year 2000.

Finally, we agree with the assessment in the draft statement that "[t]here appears to be some use for a measurement [of radioactive wastes] that would indicate at least in an approximate way not only the potential hazard of a present waste

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30/ Blomeke, et al., op. cit., p. 77.

inventory but also the degree to which that hazard will continue into the future." (p. A.2-8) The projections of future waste production should use such a form of measurement, in contrast to the current draft statement.

2. The Statement Should Explicitly Consider The Consequences Of And Reasonable Alternatives To Existing AEC Requirements For Radioactive Waste Management

Appendix F to 10 C.F.R. Part 50 establishes the requirements for solidification and delivery of radioactive wastes to a federal repository, and is intended to control the decommissioning of spent fuel reprocessing facilities (pp. 2.3-34, -35). There is no other regulation that more directly pertains to the management of commercially-generated wastes. Regrettably, the draft statement does no more than summarize the provisions of the regulation.

Instead, the draft should analyze the effects of each requirement and of alternatives to it. A pervasive problem with the existing regulations is that they were written at the time when only geological disposal without interim storage in a man-made structure was actively considered.

For instance, the new draft statement should explicitly consider requiring immediate solidification of wastes rather than allowing storage as liquid for 5 years. The calcination of high-level liquid wastes appears to be technologically and economically practical without a storage period. (p. 2.3-25)[31/]

31/ See, AEC, Final Environmental Statement, The Midwest Fuel Recovery Plant, p. 20 (December 1972). Apparently, the subsequent major technical problems at the Midwest Fuel Recovery Plant were unrelated to the waste calcination step. (p. 2.3-16) However, some problems did develop in the waste calcining step, which are not described in this draft statement. See, General Electric, "Midwest Fuel Recovery Plant, Technical Study Report," p. 39 (July 5, 1974).

Making this practice a requirement would seem to offer added safety at little, if any, additional cost.

The draft statement indicates in a footnote that one modification -- to require chemical, thermal and radiological stability of the solidified wastes beyond 90 days after receipt at a federal repository -- of Appendix F is anticipated. (p. 2.3-34) Unfortunately, the draft statement is silent about the changes in language that are under consideration, thereby leaving the Commission's position ambiguous. The new draft statement should clearly indicate the time period that the "canned" wastes will have to remain stable after delivery to a federal repository. This period should be closely linked to the anticipated operating parameters of the repository and where there are uncertainties about the requirements for satisfactory storage at the repository, indicate how these uncertainties may be reflected in this provision of Appendix F. 32/

In one regard we find the summary of provisions in Appendix F seriously misleading. The Appendix F provision on decommissioning (§ 4) is paraphrased in the draft as follows: "A design objective for fuel reprocessing plants shall be to facilitate decontamination and removal of all radioactive waste at the time the facility is permanently decommissioned." (p. 2.3-45) We believe that the new draft statement should go beyond this simple statement to discuss two issues that are contained in

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32/ The fact that the Commission has not yet provided the nuclear industry with specific instructions on how to prepare the wastes for storage is a further indication that a permanent solution is not near at hand.

Appendix F but which are not mentioned in the statement's summary. First, there should be a clear explanation of what materials will be governed by the phrase "significant radioactive wastes" and eventually removed from reprocessing facilities for permanent storage at a federal repository or other waste disposal site. (Appendix F, § 4.) This question has particular importance in light of the Commission's proposed amendment to 10 C.F.R. Part 20 to require the storage of transuranium-contaminated wastes (in excess of 10 nanocuries per gram) at the federal repository rather than at commercial burial grounds as is now permitted. (39 Fed. Reg. 32921, September 12, 1974.) Will this same 10 nanocuries per gram criterion apply to all equipment and structures at reprocessing facilities? What other criteria may be used in defining "significant"?

The second issue, which is closely related to the first, concerns the criteria that will apply to the decommissioning of spent fuel reprocessing facilities. (Appendix F, § 4.) Will the entire plant, in essence, have to be dismantled and carted off to the national repository? Certainly companies considering the construction of spent fuel reprocessing plants should know the full requirements for decommissioning as far in advance as possible.

Additionally, the section on the regulation of spent fuel reprocessing plants should discuss the implications of proposed "as low as practicable" proceedings for fuel cycle steps other

than power plants (39 Fed. Reg. 16901 (May 10, 1974)),[33] and the proposed Appendix P to 10 C.F.R. Part 50 to establish principal design criteria for fuel reprocessing plants (39 Fed. Reg. 26293 (July 18, 1974)).[34] These regulations and proposed regulations will to a large degree determine the kinds and amounts of wastes that will have to be stored at any surface or geological storage facilities. Not fully discussing the provisions of these "controlling" regulations and their reasonable alternatives makes the draft statement significantly incomplete.[35]

As indicated below, it is also important for the new draft to analyze existing regulations on the transportation of spent fuel assemblies and solidified wastes, and the new regulations concerning nuclear safeguards.

3. The Storage Of Spent Fuel Assemblies At Power Plant Sites Must Be Discussed

The management of fission product wastes actually begins at the time spent fuel assemblies are removed from nuclear power reactor cores and placed in water-cooled basins at the power plant sites. A discussion of the safety and experience of this handling and storage of the wastes is desirable because

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33/ See, NRDC submission, dated July 11, 1974.

34/ See, NRDC submission, dated September 30, 1974.

35/ Any argument that these regulations do not need to be considered in an impact statement on the radioactive waste management program prepared under the General Manager's Office of the AEC on the grounds that they are the responsibility of the Director of Licensing would be frivolous. (See, e.g., pp. C-23, -70)

the Commission relies so heavily upon the record of using these water-cooled basins to justify its assurances that the capability to construct and operate an engineered surface storage facility is within the Commission's reach. (pp. 3.1-1, C-45.) In particular, the new draft statement should elaborate upon the following answer given to an inquiry about past experience with the storage of spent fuel assemblies:

> "At [the AEC's Hanford, Savannah River, and Idaho] sites, most water-filled spent fuel storage basins and retention basins for potentially contaminated cooling water are of concrete construction. There have been occasional leaks from these basins and, although no significant radiation exposures to the public have resulted, the existence of residual radioactive contamination in the soil beneath or beside the basins represents an undesirable eventual site decommissioning problem. It is for this reason that the RSSF water basin alternative would have a stainless steel liner." (p. C-45) (Emphasis added)

The questions that need answering are: What has been the experience with water-filled storage basins at commercial nuclear power plant sites? And, what is the basis for believing that a particular basin liner will solve the leakage problem for the possible, as opposed to the hoped for, life of an engineered surface storage facility?

We regard it as possible that the best alternative will be not to reprocess at all, but to develop a permanent storage facility or facilities for spent fuel assemblies. In this way, the release of significant amounts of radioactive wastes to the environment during reprocessing will be avoided; the possibility of serious accident at a reprocessing facility and

in the handling and storage of "high-level" wastes will be eliminated; and, perhaps most importantly, there will not be large quantities of purified plutonium in existence to be accidentally released or stolen for terrorist or blackmail purposes.

Any final judgment on that major alternative would require a detailed consideration of the advantages and disadvantages of storing the spent fuel assemblies in water-cooled basins, or in some other type of structure for heat dissipation and radiation shielding. A complete evaluation of the knowledge that has been accumulated over the past two or three decades about storing spent fuel assemblies would be very useful during review of this major and apparently attractive alternative to releasing the fission products and by-product actinides from fuel rods during spent fuel reprocessing.

4. The Shipment Of Spent Fuel Assemblies To Reprocessing Plants Must Be Thoroughly Analyzed

The transportation of spent fuel assemblies -- which represents most of the "curie-miles" of radioactive materials' shipments -- must be carefully evaluated in the new draft statement because it represents a large portion of the cost in the management of commercially-generated wastes, exposes the population to significant amounts of radiation, and poses the risk of serious accidents that even AEC scientists estimate could kill hundreds or even thousands of people and significantly contaminate the local environment. Each of these costs can be

expressed in terms of dollars and they should be factored into the overall cost/benefit analysis of radioactive waste management and fully considered in the comparisons of waste management alternatives, including in discussions of the locations of possible repositories.

The draft gives only brief consideration to the transportation of spent fuel assemblies (pp. 2.3-25, 3.3-1 through 3.3-14), and even less to the shipment of solidified high-level wastes (see, esp. pp. 3.3-1 and 3.3-9). The assertions of a high degree of protection against serious radiological consequences of transportation accidents is based almost totally upon two previous surveys (p. 3.3-2) which have not been subjected to the rigorous NEPA process. Our evaluation of the transportation section of the LMFBR draft programmatic statement (WASH-1535), which relied upon these surveys and other studies, is presented in Appendix B. By this reference we explicitly intend to incorporate them in these comments on the draft programmatic statement concerning radioactive waste management.

At several places in Appendix B we critique portions of the two surveys, WASH-1238 and WASH-1248[36/] which are relied upon in this draft statement as evidence for the high degree of safety in the transportation of solidified high-level wastes.

36/ WASH-1248 is virtually an unchanged version of the earlier "Environmental Survey of the Nuclear Fuel Cycle" (November 1972)

In large part our criticisms are generic in nature and apply equally to shipments of spent fuel assemblies from all reactor types and solidified high-level radioactive wastes. Detailed, specific comments on the transportation of solidified high-level wastes, and on the shipment of spent fuel assemblies from LMFBR's, are not possible because no shipping casks have been designed yet for these radioactive materials.

In addition to responding to each of the points raised in Appendix B, we believe that the new draft statement should directly confront the recommendations of the Association of American Railroads and the Committee on Transportation of Radioactive Materials, Western Interstate Nuclear Board.

On May 3, 1974, the Board of Directors of the AAR issued the following recommendation to the railroad industry:

> "Shipments of casks containing irradiated spent fuel cores should move in special trains containing no other freight, not faster than 35 MPH. When a train handling these shipments meets, passes or is passed by another train, one train should stand while the other moves past not faster than 35 MPH."

The Board listed the following three underlying "circumstances" which prompted them to make this recommendation:

> "1. the introduction of very much heavier casks and larger quantities of irradiated fuel elements as a result of changes in nuclear technology;
>
> 2. the increasing public concern over environmental consequences of accidents involving the shipment of any hazardous material; and
>
> 3. the recognition that the transportation environment can be controlled thus reducing the probability of accidents and the intensity of the accident event."

We applaud this commendable concern with the public health and safety, and urge the Commission to give the AAR's recommendation full consideration. However, while the observance of this strict limitation on the operation of trains carrying spent fuel casks will substantially increase the margin of safety, it will also increase transportation costs. These increased costs should be calculated and presented as part of the detailed cost/benefit analysis that should be included in the new draft analysis on the management of commercially-generated radioactive wastes.

The WINB Committee on Transportation of Radioactive Materials recently reported that there are significant numbers of violations of the federal regulations that are designed to protect the public health and safety during the transportation of radioactive materials.[37/] Based upon its review of non-compliance with regulations, the Committee stated

> ". . .that the U.S. Department of Transportation should undertake a more vigorous enforcement program for hazardous material transportation in general, and radioactive material transportation in particular. The small number of inspections and frequent incidence of violation of regulations clearly indicate a need for a more vigorous and more extensive Federal regulatory effort. Regulations which call for careful packaging and transportation of radioactive material are of limited value unless compliance is strictly enforced."[38/]

37/ Transportation of Radioactive Materials In The Western States (March 1974).

38/ Id. at 47.

The Committee further recommended

> ". . .that the requirements for routing and/or alternate routing of radioactive material shipments should be reviewed by the DOT in concert with the states to determine whether any more definitive guides can be included on routing through populated areas and to determine the applicability of these requirements to rail shipments." 39/

The Committee also urged the AEC and DOT to

> ". . .make a thorough evaluation of the feasibility and desirability of unit transportation for rail shipments of spent fuel and high level radioactive waste." 40/

In the new draft statement the Commission should thoroughly review these recommendations and address the issues raised therein.

39/ Id. at 48.

40/ Id. at 50.

5. All Aspects Of Spent Fuel Reprocessing Operations Must Be Fully Considered

The bulk of the radioactive wastes ". . .are created at the reactor as fission products within the fuel elements, but separated and packaged elsewhere in a spent fuel reprocessing plant." (p. 2.2-4) The fission products are released from the fuel rod matrix and separated from plutonium and unconsumed uranium at the spent fuel reprocessing plant by the so-called cut and leach procedure. (p. 2.2-5) This processing of spent fuel is an integral part of radioactive waste management. As we have already emphasized, not to consider fully the environmental and other costs of the spent fuel reprocessing step of radioactive waste management seriously detracts from the value of this draft programmatic environmental statement.

In sections 1 and 2 above, we pointed out several matters pertaining to fuel reprocessing that need to be discussed in much greater detail and more comprehensively than the treatments in this draft statement. These issues include defining high-level wastes, the decommissioning of reprocessing plants, the timing of the solidification of high-level liquid wastes, and the proposed principal design criteria and "as low as practicable" criteria for reprocessing facilities. In section V below we consider two major alternatives to current reprocessing practices: simply storing spent fuel assemblies with no reprocessing and, alternatively, the efficient partitioning of transuranic elements for transmutation in nuclear reactors.

There are two other important issues relating to spent fuel reprocessing that need full elaboration in the draft statement.

The first is the routine practice of releasing krypton gas and tritium at reprocessing plants;[41] the second is the use of by-product plutonium in the fuel for nuclear power reactors ("plutonium recycle").

a. Release of Noble Gases and Tritium at Spent Fuel Reprocessing Plants

Because reprocessing plants will account for almost all of the krypton released into the environment from nuclear power development,[42] this draft programmatic statement should evaluate in detail the possible cumulative and health effects of these releases compared to the costs of containing and storing the noble gases.

The U.S. Environmental Protection Agency in a recent report estimated that "[o]perations of the U.S. nuclear power industry through the year 2000 could result in a total worldwide population impact (i.e., cumulative potential health effects) of about 7,000 health effects [two-thirds fatal]. . .attributable to the release of krypton-85." In addition, EPA projects about another 3,000 health effects (two-third fatal) due to the release of tritium.[43] The EPA study concluded, based upon the estimate

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41/ We wish to stress here that other routine and accidental releases of radionuclides to the environment from reprocessing facilities need to be fully analyzed in the new draft statement also. The actinides and iodine are the most notable of these other radioactive waste pollutants.

42/ Nichols and Binford, "Status of Noble Gas Removal and Disposal," ORNL-TM-3515, p. 2 (August 1971).

43/ EPA, Environmental Radiation Dose Commitment: An Application To The Nuclear Power Industry, EPA-520/4-73-002, p. 22 (February 1974). (The terminology "health effects" refers only to certain serious genetic effects and cancer. Id. at 9.) (Hereinafter "Dose Commitment".)

of health effects, that "the future impact of the release of krypton-85, especially if other releases around the world are added to these estimates, is sufficiently large that active consideration should be given to controls to limit releases of this radionuclide."[44/]

This assessment of the potential gravity of the problem is not confined to the EPA. For instance, ORNL scientists have estimated ". . .that continued (worldwide] release of ^{85}Kr through the year 2000 would cause skin dose rates from ^{85}Kr exposure that are about 5% of the dose rate that is a consequence of natural background radiation."[45/] Calculations by a scientist at the Pacific Northwest Laboratory of Battelle Memorial Institute indicates that by the year 2050 the build up of krypton from U.S. fuel reprocessing facilities could result in the general population receiving 4% of the annual genetic dose limit and 10% of the skin dose limit recommended by the International Commission on Radiological Protection.[46/] Thus, the continued release of the noble gases alone, particularly the radioisotope krypton-85, could result in much higher radiation doses than those due to the routine release of all radionuclides from

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44/ Id. at 28.

45/ Nichols and Binford, op. cit., p. 9.

46/ M.M. Hendrickson, "The Dose From ^{85}Kr Released to the Earth's Atmosphere," in IAEA, Environmental Aspects of Nuclear Power Stations, p. 237 (1971).

from nuclear power plants.[47]

There seems to be little doubt that krypton gas can be captured and contained at reprocessing plants. The EPA reported that control methods have been proposed that would reduce the amount of krypton-85 released from spent fuel reprocessing plants by a factor of 1000.[48] The 1971 ORNL study reported that "there are two processes in an advanced state of development that appear to be capable of reliably recovering up to 99.9% of xenon and krypton from effluents of reactors and fuel reprocessing plants."[49] More recently, in the "as low as practical" proceedings for nuclear power plants, a commercial firm stated that,

> "[a]t this time, Airco Cryoplants and others will guarantee a decontamination factor of 10^4 for krypton, and in our development work have measured decontamination factors greater than 10^6."[50]

Furthermore, we observe that the AEC, in its draft environmental statement (WASH-1535, March 1974) on the proposed liquid metal fast breeder reactor program, states that "[s]elective-absorption

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47/ It is particularly important that radiation exposures be calculated in man-rems in the new draft statement. This is necessary in order to give a clear perspective on the total number of adverse health effects that may result. Exposures to relatively high-levels of radiation from krypton-85 is a striking case in point. Assuming an eventual build up of krypton from reprocessing plants to a level such that each member of the general population received .30 rems and a world population of 8 billion at that time, then the total man-rems would be over 2 billion, a truly large figure.

48/ "Dose Commitment," p. 22.

49/ Nichols and Binford, op. cit., p. 31.

50/ AEC, Final Environmental Statement, Proposed Rule Making Action: Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents, WASH-1258, Volume 3, p. 64 (July 1973).

in a fluorocarbon solvent is an effective method for removing the noble gases krypton and xenon from gaseous effluents [in fuel reprocessing plants]. . .." (WASH-1535, p. 4.4-37) (footnote deleted) The LMFBR draft programmatic statement also states that the cylinders of the concentrated gases would be shipped to a "Noble Gas Storage Facility." (WASH-1535, p. 4.5-48) The programmatic statement on radioactive wastes should go into much more detail than the short description in the LMFBR statement (WASH-1535, pp. 4.6-59 through 4.6-67) to describe fully the hazards in transporting pressured cylinders of noble gases and the likely location and characteristics of the NGSF. On the other hand, if the AEC for some reason has changed its mind since the publication of the LMFBR draft statement about the need for containing and storing the noble gases from reprocessing plants, then the new draft statement on waste management should give full justification for such a new policy.

The LMFBR draft statement also discusses the possibility that the bulk of the tritium in spent fuels may be collected prior to reprocessing by alternative processes that are now under development. (WASH-1535, p. 4.4-48) The draft statement on radioactive waste management should thoroughly discuss this potential improvement in spent fuel reprocessing and indicate how and where the resulting concentrated solutions of tritium would be stored.

b. Plutonium Recycle

The draft statement sets out at the very beginning the AEC's official position that spent fuel reprocessing is <u>required</u>

because of "favorable" economics.[51/] For instance, the second page of text begins as follows:

> "The generation of electric power by nuclear reactors requires a number of support activities which are known collectively (with reactor operation) as the nuclear fuel cycle. For the type of nuclear power reactor most common in the U.S., this cycle involves. . .chemical processing of irradiated fuel to recover unused uranium, and plutonium generated in the reactor. . .recycling of uranium and (prospectively) plutonium. . .." (p. 1.2-1) (emphasis added)

A few pages on in the statement this point is reemphasized as follows:

> "To conserve this valuable [unburned fissile] material and the remaining fertile material, economics dictate that the fuel be reprocessed to recover these materials." (p. 2.2-5) (emphasis added)

We emphatically disagree with both the philosophy and the economic calculations that are presumably behind such misleading statements. First, the purported economic benefits of recovering and utilizing the fissile and fertile materials in spent fuels, even if correctly calculated, do not "require" or "dictate" any particular course of action. Rather, these economic benefits are just that -- economic benefits that must be compared to all costs, including environmental costs and possible loss of civil liberties, and to the costs and benefits

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51/ Although the draft statement does not make it clear, it is actually the recycle of plutonium that makes spent fuel reprocessing economically attractive. "Recovery and recycle of uranium are not now economically feasible unless plutonium is also recycled, since the cost of recovery exceeds the value of the uranium." (WASH-1327, p. S-14.)

of other possible courses of action, such as permanently storing spent fuel assemblies instead of reprocessing. As we have stated on a previous occasion, in comments on the LMFBR draft programmatic statement,[52]

> "[i]t is well known that cost-benefit analysis was not designed to make judgments about the fair distribution of economic well-being, either between people living in the present or between people living in different generations of time.[53] Consequently, cost-benefit analysis is most appropriate for evaluating decisions whose potential effects have little impact on distribution.[54]"

Second, even using AEC figures, there is little economic benefit in recycling plutonium in light water-cooled reactors ("LWR's"). According to the cost/benefit analysis in the draft impact statement, Generic Environmental Statement--Mixed Oxide Fuel (WASH-1327, August 1974)(hereinafter referred to as GESMO), the addition of uranium and plutonium recycle would reduce fuel cycle costs in 1990 by less than 15%. (WASH-1327, p. S-15) Since total fuel cycle costs are only about 25% of the total cost of generating electricity at nuclear power plants, the economic penalty to the ultimate consumer would be at most only a few percent increase in the cost of electricity if spent fuel reprocessing did not take place.

52/ Cochran and Tamplin, "NRDC Comments on WASH-1535: Cost-Benefit Analysis," submitted to the AEC.

53/ This is analogous to the observation that markets do not tell us how wealth should be distributed; they only tell us what is an efficient allocation of resources for a given distribution of wealth.

54/ See Arnold Harberger, "Three Basic Postulates for Applied Welfare Economics," Journal of Economic Literature, Vol. IX, No. 3 (Sept. 1971).

While spent fuel reprocessing releases large quantities of radionuclides, e.g., krypton-85, to the environment, "[p]erhaps the greatest potential adverse impact of plutonium recycle involves the increased exposure of plutonium to theft or sabotage." (WASH-1327, p. S-47) The implications of the "plutonium economy" are explored at length in Appendix C, "The Plutonium Decision: A Report On The Risks Of Plutonium Recycle" by Speth, Tamplin and Cochran.[55/] The safeguards problem of plutonium recycle are inextricably interwoven with spent fuel reprocessing and, therefore, the generation of high-level and transuranium-contaminated wastes. The draft statement should make meaningful reference to the hazards of plutonium recycle and make explicit reference to GESMO. To do less is to present only a part of the picture.

In order to understand some of the dimensions of the safeguards issue, we simply quote from GESMO some of the measures which are now under active consideration to improve current safeguards against theft or diversion of plutonium or sabotage of nuclear facilities which are "judged" by the AEC to be inadequate:

> "1. Minimization or elimination of the transportation of plutonium from reprocessing plants to mixed oxide fuel fabrication facilities which is the operation most vulnerable to an attempted act of theft or sabotage. To the extent that such shipments are minimized or eliminated, the safeguarding of plutonium would be enhanced. This objective could be accomplished by locating mixed oxide fuel

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55/ See, also, Abrahamson, "NRDC Comments on WASH-1535: Safeguards and Diversion of Special Nuclear Materials," submitted to the AEC.

fabrication plants in close proximity or immediately adjacent to reprocessing plants in Integrated Fuel Cycle Facilities. Although some safeguards advantages of this concept are apparent, such a plan would require careful analysis of a number of social, economic, environmental and political factors. In addition to the elimination of a key transportation step, the Integrated Fuel Cycle Facility would also make it economically possible to provide more effective onsite physical protection measures for prevention of theft of plutonium or sabotage. An early evaluation of this concept is necessary (while the industry is in the evolutionary stage) so that decisions can be made before large capital investments are required.

2. Further protection of transportation functions by use of massive shipping containers, special escorts or convoying measures, vehicles hardened against attacks, improved communications and strengthened response capabilities.

3. Additional hardening of facilities through new barrier requirements, new surveillance instrumentation and new delaying capabilities.

4. Upgrading of operating and guard functions through the use of personnel security clearance procedures, a Federally operated nuclear security system, more effective systems for monitoring and searching of personnel, and closer liaison with law enforcement authorities.

5. Improving the timeliness and sensitivity of the system of internal control and accountability of plutonium.

6. Use of 'spiked' plutonium* which would be less susceptible to theft and would be more difficult to manufacture into a nuclear explosive because of the required elaborate handling procedures."

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* "Spiked" plutonium is plutonium which is combined with radioactive material emitting high levels of penetrating radiation.

> "Studies on some of these aspects (Federal Security Force, threat analysis, personnel security clearances, strengthened physical protection measures at fixed-sites and in transportation, and improved material accountability methods) are underway and other studies (e.g., Integrated Fuel Cycle Facilities and 'spiked' plutonium) are being initiated." (WASH-1327, p. S-45)

We believe that the prospects of establishing a "Federal Security Force" to protect hundreds of nuclear power plants, spent fuel reprocessing plants, fuel fabrication plants and thousands of shipments of radioactive materials, and the institution of "personnel security clearance procedures" and "more effective systems for. . .searching personnel" at all of these nuclear facilities raises serious questions about the possible loss of civil liberties by the employees of utilities, manufacturers of nuclear power equipment, and even the plumbers, electricians and others who may come in contact with nuclear facilities. The prospect of nuclear power at gun point and massive use of lie detector tests and background investigations on thousands of workers should receive forthright discussion in the draft statement concerning the management of commercially-generated radioactive wastes. The AEC seriously erred in deferring a discussion of the safeguards issue to the final statement. (p. 3.1-33)

c. Solidification of High-Level Wastes at Reprocessing Plants

We have discussed above the need for the draft statement to include an analysis of the alternative of solidifying high-level liquid wastes immediately after their generation, as was

proposed for the Midwest Fuel Recovery Plant, instead of allowing for a ten-year storage period during which time the tanks could leak and seriously contaminate ground and surface waters. Additionally, detailed consideration should be given to requiring the solidified wastes to be put into a glass-like form in order to minimize the possibility of the wastes escaping during a serious transportation accident in route to or in handling at a national repository. If techniques are not now, or soon will not be, available for fixing the solidified high-level wastes into an insoluble matrix, then a clear explanation should be given as to why the Waste Solidification Engineering Prototype (WSEP) facility at Hanford has not been able to come up with a solution during its ten years of operation. (p. 2.3-17)

Similarly, we believe that there needs to be a fuller explanation of, and detailed consideration of alternatives to, the proposed Calcine Conversion Facility (CCF). (pp. 2.5-31 through 2.5-34) In particular there should be an analysis of the advantages of establishing such a facility at a commercial reprocessing plant in order to maximize the probability of its practicality and in order to take fuller advantage of the safety of transporting and handling the fixed wastes.

6. The Management Of Transuranium-Contaminated Wastes Needs To Be Discussed In Detail

The discussion of the proposed federal management of radioactive wastes containing more than 10 nanocuries per gram of transuranic elements lacks important detail and, as in the case of high-level wastes, does not consider the possible

environmental effects of storing the wastes until they decay to innocuous levels.

a. Definition and Regulation

As mentioned in section III.A.1.b. of these comments, above, the draft statement should have described the "administrative means" that will be used in practice to "define" wastes containing in excess of 10 nanocuries of transuranic elements per gram, since it is currently impossible to measure such a low-level of alpha activity from the outside of containers. Also, the draft statement should have included the proposed new regulations, which were available at the time the draft was released,[56/] requiring federal custody of such wastes.

The optimum methods for temporarily and permanently storing transuranium-contaminated wastes will depend on the extent and character of the wastes. In order to plan wisely for their management, their chemical, physical and radiological characteristics should be predicted as precisely as possible. Regrettably, the draft statement fails to do this. For instance, the statement vacillates on whether or not "hulls" will be treated as high-level wastes or as transuranium-contaminated wastes. (pp. 2.4-12, 2.6-8) In part, due to the emission of penetrating radiation from hulls, this is an important issue. The new draft statement should state how the hulls will be treated and present the basis for that decision in detail. Further, the new draft statement should describe the amounts and kinds of wastes, including uranium alpha wastes, that will eventually be treated as transuranium-contaminated wastes.

56/ 39 Fed. Reg. 32921-29, September 12, 1974.

b. Desirability of Federal Custody

While it appears that the transuranium-contaminated wastes should be more securely contained than they have been in the past, the basis for the decision to stop commercial burial and substitute federal custody over the wastes needs full explication in the draft statement. For instance, the new draft statement should explain why AEC "reassurances as to the absence of any near-term problem [concerning the shallow burial of plutonium-contaminated wastes at NRTS] did not fully satisfy the concern of Idaho officials as to the long-term status of the aquifer underlying the NRTS." (p. 2.4-10) In other words, what was the evidence which persuaded the AEC not only to stop burying the plutonium-contaminated wastes, but also to dig up the existing wastes? And, how does this decision square with the AEC's assertion that there is no need to remove transuranium-contaminated wastes buried at commercial sites? Are the chances of a health problem arising at NRTS greater than at existing commercial burial grounds in Kentucky, South Carolina, Illinois or New York, where there are considerably more moist conditions and not as much soil between the burial site and the ground water aquifer? As indicated in the statement (p. 2.7-2), there is the possibility of confusion when on the one hand the AEC claims that existing deposits of transuranium-contaminated wastes in shallow trenches are safely contained and then on the other hand it states that there is a need for future wastes to be stored in more secure federal facilities.

The fact is, of course, that the commercial firms' current procedure of burying wastes containing transuranic elements in

shallow trenches is wholly unacceptable. The real question is not if the transuranic elements will migrate away from such disposal sites, but when. Bald assertions that "[t]o date, there has been no indication of migration of radioactivity from any commercial burial site" (p. 2.4-3) do not squarely face the problem.

Whether or not any indications of transuranic element migration are found depends on the types and sensitivities of tests that were performed. How far away from a known deposit of plutonium were the measurements made? How sensitive were the measurements? How many and how systematically made were the measurements? Answers to these and other questions need to be provided before any significance whatsoever can be attached to an unreferenced and unsupported statement that there is no indication of movement. This information is needed, furthermore, in order to verify initial assessments that ". . .after burial the radioactive material in the waste will be retained at the site and not migrate from the vicinity of the burial location." (p. 2.4-2) In the following comments on WASH-1535, the U.S. Environmental Protection Agency has stated that detailed studies need to be performed in order to determine whether or not the sites for commercial burial were selected carefully enough:

> "We have reviewed the engineering and hydrogeological reports used for the licensing of the existing commercial burial grounds. In our view these were preliminary reports suitable for identifying potentially acceptable burial sites. However, the investigations described in these reports did not include sufficient detail to, '. . .demonstrate that radioactive waste will not

> migrate from the site.' Additional detailed engineering and hydrogeological studies of the type (but certainly smaller in scale) made at NRTS and Hanford and conducted over a period of years after the burial grounds have been in operation are necessary to establish that the assumptions made initially were indeed valid and that the wastes will not migrate from the burial site. The AEC should present in the final statement the results of any studies which have been conducted at these commercial burial sites, subsequent to the beginning burial operations, which would corroborate or validate the conclusions reached in the original evaluation, 'that wastes will not migrate from the sites.'" 57/

The new draft statement should go into this matter in considerable detail in order to substantiate its claims that there is no hazard from existing commercial burial sites (p. 2.4-1) and that only new transuranium-contaminated wastes need to be stored more securely. The new draft should also describe the criteria that will determine when "corrective actions" (p. 2.4-3) will be taken to prevent further migration of transuranic elements from existing burial grounds and explain who will be responsible for monitoring for such migration during the next 100,000 or more years. The cost/benefit analysis should present figures on the relative costs of removing the existing wastes for transfer to federal custody compared to maintaining perpetual monitoring.

The draft statement has a section (p. 2.8-1) on the general criteria for selecting a site for the retrievable surface storage facility (RSSF) for the solidified high-level wastes.

57/ EPA, "Environmental Statement Comments, Liquid Metal Fast Breeder Reactor Program," D-AEC-00106-00, p. 24 (April 1974).

It is stated that the principal alternative sites for the RSSF ". . .are also considered principal alternative sites for retrievable storage of commercial transuranium-contaminated wastes." (p. 2.8-1) However, the general discussions of the advantages and disadvantages of the three sites, NRTS, Hanford and NTS, are in terms which refer only to the requirements of the RSSF and not in terms of the requirements of the three suggested storage means for transuranium-contaminated wastes (pp. 2.6-1, 2.6-6). It is even left uncertain whether or not the high-level and the transuranium-contaminated wastes will be stored at the same site. And while the land area requirements for the three alternative designs of an RSSF are estimated for the year 2000 (Table 3.1.1, p. 3.1-7), for instance, the land area requirements for transuranium-contaminated wastes are not so quantified. Instead, it is simply stated that there would be "some temporary commitment of land." (p. 3.2-5) The question is how much land will be required not only in the year 2000, but for years far into the future, in the event that a suitable geological repository is never found.

The new draft statement should expressly consider the criteria for selecting a means and site for retrievable surface storage of transuranium-contaminated wastes and rank the three principal alternative means and sites in terms of each criterion.

c. Compaction and Other Treatments

It is anticipated that some of the transuranium-contaminated wastes will be reduced in volume in order to facilitate cheaper and easier storage. The draft statement devotes only a few

sentences to each of five volume-reduction processes that are under development for AEC-generated wastes. (pp. 2.6-16-17) There is a longer, but still inadequate, discussion of treatment means for "hulls". (pp. 2.6-18 through 2.6-21) However, this section is concluded by the caveat that even if these volume-reduction processes were fully developed, they would not be suitable for commercially-generated wastes. (p. 2.6-21) A six-point program, which apparently has just been initiated, is then outlined in only the briefest of terms. The purpose of the new program is ". . .to identify, evaluate, and accommodate the waste management needs of the nuclear fuel cycle industry, per se." (p. 2.6-22)

In other words, there does not now exist a coordinated plan for the satisfactory treatment and interim storage of transuranium-contaminated wastes. There is no analysis of how much money, manpower and time will be required to complete the program which has been initiated. There is no description of the goals of the program beyond volume reduction. We wonder what wastes will have to be reduced to what volume in order for the program to meet its objectives. What are the cost/benefit trade-offs for varying degrees of volume reduction? What are the environmental effects of the various volume reduction procedures that are under investigation? What changes in regulations would be required to accommodate each process that is being studied?

It is stated that "industrial participation is considered the key factor in achieving acceptance of improved transuranic

waste processing and packaging." (p. 2.6-22) What administrative mechanisms have been set up for this desired industry participation? What is industry's financial contribution to the program compared to the federal government's share? What opportunities are there for environmental and citizen groups to participate with industry in establishing the parameters of the volume-reduction processes? How will it be determined what levels of reduction and what releases of radionuclides to the environment are cost justified? The draft statement provides no answers to any of these important questions, in part we imagine, because the AEC's program is too ill-defined at this point.

The new draft statement should at least describe the detailed guidelines that will be followed in implementing the volume-reduction program, and the anticipated time table for arriving at acceptable solutions to the various aspects of the program. The minimum budgetary requirements for meeting these goals should also be indicated.

B. The Environmental Statement Should Fully Describe The Procedures For The Selection Of And The Environmental Effects Of Proposed Engineered Surface Storage Facility Designs And Sites

The discussion of alternative designs and sites for the proposed retrievable surface storage facility (RSSF) is inadequate for decision-making purposes, because there are no detailed comparisons of the degree to which each principal alternative site and design meet each of the generalized design (pp. 2.5-1-2) and siting (pp. 2.8-2 through 2.8-5) criteria. Nor is there any clear priority ranking of the basic criteria themselves.

The vague discussions of the relative merits and demerits of each principal alternative design and site with respect to these generalized criteria provide no detailed comparative basis for the Commission's consideration in its decision making. The new draft statement should provide a clear priority ranking of the basic ten design criteria and eleven (not ten as stated) siting criteria, and compare, quantitatively wherever possible, the relative degree to which each design and site meets each of the ranked, general criteria. This is necessary in order to provide the Commission with a sound basis for its selection of a particular design and site. To the extent that the Commission does not rely on such a sound procedure in its decision making, the final decision will be arbitrary, an abuse of its discretion, and not consonant with its responsibility for protecting the public health and safety.

Beyond this procedural issue, we believe that there are numerous highly significant omissions in the analysis of the three principal alternative sites and designs for the RSSF. For instance, regarding the Hanford site, there is no mention that the discharge of large quantities of water from the water-cooled basin design may destabilize the large inventory of radionuclides that reside in the soil because of the continuing practice of using the soil as a radioactive waste dump.

Another example of a serious deficiency is the omission of a discussion concerning the amounts of concrete and steel shielding that should be provided in the sealed cask design. The design consisting of 2 inches of steel and 38 inches of concrete was chosen "[a]fter evaluation of the

factors involved. . .." (p. 2.5-21) However, there is no precise consideration of those factors and their relative importance. Why not use 14 inches of steel and 11 inches of concrete, or some other combination? The new draft should provide enough information to provide a clear basis for its selection of a particular amount of steel and concrete for each sealed cask.

In the new draft, careful attention should be paid to providing a detailed framework to support the Commission's selection of a particular design and site.

C. The Environmental Statement Should Fully Describe The Procedures For The Selection Of An Acceptable Geological Formation And Site For A Permanent National Radioactive Waste Repository

If long-lived radioactive wastes, such as the actinides, are produced by the nuclear power industry in large quantities, a means for disposal will have to be found to prevent these wastes from escaping into the human environment for a period of time of several hundred thousand years. The storage means must be able to resist successfully man's purposeful and accidental actions, including wars and complete breakdown of social order, and natural events. There is no known instance where this has been accomplished in the past. Indeed, examples such as the Egyptian pyramids, suggest the difficulty in constructing a container that will remain inviolable for such extraordinarily long periods of time.

It should have been one of the AEC's primary purposes in this draft statement to lay out in great detail the scientific basis for its belief ". . .that construction of a GDPP [geological

disposal pilot plant], and successful completion of the pilot phase could lead to availability of permanent disposal by two or three decades from now." (p. 25-36) The draft statement fails entirely to provide any information to support such a rosy prediction. Indeed, the available information indicates that pessimism about finding a suitable geological formation and site is more in order than the AEC's unsubstantiated optimism, for in spite of two decades of research and searching, no site has even been found for the proposed geological disposal pilot plant let alone a permanent repository.

At the outset, the draft statement proclaims that a "basic purpose of this statement is to assess the environmental consequences. . .of evaluating geological formations and sites for the purpose of developing a repository for permanent disposal. . .." (p. 2.1-1) Given this basic purpose, the paucity of information about possible geological formations and sites is truly astounding. There is not even any description of possible formations (other than salt beds) and sites for a pilot plant and permanent repository.

The most information is presented about bedded salt deposits, which apparently successive NAS-NRC advisory committees have considered the best currently available permanent disposal option. The draft states that the basis of the committees' recommendations is ". . .the isolation, shielding, heat dissipation, and self-sealing provided by bedded salt." (p. 2.3-20) The only other suggestive statement for the conclusion that bedded salt is acceptable is the unsubstantiated, unreferenced

conclusion that "fuel elements, simulating encapsulated solidified high-level wastes, were experimentally stored in a deep bedded salt formation for eighteen months without any unusual or unexpected effects of radiation or heat upon the salt." (p. 2.3-26) "The results of this experiment, together with other [unspecified] data and considerations, led the AEC to conclude that disposal in bedded salt formation is a safe and acceptable approach to the problem of long-term isolation of solidified high-level waste from man's environment." (p. 2.3-27) Thus, this discussion consists solely of a conclusion. There is no scientific data and analysis that would allow experts to arrive at the same conclusion. And because 20 years have elapsed since the first NAS-NRC recommendation favoring bedded salt and there still is not a pilot repository at a bedded salt deposit, it is especially important that the draft statement present the detailed scientific basis for its conclusion that bedded salt is safe for permanent disposal of long-lived wastes rather than merely asserting it.

In the end, the AEC apparently expects the reader of the draft statement simply to have faith that its conclusions are well-founded. This is simply an unacceptable approach under NEPA. It is especially unsatisfactory in light of the AEC's mismanagement of its own wastes and its inability after 20 years to locate even one suitable bedded salt deposit for a geological disposal pilot plant.

In this regard, we believe that the new draft statement present detailed results of the AEC's investigation into the suitability of bedded salt despoits near Carlsbad, New Mexico. The statement should particularly address itself to the issue

of why the AEC is not moving ahead as fast as possible in verifying the acceptability of the Carlsbad site. If there are no problems with those salt bed formations, why should an expensive, temporary surface storage facility be constructed when the NAS-NRC advisory committees have repeatedly endorsed the use of bedded salt? If there are site-specific problems at Carlsbad, why has the AEC twice selected locations with serious site-specific problems? These are important questions that deserve forthright answers in the new statement.

The other geological formations which "appear [to be] possible choices for disposal of high-level wastes. . ." are simply named: domed salt, granite and limestone. (p. 2.3-27) There are no references or discussions to explain why these formations are considered "promising" candidates for a geological disposal pilot plant (p. 2.5-26). And, although it is stated that there are also "specific promising sites" for study, they are not identified. No information is presented to indicate why these unnamed sites are "promising" or where they are.

Furthermore, there is no discussion of why the three types of geological formations that are mentioned as promising have been singled out for special investigation and attention. Other formations are certainly possible candidates for geological disposal. For instance, a U.S. Geological Survey scientist has recently published a paper endorsing research into the possibility of using the vadose zone in the Southwest as a national radioactive waste repository.[58/] The new draft should

58/ Winograd, "Radioactive Waste Storage in the Arid Zone," Journal of the American Geophysical Union, p. 884 (October 1974).

contain a detailed evaluation of all geological formations under consideration for study.

And, perhaps more importantly, there is no explanation of why the AEC is seriously looking at these other formations in the face of its strong statements that bedded salt is safe.

Finally, we observe that there are no detailed criteria presented that will guide the AEC in deciding whether or not a particular geological disposal pilot plant is suitable for conversion to a permanent repository. Such advanced planning should be completed now so that there will be a better understanding of how long it might take to certify a pilot plant as safe for a permanent disposal site and what uncertainties might remain even after that decision is made.

IV

THE DISCUSSION OF PAST AND PRESENT RADIOACTIVE WASTE MANAGEMENT ACTIVITIES IN THE ENVIRONMENTAL IMPACT STATEMENT IS INCOMPLETE AND MISLEADING

The draft statement fails to deal systematically and candidly with the AEC's experience to date in the management of its own vast amounts of high-level and transuranium-contaminated radioactive wastes. This is a serious deficiency because surer lessons can be drawn from actual operating experience than from most generalized projections. The AEC experience is -- as with all large organizations -- replete with errors of judgment, employee lapses, carelessness, failure to abide by regulations and, imprudent efforts to economize and shortcut. The draft statement also draws misleading conclusions from the existence of the large amounts of wastes which were generated by the nation's weapons program.

In addition, the draft fails to deal with the existing substantial accumulation of commercial high-level wastes at the Nuclear Fuel Services Plant in New York.

A. The Environmental Statement Does Not Accurately Describe The History Of The Proposed National Repository At Lyons, Kansas

In its brief review of the history of radioactive waste disposal concepts, the draft statement purports to describe the effort to develop a bedded salt formation near Lyons, Kansas, as a permanent waste repository. Since that project was the

major AEC hope for several years, the unforeseen safety hazards with it suggest that extreme caution is called for and that a satisfactory disposal means for high-level radioactive wastes will not be easy to find. The draft statement, however, gives no hint of the errors of judgment and the breakdown that occurred with respect to that proposal. As such, it presents a misleadingly optimistic picture of our national experience.

The short description in the draft statement suggests that the AEC was at all times highly tentative and qualified in its proposal that the Lyons, Kansas, site might provide a satisfactory disposal site for the nation's radioactive wastes. In fact, after "substantial investigation", the AEC in 1971 claimed before the Joint Commission on Atomic Energy that all the necessary studies for confirming the mine's suitability had been complete and that a demonstration project should be constructed there.

However, citizens, scientists and organizations from Kansas argued that it was premature to place actual radioactive wastes in the mine and that additional studies needed to be conducted. And, in fact, further analysis proved that the Lyons site was unsuitable. In the words of one observer:

> "On September 30, 1971, the AEC reported to the JCAE that certain additional information became available, all of which raised questions concerning the long-term safety of the Lyons Waste Repository -- the long-term operations of the American Salt Company near the Lyons site, and the problems of plugging numerous oil and gas wells on or immediately adjacent to the Lyons site. This late amendment to the assessment was

taken by many critics as vindication of their doubts."59/

It may be doubted then whether, without the prodding of those outside citizens and scientists, the solution mining and nearby wells which made the Lyons site unsafe would have been discovered. A review of the events surrounding the Lyons, Kansas, affair can be found in the June, 1971 issue of the Bulletin of Atomic Scientists.60/

B. Although The Statement Rests On The Assumption That Long-Term Disposal Means Will Be Found In The Foreseeable Future, The Draft Fails To Discuss The Fact That Less Intensive Efforts Than In The Past Are Being Made To Construct A Test Project At The Presently Favored Site Near Carlsbad, New Mexico

Although the draft concedes that the required permanent disposal site has not been found, it indicates that bedded salt deposits or another geological formation is likely to prove acceptable for that purpose in only two or three decades. The AEC's present plan of action which is not discussed in any detail in the draft, raises doubts about the validity of this conclusion. After the failure at Lyons, Kansas, the AEC turned to salt formations near Carlsbad, New Mexico, as the most likely site for a pilot disposal project. In the past year -- perhaps to shift resources to the near-surface storage facilities concept or to

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59/ Kubo, Technology Assessment of High-Level Nuclear Waste Management, Ph.D. Thesis, Massachusetts Institute of Technology, p. 243 (May 1973).

60/ See also Hambleton, "The Unsolved Problem of Nuclear Wastes" Technology Review, (March-April 1973) at 15-19; and Holden, "Nuclear Waste: Kansans Riled by AEC Plans for Atom Dump," Science 172, p. 249 (April 16, 1972).

allow the development of nearby fossil fuel deposits[61/] -- AEC's work at Carlsbad has been brought to a virtual halt.[62/]

Although the AEC has asserted that it is vigorously exploring geological disposal facilities, more detail about just which sites and which opportunities are being explored and the findings to date are required in the draft to sustain the prediction that satisfactory disposal means will be found in the near future. This need for assurance is particularly great in light of the surprising termination of efforts at Carlsbad.

C. The Draft Statement Does Not Describe The Problems Posed By And The Projected Management Of Existing Radioactive Wastes At Commercial Spent Fuel Reprocessing Plants

Management of commercial high-level and transuranium-contaminated wastes is not entirely a prospective problem. The Nuclear Fuel Services' commercial reprocessing plant at West Valley, New York, has operated for several years and generated some 600,000 gallons of high-level liquid wastes, which are presently stored in tanks on the site. These wastes will present particularly troublesome management challenges because they are stored as neutral solutions that cannot be solidified by the calcination process developed at NRTS. In addition, the

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61/ One of the original criteria for selecting a satisfactory bedded salt deposit for a national repository was that it not be near fossil fuel resources. (See, AEC Environmental Statement, Radioactive Waste Repository, Lyons, Kansas, WASH-1503, p. 21 (June 1971). We wonder if this criterion is still in effect and whether or not it has foreclosed the use of the Carlsbad site.

62/ Western Interstate Nuclear Board, WINB Developments (June 14, 1974, p. 3).

general discussion of waste management at reprocessing plants in the draft statement apparently does not apply to the existing wastes at NFS because the regulations promulgated at Appendix F of 10 C.F.R. Part 50, which prescribe the handling of high-level wastes, specifically do not apply to existing commercial fuel reprocessing plants. The omission of this entire subject is a serious inadequacy in the draft. The new draft should explicitly describe how and when the existing high-level liquid wastes at NFS will be solidified and transported to a federal repository.

Furthermore, the new draft should address the same issues as they pertain to the Barnwell reprocessing plant which is nearing completion.

D. The Conclusions Drawn In The Draft From The Fact Of And AEC Experience With High-Level And Transuranium-Contaminated Wastes Generated In The Nation's Weapons Program Are Incorrect And Misleading

In a number of places, the draft improperly suggests that the AEC experience with management of weapons-generated wastes is a basis for optimism concerning prospective management of commercial wastes. As discussed above with respect to the draft's conclusion regarding water-cooled basins, the AEC's experience to date with high-level and transuranium-contaminated waste management is an important reference point for projections into the future. Unfortunately, we find that experience far from comforting. The draft is seriously deficient in failing adequately to deal with

or even admit to past errors. The incidents at Hanford such as the disposal of such large quantities of plutonium into the earthen trench Z-9,[63/] that a nuclear chain reaction in it was once thought be be "conceivable" and the 50-day leak of 115,000 gallons of high-level liquid wastes into the surrounding soil from tank 106-T[64/] should be analyzed for their bearing on the sort of management mistakes and accidents which may arise in the future. The Commission can not reasonably rely on an assumption that no such serious mistakes or accidents will occur again. The draft, moreover, cannot fairly draw only highly favorable conclusions from what is in fact a checkered past.[65/]

To indicate that there are potential uncertainties even with storage schemes that rely upon "proven" technology, it is worth considering the underground tank system at Hanford. Prior to the construction of the storage tanks at Hanford, alkaline wastes had been satisfactorily stored in carbon steel tanks for

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63/ See, (1) AEC, Environmental Statement, Contaminated Soil Removal Facility, WASH-1520 (April 1972); (2) Atlantic Richfield Hanford Company, Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench, ARH-2915 (December 1973); and (3) Ames, Battelle Pacific Northwest Laboratories, Characterization of Actinide Bearing Soils: Top Sixty Centimeters of 216-Z-9 Enclosed Trench, BNWL-1812 (February 1974).

64/ See, AEC, Report on the Investigation of the 106-T Tank Leak at the Hanford Reservation (July 1973).

65/Another serious error in judgment occurred when the AEC permitted plutonium-bearing wastes to be buried in shallow trenches at NRTS in Idaho. Now these wastes have to be removed and stored at great cost and effort. (p. 2.4-10).

short periods of time. Thus, carbon steel tanks were installed at Hanford

> ". . . because both alkaline waste storage technology was developed and experience with it had been satisfactory."66/

Contrary to expectation,however, some of the single-walled tanks began to leak shortly after they were used. There have now been 16 such leaks in the underground storage tanks, and several leaks in pipes connecting the tanks, including one that resulted in high-level wastes spreading out over the ground surface. Approximately 500,000 gallons of high-level liquid wastes have now seeped into the Hanford soil from these leaks. It is fully anticipated that leaks will continue to occur at a significant frequency.

The leaks, which began in the latter part of the fifties, have caused serious problems that continue today. The General Accounting Office has completed two investigations that consider the waste management program at Hanford.67/ After the first investigation, the GAO concluded that the situation appeared to be reaching a particularly hazardous point toward the end of 1969:

> "At the time of our review, Richland was faced with a potentially serious situation

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66/ Wm. L. Lennemann, "Management of Radioactive Aqueous Wastes From U.S. Atomic Energy Commission's Fuel Reprocessing Operations, Experience and Planning," presented at the Symposium on the Management of Radioactive Wastes, Paris, France, November 27 to December 1, 1972, p. 13.

67/ (a) General Accounting Office, Observations Concerning The Management Of High-Level Radioactive Waste Material (B-164052), May 29, 1968. (Hereinafter "Observations".)

(b) General Accounting Office, Progress And Problems In Programs For Managing High-Level Radioactive Wastes (B-164052), January 29, 1971. (Hereinafter "Progress".)

> with respect to the conditions of its existing tanks. The operating contractor has estimated that the expected life of the 20 Richland tanks equipped to accommodate self-boiling wastes is probably no more than 20 years or could be as little as 10 to 15 years. Eleven of the 20 tanks have been in service for 10 years or more. Further, recent studies have cast doubt upon the wisdom of reusing such tanks after they have been emptied, regardless of their age. In this regard, it appears that in the last half of 1969, Richland may be confronted with a situation of having only used tanks available as spare tanks for high-level self-boiling waste storage."68/

The principal point that we wish to make here is that at the time that the combination of alkaline wastes and carbon steel tanks was selected, it was believed that "proven" technology was being applied to the solution of a very serious problem -- the safe storage of large quantities of liquid high-level wastes. Clearly, however, a costly error in judgment was made. It is now believed that another storage system should have been chosen:

> "Longer tank service life, significantly smaller quantities of waste, better feed for further treatment, and cost analyses all indicate that, for today's fuel reprocessing technology, acid waste storage is preferable." 69/

As indicated in the above statement, the production of wastes has complicated the long-term[70/] waste storage problem at Hanford because techniques are not now available to convert the high-salt content (alkaline) wastes into a manageable solid. The

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68/ "Observations", p. 12.

69/ Lennemann, op. cit. p. 13.

70/ In this case, "long-term" means a time period greater than a few decades.

current practice of evaporating the liquid into a salt cake/sludge is only desirable in the short term, because it reduces the possibility for additional large leakages of waste. Unfortunately, it complicates the problem of finding a way to contain adequately the wastes for the next several thousand years, for the tanks will completely lose their integrity long before then.

The option of simply digging the salt cake/sludge out of the tanks and transporting them to a permanent storage site is economically very unattractive, as indicated by the GAO after the second investigation:

> "AEC informed us that the Lyons location probably could be used for long-term storage of AEC's high-level radioactive wastes; however, because of the estimated high cost (preliminary estimates are in the range of $1.5 to 2 billion) of processing, packaging, and shipping the wastes from Richland and Savannah River to Lyons, efforts are under way to determine whether suitable long-term-storage locations and methods can be developed at the two AEC sites. AEC believes that the cost of exploring and developing a long-term-storage method at these sites is justified, because of the potential expense of shipping the large quantities of waste at these sites to another location. AEC advised us that it probably would not be economically attractive for a commercial plant to make similar studies for its own location." 71/

Apparently the best that can be done now is to try to find a satisfactory way of stabilizing the wastes in the underground tanks. Regardless of the merits of any procedure that is finally selected, however, we know that it would not have been

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71/ "Progress", p. 16. It should be noted that the Legislature in South Carolina is opposed to permanent storage of high-level wastes in South Carolina. See, Report of the Committee To Study The Establishment of Plants or Facilities for the Recovery of Nuclear Fuel and the Storage of Waste Nuclear Material, p. 20 (1972).

chosen in open competition with alternatives that are not applicable to the Hanford wastes because of previous decisions. Thus, not only were the short-term storage requirements not satisfactorily met when a "proven" technology was adopted, but the long-term storage problem was exacerbated in the process.

Perhaps more disturbing, yet, are suggestions in the draft that the fact that large quantities of waste from the weapons program already exist is a reason in itself not to consider seriously the option of not generating commercial wastes.

Thus the draft suggests that even if no future wastes were to be generated "[t]here would still be a need to develop permanent geological disposal . . ." for existing waste and waste to be generated in the weapons program. This suggestion is misleading. While it is true that permanent disposal means must be developed for existing weapons-generated waste, it is not true as implicitly suggested that that effort will be largely the same as or suffice for disposal of commercially-generated waste. The bulk of the nation's weapons program waste is at Hanford, Washington. As indicated above, it is unlikely that those wastes will ever be removed from Hanford.

For prospective commercially-generated radioactive wastes, which will be solidified into manageable form, however, the effort will be to find the best available geological or other disposal means, which undoubtedly will not be near-surface storage tanks at Hanford. Thus, the problem of permanently disposing of existing weapons program waste is significantly different from the

problem posed by commercially-generated wastes. The requirement that the AEC find a disposal means for the wastes at Hanford does not of itself mean that a satisfactory solution will be found for the permanent disposal of commercially-generated wastes.

V

THE DISCUSSION OF MAJOR ALTERNATIVE RADIOACTIVE WASTE MANAGEMENT PROCEDURES IN THE DRAFT ENVIRONMENTAL IMPACT STATEMENT IS WHOLLY INADEQUATE

By narrowly limiting the range of topics considered in the draft statement, major alternative courses of action were given no or very little consideration.[72/] In particular, we believe that the new draft statement should thoroughly evaluate at least the following three potentially more attractive options: disposal of spent fuel assemblies and transmutation of the long-lived actinide-bearing wastes and retrievable geological storage.

A. The Environmental Statement Does Not Adequately Consider The Possibility Of Not Reprocessing Spent Fuels

The principal reason for the proposed rapid construction of an engineered surface storage facility (p. 1.2-17) is the possible start of one or two spent fuel reprocessing plants within the next three or four years.[73/]

One major alternative to this proposed course of action is the disposal or permanent storage of spent fuel assemblies, thereby simply foregoing the reprocessing and management of solidified high-level waste steps. Surprisingly, this attractive option is not considered in Section 5 on alternatives. (pp.

72/ In addition to the three major alternatives discussed here, the new draft statement should thoroughly consider the advantages of nuclear parks for waste storage. See, for instance, Winegardner and Kaser, Radioactive Waste Management For Nuclear Energy Center - Draft Appendix G, BNWL-B-334 (January 1974).

73/ Nuclear Assurance Corporation, Spent Fuel Storage Capability In The USA, pp. 3, 4 (July 1974).

5.1-1 et seq.) However, a cursory discussion of a similar option does appear in Section 9, which purports to be a cost/benefit analysis of alternative waste management programs. (p. 9.1-15) The option considered in Section 9 differs from the alternative proposed here in that we assume no reprocessing and permanent storage of spent fuel assemblies, whereas the Section 9 option assumes that a safer, economical means for reprocessing will be found in the future and that the stored spent fuels will then be treated to remove plutonium and uranium. While the latter might be a potentially attractive alternative,[74/] the possibility of never reprocessing should also be evaluated in detail.

The draft statement basically raises three objections to the permanent storage of spent fuel assemblies. First, not using plutonium in fuel would result in increased uranium mining, milling, enrichment, and fuel fabrication, if the amount of electricity generated at uranium-fueled nuclear fission plants is held constant. Second, industry investments in spent fuel reprocessing and plutonium fuel fabrication plants and facilities would be lost. Three, there would be significant costs associated with the construction and administration of storage facilities for the spent fuel assemblies.

We submit that these objections, individually or collectively, are not persuasive. As we have pointed out in our comments on the LMFBR draft programmatic statement, there are

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74/ See the discussion of transmutation of actinides, below.

major uncertainties as to domestic uranium resources.[75] Until these uncertainties are more fully resolved it would be unwise, in our opinion, to base a decision to reprocess on the presumption that the plutonium and unused uranium are "needed."

Regarding industry investments we note that by mid-1974 the General Electric Company had ". . . expended $64 million in the Midwest Fuel Recovery Plant, which continues to be a non-operational facility."[76] It is expected that GE will simply accept this plant as a total loss and not invest the estimated additional $100 million that may be necessary to make it operational.[77] Intervenor groups are opposed to the operation of the other two reprocessing plants that may become operational in the next few years. It seems entirely possible to us that these plants also may not become operational. Thus, whether or not a decision is made not to reprocess existing and future spent fuels, the industry has already taken a substantial financial loss. The question is, what would be the incremental loss compared to the savings?

The third objection is not peculiar to this alternative. No matter what course of action is taken, spent fuels and/or

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75/ Cochran and Tamplin, NRDC Comments on WASH-1535, "Cost-Benefit Analysis of the U.S. Breeder Reactor Program," pp. 46-54, submitted to the AEC.

76/ General Electric, Midwest Fuel Recovery Plant, Technical Study Report, p. 1 (July 5, 1974).

77/ Kramer, "GE Hits A Chain Reaction of Problems, May Have To Close Nuclear Fuel Facility," Wall Street Journal, p. 3 (August 28, 1974).

solidified high-level wastes will have to be stored in interim facilities while a geological or other disposal means is proved suitable. Indeed, because of the delay in previously anticipated start-up dates for reprocessing plants, a formal proposal to construct a commercial centralized storage facility for spent fuel assemblies has already been circulated to utilities operating nuclear power plants.78/

The only advantage of this option that is mentioned in the draft statement is that the wastes would be contained by the "high integrity" fuel cladding. (p. 9.1-16) While this is an advantage, there are others which are, perhaps, even more important. First and foremost, not reprocessing eliminates the possibility of future supplies of purified plutonium being stolen. This major concern is addressed in Appendix C. Second, the routine release of radioactive noble gases, tritium, iodine, actinides and other materials from reprocessing facilities would be prevented. Third, since water-cooled basins for the storage of spent fuel assemblies have already been constructed, no new types of facilities will have to be designed, resulting in less chance for design error. Fourth, virtually no new technology, such as the fixation of solidified wastes into glass, would have to be developed. Fifth, the volume and amount of transuranium-contamined wastes would be substantially reduced -- perhaps enough so that new volume-reduction processes would not

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78/ Nucleonics Week, p. 1 (August 22, 1974).

have to be developed. Sixth, at least for the next few decades economic considerations may favor this option. The failure to consider this major alternative is a major defect in the draft statement.

B. The Environmental Statement Does Not Adequately Consider The Possibility Of Temporarily Storing Spent Fuels Until Actinide Partitioning And Transmutation Are Fully Developed

The draft statement briefly mentions the possibility of separating (partitioning) the long-lived actinide wastes from the shorter-lived fission product wastes during reprocessing, and then transmuting the purified actinides into shorter-lived radionuclides in reactors. In this way, the high-level radioactive waste storage problem, in principle, could be converted from a million-year problem to a thousand-year one.[79/] The draft statement's cursory discussion includes the assessment that this option appears to have potential for "reducing the long-term hazards aspect of high-level waste." (p. 5.3-9) However, without considering all of the possibilites, the statement summarily dismisses transmutation as "a viable alternative for retrievable surface storage of high-level radioactive waste" (p. 5.3-9) because a significant research and development program is needed to make it commercially practicable. The draft statement should have explicitly considered the possibility of temporarily storing spent fuel assemblies until it is commercially feasible to partition and transmute the actinide wastes.

79/ Kubo and Rose, "Disposal of Nuclear Wastes," Science, p. 1205 (December 21, 1973); and Blomeke, et al., "Managing Radioactive Wastes," Physics Today, p. 36 (August 1973).

Furthermore, by permitting some reprocessing to take place for a substantial period of time without the efficient partitioning of the actinides, the possibility exists, depending on a number of factors, that a national repository would have to maintain its integrity for several hundred thousand years, even though this advanced reprocessing technology is eventaully developed to commercial practicality. In other words, by not taking every step now to prevent the generation of solidified high-level wastes containing actinides, the primary advantage of this option -- reducing the required storage time by a thousand fold -- may be eliminated.

C. The Environmental Statement Does Not Consider Constructing A Retrievable Geological Storage Facility

The draft statement concludes that geological disposal (in contrast to storage) is not now a viable alternative to the proposed retrievable surface storage facility because a suitable site does not exist and it will take a long time to prove the safety of a specific geological site once one is chosen. (p. 5.3-1) However, there appears to be no consideration of developing a retrievable storage facility in a geological formation.

Since the high-level and transuranium-contaminated wastes will, in all likelihood, eventually be placed in a geological formation for disposal, it would seem to be very advantageous to eliminate the interim surface storage step and establish the acceptability of a geological site as soon as possible. We understand that the AEC's investigation of salt beds near Carlsbad, New Mexico, indicates that this site is suitable

for disposal of the long-lived wastes. In our opinion, the draft should seriously consider building upon the results of these studies by constructing a retrievable storage facility within the bedded salt formation. In this way, if the site in fact proves to be acceptable for disposal (i.e., no planned retrieval) of long-lived wastes, then the expense and hazard of building the more vulnerable surface storage facility would be eliminated. If the wastes, either as solidified high-level wastes or intact spent fuel assemblies, can be retrievably stored, as was done for 18 months in bedded salt at Lyons, without any apparent adverse effects (p. 2.3-26), then that possibility should be further explored.

We see three possible advantages to this course of action over the RSSF concept. First, the leading geological site would be rapidly studied for its acceptability as a disposal facility. Second, even if the wastes were eventually shipped to another location for disposal, they may be more securely stored during the interim period than at a surface facility. Third, if the Carlsbad site proves to be suitable for disposal, then significant costs and hazards would have been avoided. The new draft statement should thoroughly evaluate this alternative, explicitly estimating the cost of developing the Carlsbad site as a retrievable storage facility on a time frame comparable to the proposed development of an engineered surface storage facility.

VI

THE DRAFT ENVIRONMENTAL IMPACT STATEMENT DOES NOT CONTAIN COST-BENEFIT ANALYSES

Section 9 of the draft statement is entitled "Cost-Benefit Analysis Of Alternatives". Inexplicably, however, there is no cost-benefit analysis of the standard type in that section. That is, there is no quantification-- in dollars and cents terms -- of the relative financial and other costs of alternative waste management programs. The discussion of financial costs is simply a table listing the total estimated costs of constructing and operating the three alternative retrievable surface storage facilities. (p. 9.1-25) There is no explanation of how these costs were calculated.

In the new draft statement, the costs of each reasonable alternative waste management concept, including permanent storage of spent fuel assemblies and the partitioning and transmuting of actinide wastes, should be set out in detail. Full explanations of how the costs were calculated must be included. Furthermore, for each option the total cost of waste management, from the time that the spent fuel assemblies are removed from reactor cores to the time that the wastes have decayed to innocuous levels, must be included. The costs of decommissioning reprocessing and mixed-oxide fuel fabrication plants and storage facilities should be explicitly considered. The costs

in developing a commercially acceptable solidification means, and in developing a volume-reduction procedure for transuranium-contaminated wastes should also be discussed because these expenses would not be incurred if spent fuel assemblies were permanently stored.

Additionally, the "trust fund approach" must be explained in sufficient detail so that it is clear to industry and the public that the full costs of storing the wastes in perpetuity will be charged to the nuclear industry. Mere reference to a trust fund approach (p.9.1-27)with a statement that it is the AEC's policy to recover costs is wholly inadequate. Also, the charge levied upon receipt of wastes should be calculated under different conditions of nuclear development. That is, the draft statement should evaluate how the charge will vary according to the amounts of wastes that are generated. It should be explicitly considered how a moratorium on the construction of new nuclear power plants after, say, 1980 would effect the economics of a retrievable surface storage facility relative to the other waste management alternatives. The other extreme that should be carefully evaluated is the need to operate permanently the engineered surface storage facility in case a suitable geological disposal site is never found. Several intermediate cases should also be considered in detail. Such contingency planning must be performed in advance of commitment to any one storage or disposal means. Any suggestion that either of the extreme cases is unrealistic and, therefore, does not need to be evaluated in detail would be ill-founded and a serious mistake.

VII

CONCLUSIONS AND RECOMMENDATIONS

For the reasons set forth above, we believe that a new draft environmental statement on the handling and storage of commercially-generated radioactive wastes is required by NEPA. In our opinion, it is imperative that the nation's radioactive waste management program be subjected to thorough analysis in an environmental statement and careful scrutiny by the public, in order that no unnecessary risks are taken. Further, the executive, Congress and the public should be fully informed now of the uncertainties in safety and the environmental, societal and financial costs that will have to be paid in perpetuity as a result of generating toxic, long-lived radioactive wastes.

Fortunately, it is not necessary to push rapidly ahead with the AEC's current plan to build an engineered surface storage facility. If the AEC's assurances are correct, the existing spent fuel assemblies can be stored relatively safely for a short period while the longer term options are more fully considered to determine whether or not a satisfactory permanent solution is close at hand and, if not, how best to proceed. In connection with the needed full exploration of alternatives, an ad hoc independent body of prestigious scientists and lay persons should be commissioned to study the AEC's program and to report its findings publicly. We believe that such a course of action is

prudent from the standpoint of ensuring that no unnecessary risks are taken and also to establish the credibility of the program.

The fiasco at Lyons, the many problems at Hanford, the concern that the Joint Committee acts more like high-level management than a Congressional watchdog and that most nuclear scientists are beholden to the AEC or the nuclear industry, and the summary dismissal of the former National Academy of Sciences committee which publicly criticized the AEC, have called the AEC's program into serious question. Until a truly independent group of experts comprehensively examines the AEC's radioactive waste management program and publicly reports its findings, deep suspicion will remain, to the detriment of all.

The first step to correcting the current sorry situation is the preparation and circulation of a new draft statement and the holding of hearings and other actions to ensure that the appropriate regional, state and local governmental agencies and citizens' groups can review and comment on the AEC's program. Further, the public should have the benefit of the outside experts' opinions during its review and the results of environmental impact assessments concerning the Hanford, NRTS and Savannah River Plant waste management operations.

Dr. Frank K. Pittman, director of the AEC Division of Waste Management and Transportation, in a press briefing on this draft impact statement reported:

> "[The draft] covers the wastes generated from the nuclear industry from the time it comes out of the reactor on through

> the rest of the system, including the potential recycle and reuse of plutonium and the waste therefrom."

We agree that the draft required by NEPA should be as broad as that described by Dr. Pittman. To reach that standard, a new draft is required.

V.73-95

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Dr. Terry R. Lash
Natural Resources Defense Council
664 Hamilton Avenue
Palo Alto, California 94301

Dear Dr. Lash:

Thank you for your letter of April 9, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Your comments indicate that you feel that the discussion of the management of radioactive wastes in the Statement was inadequate. The Energy Research and Development Administration (ERDA) agrees that an ultimate waste management system has not as yet been developed and therefore the issue of waste disposal remains to be resolved before a commitment to widespread deployment of LMFBRs can be made. However, we cannot agree that the discussion of the waste management issues in the PFES is inadequate since it thoroughly evaluated the status of the waste management program at that time and described the measures being taken to resolve the issues. In addition to the sections in the PFES which you have reviewed, you are referred to Section III D of the Final Environmental Statement for additional information on the waste management program. Staff responses to your specific comments are included in the enclosures.

Your comments concerning the AEC's Draft Environmental Statement, Management of Commercial High-Level and Transuranium - Contaminated Radioactive Waste, WASH-1539, will be considered in the preparation of the revision of that document. As you are undoubtedly aware, ERDA announced on April 11, 1975, that WASH-1539 will be expanded before it is reissued in draft form for review and comments.

Thank you again for your comments. A copy of the Final Environmental Statement is enclosed for your information.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific NRDC Comments
2. Final Environmental Statement, LMFBR Program

ERDA Staff Responses to Comments by NRDC

NRDC Comments (pages 2-5):

"The Proposed Final Environmental Statement Does Not Adequately Consider The Ultimate Disposal Of High-Level And Transuranic Radioactive Wastes"

ERDA Response:

At the time that the PFES was written, a detailed plan for selection of an ultimate disposal method had not been developed. The plan was to develop the interim RSSF first. The investigation of the various ultimate disposal alternatives is still in the evaluation stage. The numerous alternatives have been identified and assessed to determine general technical feasibility, research requirements, costs, and time schedule.

As a result, only the general approach to development of an ultimate disposal method was included in the PFES. General descriptions were presented for the primary alternatives, and the general approach to determining and implementing the final disposal scheme was described.

A comprehensive action plan for developing an acceptable method for ultimate disposal of commercial high-level and transuranic wastes is currently being prepared. The plan is scheduled for completion by the spring of 1976. This plan is expected to describe the general developmental approach, outline the program components, and estimate the time schedule and the program costs.

It is believed that a satisfactory disposal method can be identified and implemented prior to the time when significant quantities of high-level and transuranic wastes from LMFBRs would require disposal. Until all research and development activities are completed, however, there is by definition an uncertainty that the expected results will be realized.

NRDC Comment (pages 5-6):

"The Proposed Final Environmental Statement Does Not Adequately Consider The Special Problems Posed By The Radioactive Wastes Generated By The LMFBR Program"

Two special problems were identified regarding this comment:

(1) Implementing the LMFBR program will require reprocessing of spent fuels and thereby preclude disposing of spent fuel rods in geological formations, and,

(2) High-level wastes from LMFBR's will have a different impact and disposal problem than will high-level wastes from LWR's.

ERDA Response:

Direct disposal of spent fuel from LMFBR's was not addressed in the PFES because direct disposal without reprocessing to recover plutonium would be illogical over the time span considered. If growth in installed nuclear power capacity were to cease at 2020 and beyond, then direct disposal of that portion of spent LMFBR fuel containing plutonium which is surplus to steady state needs could be considered.

The differences between LMFBR and LWR high-level wastes are not sufficient to suggest to us that "...wastes from LMFBRs should be disposed of in a more secure geological formation than wastes from LWRs." We feel confident that the correct philosophy for the disposal of high level wastes is to isolate them as securely as possible without regard to their origins.

NRDC Comment (pages 7-8):

"The Discussion Of Radioactive Waste Management In The Summary (Volume I) Does Not Accurately Reflect The Material In The Body Of The Proposed Final Environmental Statement And Does Not Adequately Present The Potential Hazards Posed By Radioactive Wastes."

ERDA Response:

Whether or not the summary adequately represents the material in the text is a matter of opinion. The summary represents ERDA staff judgment regarding the summarization of the radioactive waste management material in the text. Much of this NRDC comment is addressed toward the lack of a description of how the AEC plans to choose the ultimate disposal method for the high-level wastes. This aspect was discussed in the answer to the first NRDC comment.

NRDC Comment (pages 9-11):

"The AEC's Responses To NRDC's Comments On The Discussion Of Radioactive Waste Management In the Draft Statement Is Inadequate."

The primary items of concern in this comment appear to be:

1. Lack of descriptions of a detailed action plan for determining and implementing the best method for ultimate high-level waste disposal, and

2. Lack of adequate descriptions of societal and environmental problems and of alternatives for high-level waste disposal.

ERDA Response:

The lack of a detailed action plan for determining and implementing ultimate waste disposal is discussed in the answer to the first NRDC comment.

The lack of adequate descriptive material on problems and alternatives is a matter of opinion. An environmental statement is, of necessity, limited to summarizing and interpreting the information available with adequate referencing of the detailed supporting material. Otherwise, the total volume would become excessive and the statement for as complicated a subject as the LMFBR Program could become a presentation of a major portion of the current information available on each of the topics related to the LMFBR. In any event, the ultimate disposal method for the high-level and transuranic wastes has not been selected. It is therefore not possible to describe in detail the environmental and societal effects of a solution that has not been selected. As a result, the impacts were discussed in only the detail needed to define the potential problems and the magnitude of those problems.

NRDC Comment (pages 10 and 11):

> "The AEC staff states that regarding the partitioning of actinides, 'there are serious questions about the overall hazard involved...' Yet there is no detailed description of those 'questions' or how they will be resolved....Furthermore, the AEC staff does not explain how the final decision can ever be rationally made if no money is spent on the research to obtain the basic data that is required for a fair analysis of this potential option. A full explanation of the reason the AEC terminated funding for research of partitioning in the proposed FY 1976 budget should have been presented in the PFES."

ERDA Response:

Following studies of partitioning by Battelle (Pacific Northwest Laboratories) and Holifield National Laboratory in FY 1974 and FY 1975 it was concluded that it would be more desirable and logical to develop

irradiated fuel processing technology which results in more efficient extraction of selected waste materials than to develop secondary partitioning treatment of the waste which results in additional volumes of waste. Two factors are paradoxical in deciding to partition waste. First is that the process increases the waste volume, complicates process equipment and may entail additional dose commitments to operating personnel. Second is that the degree of purification that can be reliably achieved in such processes may make little or no difference in the total hazard of the wastes that must be managed and make only marginal difference in the manner in which the waste is managed and disposed of. With these factors in mind, it is our intent to concentrate partitioning efforts on improvements in irradiated fuel processing in order to:

1. Maximize the recovery of plutonium and possibly isolate all actinides for recycle or separate management,

2. If possible, produce the bulk of the waste in such a way that it contains mostly chemical salts with relatively short half life radionuclides, and

3. Produce a minimum volume of waste containing the very long half life radionuclides such as the actinides, I-129, etc.

With regard to the budget, the title "Waste Partitioning" is no longer applicable as it is really total irradiated fuel processing which is being evaluated. As "Advanced Waste Management Concepts" was an existing budget category, the new or redirected work, evaluating improved methods for irradiated fuel processing is now included there. This is a new approach to this problem and budget restrictions during FY 1976 will limit this effort but it is expected to grow in future years and be coordinated with other nuclear fuel cycle programs.

April 10, 1975

Mr. W. H. Pennington
Assessment Officer
Div. of Biomedical and Environmental Research
U. S. ERDA
Washington, D. C. 20545

Dear Sir:

Re: Liquid Metal Fast Breeder Reactor Program

I would like to register my opposition to the above for the following reasons:

1. Plutonium 239 has a half-life of 24,400 years.

2. Dr. Edward Teller a famous nuclear scientist feels the hazards are too great.

3. The technology is too sophisticated to leave in the hands of technicians once a reactor is established. Think what would happen if the quality control were to equal that of our manufactured goods such as automobiles, appliances and hundreds of other items.

4. The danger of the theft of plutonium, thus creating a threat to personal and national security.

5. Sabotage.

6. Cost!. An article in the Wall Street Journal indicates it will cost the taxpayers between $2 billion and $7 billion dollars.

7. The fact that the end result is Cancer, is frightening. I have two beautiful children and hundreds of thousands of other parents have beautiful children that they wish to live a full life. We musn't sit back and let them down.

There are many other reasons why this program should be stopped and I am sure you will hear them all by the time all of the testimony is in.

I do hope you will proceed with great caution.

Very truly yours,

(Mrs.) Ruth Zhat

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mrs. Ruth Zaat
27 Wenona Ave.
Oakland, New Jersey 07436

Dear Mrs. Zaat:

Thank you for your letter of April 10, 1975 commenting on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Please be assured that the Energy Research and Development Administration (ERDA) is proceeding with due caution in the development of the LMFBR. ERDA has reviewed all written comments received on the Proposed Final Environmental Statement (PFES) for the LMFBR as well as the testimony received during the Public Hearing held on May 27-28, 1975 and has taken these views into account in the preparation of the Final Environmental Statement (FES) for the LMFBR Program. A copy of that Statement is enclosed for your information.

The concerns you raised with regard to safety of LMFBR's, safeguarding plutonium, toxicity of plutonium and cost of the LMFBR have all been carefully examined. Please refer to Sections 4.2.7, 7.4, 4.7, 11, respectively of the PFES (WASH-1535) which has been incorporated as Section II of the FES. Also, supplemental material on a number of your concerns appears in Section III.

Although our environmental review of the LMFBR Program has led ERDA to conclude that continuation of research, development and demonstration of the LMFBR concept is needed, any decision on commercial deployment of the LMFBR must await the resolution of several environmental issues on which the necessary research, development and demonstration have not as yet been completed.

Hopefully your review of the enclosed Environmental Statement will alleviate your concerns. Thank you for your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

V.75-1

COMMONWEALTH OF VIRGINIA
OFFICE OF THE GOVERNOR
COUNCIL ON THE ENVIRONMENT

P. O. BOX 790
RICHMOND 23206

GERALD P. McCARTHY
Chairman

FITZGERALD BEMISS
RICHARD D. ROBERTSON
T. EDWARD TEMPLE
Executive Committee

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Chairman, State Water Control Board

MACK I. SHANHOLTZ, M.D.
State Health Commissioner

WILLIAM H. STANHAGEN
Chairman, Board of Conservation and Economic Development

WILLIAM H. WEST
Chairman, Commission of Game and Inland Fisheries

April 16, 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental Research
U.S. Energy Research and Development Administration
Washington, D.C. 20545

Subject: Proposed Final Environmental Statement WASH-1535, for the LMFBR Program

Dear Mr. Pennington:

We have reviewed the subject document, and offer the following comments.

The Commonwealth of Virginia recognizes the need for additional power generating capacity, and we are certainly interested in new technologies that would create dependable sources of energy at reasonable cost to the consumer, keeping uppermost in mind the safety and environmental impact aspects of such technology.

The economic realities of providing safe, reliable electricity are such that the development of Liquid Metal Fast Breeder Reactor technology should be scrutinized with these costs in mind.

We are not prepared to make a thorough critique and technical commentary on this seven-volume Proposed Final Environmental Impact Statement, and cannot give you an opinion regarding its safety and effects. We are reluctant to commit ourselves to this technology at the present time until we learn more about it.

I trust that as further developments occur, you will keep us informed.

Sincerely,

Gerald P. McCarthy

GPM:dls

cc: Honorable Mills E. Godwin, Jr.
Honorable Earl J. Shiflet
Mr. Charles Burbach
Mr. Bryce P. Schofield
Mr. J. L. Hamrick
Mr. J. Frank Alspaugh

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Gerald P. McCarthy
Chairman, Council on the Environment
Office of the Governor
Commonwealth of Virginia
Box 790
Richmond, Virginia 23206

Dear Mr. McCarthy:

Thank you for your letter of April 16, 1975 commenting on the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. We are pleased that the Commonwealth of Virginia recognizes the need for additional power generating capacity, and is interested in new technologies that would create dependable sources of energy at reasonable cost to the consumer, keeping uppermost in mind the safety and environmental impact aspects of such technology. We agree that the economic realities of providing safe, reliable electricity are such that the development of LMFBR technology should be scrutinized with these costs in mind.

We regret that the Commonwealth of Virginia was not able to provide detailed comments on the Proposed Final Environmental Statement or to form an opinion regarding the safety and effects of the LMFBR Program. A copy of the Final Environmental Statement is enclosed for your information which we trust will enable you to reach the conclusion that the LMFBR can be developed as a safe, clean, reliable and economic electric power generation system.

Thank you again for your comments and your interest in the LMFBR Program. We will be pleased to keep you informed of future developments in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

April 14, 1975

W.H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental Research
U.S. Energy Research and Development Administration
Washington, D.C. 20545

Gentlemen:

Thank you for an opportunity to review and comment on the Proposed Final Environmental Statement, WASH-1535, Liquid Metal Fast Breeder Reactor Program. Although my comments are postmarked after the April 9, 1975 receipt deadline, I hope you will accept them and enter them into the record.

It is my belief that the nuclear power reactor program is needed to satisfy the national power requirements, and that the program can be operated in a safe and environmentally acceptable manner. I also feel that many relatively small details of the current regulatory system have been neglected to the point that very significant breakdowns in control can occur. In specific instances such breakdowns have already occured on occasion. These regulatory deficiencies must be immediately eliminated in order to safely advance the power reactor program.

Comments which I have to offer are attached. Thank you for your attention.

Sincerely yours,

Bobby M. Wilson

Bobby M. Wilson
330 Senate Drive
Frankfort, Kentucky 40601

Attachment

VOLUME II, Section 4

1. 4.5 Transportation of Radioactive Materials

A. 4.5.1.1 Principles of Safety in Transport (p.4.5.-1)

"The public and transport workers are protected from radiation during the shipment of radioactive materials by the container designs and limitations on the contents".

Comment:

Repeated transportation incidents of significance have occured over the last few years. These have occured due to violations of regulations and the failure of the regulatory agencies to achieve compliance. The Air-Lines Pilots Association has had to virtually take the regulation of air-freight radioactive materials into its own hands. The transport regulatory agencies absolutely could not confirm shipper compliance sufficiently to ally pilot fears.

It appears that the same inspection and compliance deficiencies can be found in highway and rail transportations.

2. 4.6 Radioactive Waste Management

A. 4.6.1 Introduction (p.4.6-3)

"Current regulations indicate that wastes other than high-level wastes can be disposed of in commercial burial grounds".

Comment:

Significant problems now exist with omissions, discrepancies, interpretations and applications of transportation and handling regulations for radioactive materials. As a result, serious environmental problems have already occured. With further progress on the "As Low As Practicable (ALAP)" principle, some of the problems may intensify. For example, under Appendix I release guides for LWR's, a reactor facility may, and do, transfer radioactive waste to a commercial waste handler. The commercial waste handler may legally dispose of the waste to the environment under CFR Part 20 MPC guides, thus circumventing the ALAP principle. A regulatory question of philosophy than begs to be answered: Should a radioactive waste "disposal" facility be permitted to release waste under MPC guidelines, or should "disposal" be interpreted as an absolute action?

B. 4.6.3.2.1 Beta-Gamma Waste (p.4.6-44)

"(1) Tritium."

Comment:

Currently available evidence, supported by past experimental predictions, shows that land burial waste facilities have not and will not contain tritium. Calcium hydroxide is put forward as a stabilizing method which is untested. Further

environmental insult in the vicinity of current commercial burial sites due to the release of additional tritium from yet another unproved method may not be tolerable.

C. 4.6.3.2.1 Site Considerations for Land Burial Facility (p. 4.6-45-46)

1. "Licensees who bury waste received from others must do so on land owned by either a state or Federal Government. The purpose of this requirement is to assure long-term control of the site in the event of default or abandonment of the site by the commercial operator."

Comment:

Experience has demonstrated that state, or federal ownership of land may not guarantee adequate short or long-term control, with or without abandonment.

2. "The states have the obligation for perpetual care and maintenance of land burial sites to assure their dedication to waste burial and to assure their restriction from other uses."

Comment:

Experience has demonstrated that states may not have the ability to administer a perpetual care and maintenance obligation in a continuing, responsible manner.

3. "Authorization to operate a commercial land burial facility is based on an analysis of the nature and location of potentially affected facilities; of the site topographical, geographical, meteorological, and hydrological characteristics; and of groundwater and surface water use in the general area which must demonstrate that buried radioactive waste will not migrate from the site".

Comment:

Criteria for site selection and evaluation has not been developed well and does not seem to have been uniformly applied. Advances in earth science knowledge have not been applied to full advantage. Predictions and findings in even early site evaluations have, on occasion, been overlooked or ignored. In any event, not all existing sites, if any, have been evaluated to such an extent to demonstrate that buried waste will not migrate. On the contrary, waste management experts speak in terms of rate of migration, knowing that movement is inevitable.

4. "To date, there have been no reports of migration of radioactive material from commercial burial sites".

Comment:

An oral report of migration from one such site was made to the AEC by representatives from an Agreement State as early as October, 1974. Information was reportedly made available to the AEC on migration from at least two sites much earlier, perhaps in 1972 or 1973.

5. "In the unlikely event that there would be such a finding, several courses of action could be taken, including: (1) a halt to burial operations, (2) removal of the radioactive material from the burial area in which it originated, (3) grouting of the site from which the radioactive material originated, or (4) other such procedures that might be necessary, depending on the extent of migration of radioactive material from the site".

Comments:

(1) If waste disposal operations by burial is required to halt at this stage of commitment to nuclear power, it will result in a severe impact on the operation of LWR's and other nuclear industries. Significant radiation safety problems could be generated as large volumes of waste, much of which is quite highly radioactive, accumulate at individual facilities.

(2) Removal of previously buried waste would be an astronomically expensive operation. It would undoubtedly create another round of expensive and time consuming study and debate on procedure and alternatives.

(3) Some earth scientists seem to be very skeptical of the success of grouting operations.

(4) "Other such procedures..." are likely to remain undefined, undefinable and would unquestionably be exceedingly expensive

6. "The areas in which wastes are buried are enclosed by fences, and access to the sites is carefully controlled by the site operator".

Comment:

This statement seems to imply adequate control. In fact, this is an assumption which may be incorrect. While active burial areas may be fenced, contamination and radioactive effluents may, and in some cases do, extend well beyond restricted areas. Fences and guards have not been sufficient to prevent apparently deliberate diversion of stored waste, including plutonium.

7. "No credit is taken for containment provided by the packages once they are buried".

Comment:

At least one burial site has been allowed to dispose of large quantities of tritium waste, if packaged in accordance with licensed criteria. Evidence indicates that both container and geological integrity of the site has been inadequate in retaining tritium waste. Certain burial procedures have also been approved when the waste is contained in DOT approved packages. DOT container approval is based on relatively short-term transportation hazard potential, not long-term content retention considerations necessary of disposal by burial. Apparently, the concept of tritium disposal by converting to calcium hydroxide and sealing in special containers would also be outside the "no credit for containment" philosophy.

8. "Description of Model Land Burial Facility" (p. 4.6-46,47)

Comment:

This description is highly idealized as naive if meant to encompass all existing sites. Based on personal experience with a single site, exceptions were noted in six of the nine paragraphs describing a "model" site operation compared to actual operations.

9. "Environmental Effects of Land Burial Facility Operation" (p.4.6-48)

Comments:

a) Radioactive effluent releases are routine for at least one site.
b) The total quantity of radioactive material contained in a burial site will be quite large.
c) Evidence indicates that plutonium can be included in the list of isotopes which have apparently migrated to surface soils and deep wells outside the restricted area of a site.

10. "Monitoring"

Comment:

The description is naive, presumptive, idealized and does not speak to very difficult problems in monitoring design and data interpretation. Approval of corrective actions by the AEC or an agreement state may not, in itself, have any effect on advancing on a particular problem when it developes.

D. 4.6.3.2.2 "Plutonium Bearing or Alpha Waste" (p. 4.6-49)

Comment:

Plutonium 238 and 239 in quantities above probable fall-out levels has been measured in deep wells and surface soils in - and out - side the restricted area of at least one burial site.

VOLUME VII

1. U.S. EPA Comments, Modifications to Current Practices, Potential Impact: (p. VII. 53-27)

Comment:

The EPA observations touch upon a very critical issue in the commercial waste disposal industry. It appears that the disposal industry has become locked into a purely competitive business with the fee structure being based on units not indicative of the actual situation (cubic feet of waste, price per cubic foot). The major waste generators have been heavily subsidized by publicly funded research and development. Disposal companies have not had the benefit of much of this research for better methods. At the same time, the pressure to accomodate rapidly increasing volumes of waste, in the same manner, and at much the same price, has grown. If disposal companies had been pressured by regulatory agencies to

constantly improve on procedures, had enforced long standing receipt and transfer records requirements, disposal methods would be advanced much beyond those now in use. Strict enforcement of existing regulations would have aided in creating a waste disposal fee structure based on radioactive content and isotope hazard. This could have promoted the setting of true cost recovery disposal charges, including investments in improved methods, continueing site evaluation, environmental monitoring and other operating expenses of the companies. Full cost recovery charges could have also adequately funded long-term site care and maintainence programs.

2. AEC Response to EPA Comments (p. VII .53-139)

"After issuance of a license and startup of burial operations, licensees are audited on an annual basis by AEC inspectors (or "agreement State" inspectors) to determine that all conditions of the license and of the regulations are being met."

Comment:

This close inspection and enforcement attitude apparently was not conducted uniformly with at least one large burial site (Kentucky). Inspection gaps of two to four years have apparently occured, with little or no effort to clearly settle deficiencies noted.

AEC auditors have periodically reviewed the Kentucky (an agreement state) radioactive material regulatory program to verify compatibility with AEC procedures. The first known review of the disposal site was a cursory site visit in 1972. AEC auditors had, on occasion, been asked to review the disposal site inspection, compliance and environmental monitoring files, but had declined.

In summary, it is my belief that an in-depth, objective review of the radioactive material transportation and disposal regulatory agencies should be done. It appears that in certain areas the regulations have not been enforced as written, as the public has a right to expect.

Regulatory policies and methods must be improved in design and enforcement to cope with current and future programs in order to assure an adequate degree of public safety and confidence.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Bobby M. Wilson
330 Senate Drive
Frankfort, Kentucky 40601

Dear Mr. Wilson:

Thank you for your letter of April 14, 1975 commenting on the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. We concur in your belief that the LMFBR Program is needed to satisfy future national energy needs and that the program can be accomplished in a safe and environmentally acceptable manner. Responses to your specific comments are enclosed. The majority of these responses were provided by the Nuclear Regulatory Commission.

Thank you again for your comments and for your interest in the LMFBR Program. A copy of the Final Environmental Statement is enclosed for your information.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific Comments
2. Final Environmental Statement, LMFBR Program

ERDA* Staff Responses to Specific Comments by Bobby W. Wilson

Comment 1.A. (page 1):

> "Repeated transportation incidents of significance have occured over the last few years. These have occured due to violations of regulations and the failure of the regulatory agencies to achieve compliance. The Air-Lines Pilots Association has had to virtually take the regulation of air-freight radioactive materials into its own hands. The transport regulatory agencies absolutely could not confirm shipper compliance sufficiently to ally pilot fears.
>
> "It appears that the same inspection and compliance deficiencies can be found in highway and rail transportations."

ERDA Response:

The record does not support the allegation that the same inspection and compliance deficiencies are to be found in highway, rail or barge transportation. As noted on page 4.5-5 of the LMFBR Program Proposed Final Environmental Statement, air transport is not expected to be used for the LMFBR fuel cycle.

"Aircraft, while used frequently in the shipment of radiopharmaceuticals (particularly when short half-life material is involved), are not expected to be used for the shipment of radioactive materials in the fuel cycle; therefore, air shipment has not been assessed. Shipping costs are expected to remain higher than for rail or truck, and the high speeds available in air shipment would be of little advantage. Also, there are obvious weight limitations for air shipments."

Comment 2.A. (page 1):

> "Significant problems now exist with omissions, discrepancies, interpretations and applications of transportation and handling regulations for radioactive materials. For example, under Appendix I release guides for LWR's a reactor facility may, and do, transfer radioactive waste to a commercial waste handler. The commercial waste handler may legally dispose of the waste to the environment under CFR Part 20 MPC guides, thus circumventing the ALAP principle. Should a radioactive waste 'disposal' facility be permitted to release waste under MPC guidelines, or should 'disposal' be interpreted as an absolute action?"

*Specific responses mostly provided by NRC Staff.

ERDA Response:

NRC and equivalent Agreement State regulations and the conditions of licenses issued by the NRC and Agreement States to commercial waste burial area operators do not permit the operators to release radioactive waste to the environment prior to burial.

These licenses authorize the receipt of packaged solid radioactive waste for disposal by burial in the soil. The licenses issued to certain operators also authorize the receipt of waste, in other than a solid form, for processing, packaging and disposal as solid waste by burial in the soil. We know of no commercial waste burial area operator who is disposing of commercial waste by release to the environment under Part 20 Maximum Permissible Concentrations. However, two sites, (Nuclear Fuel Services, West Valley, New York and Nuclear Engineering Company, Inc., Maxey Flats, Kentucky) are experiencing difficulty in the water management aspects of site operations. Since water is a principal contributing factor to the movement of buried waste, New York and Kentucky have authorized the pumping of liquids from trenches at these sites to reduce the volume of water in the trenches, thus minimizing the possibility for migration. Since the water extracted from the trenches has been in contact with the waste, it is treated as a contaminated liquid and is processed through a treatment system to reduce the volume and remove radioactive contaminants. Environmental releases of radioactivity occur through treatment system operations (primarily tritium). The Part 20 Maximum Permissible Concentration values are appropriate for evaluating the releases from these treatment operations.

Comment 2.B. (pages 1 and 2):

> "Currently available evidence, supported by past experimental predictions, shows that land burial waste facilities have not and will not contain tritium. Calcium hydroxide is put forward as a stabilizing method which is untested. Further environmental insult in the vicinity of current commercial burial sites due to the release of additional tritium from yet another unproved method may not be tolerable."

ERDA Response:

The report, "Six Month Study of Radiation Concentrations and Transport Mechanisms at the Maxey Flats Area of Fleming County, Kentucky," concludes on the basis of the study that "Existing geological mechanisms are not effective in maintaining tritium waste within the disposal trenches." The report further states (pg. 17) that "the rate of tritium migration was not determined by the study." Studies conducted at the West Valley, New York site have also detected tritium in soil samples

taken adjacent to trenches which contained water. The problems being experienced in the infiltration of water into completed trenches at these sites has contributed to the movement of tritium from the trenches. Other commercial waste burial sites do not appear to have problems with the management of water and have reported no movement of radioactivity from burial trenches.

Comment 2.C.1. (page 2):

> "Experience has demonstrated that state, or federal ownership of land may not guarantee adequate short or long-term control, with or without abandonment."

ERDA Response:

It is granted that recent experience is a cause for concern. However, there appears to be no valid reason to believe that the Federal or State ownership of land will not guarantee adequate short or long term control of the site.

The release of low levels of radioactivity to the environment at the Kentucky and New York State sites due to problems with water management have been determined by Kentucky and New York to not constitute a public health hazard. Kentucky and New York are taking action to further assess site conditions and procedures for continued operation of the sites. Kentucky has established a committee of Federal and State representatives to design further studies at the Maxey Flats site. The studies will be directed at determing the nature of conditions at the site and the long range potential health and safety significance of the radioactivity detected at the Maxey Flats site area. New York State has retained consultants and is working closely with the site operator in determining what further studies should be done at the West Valley site to assess current conditions at the site and procedures for operation of the site. In addition, the U.S. Geological Survey and Environmental Protection Agency are conducting studies at several commercial burial sites.

Comment 2.C.2. (page 2):

> "Experience has demonstrated that states may not have the ability to administer a perpetual care and maintenance obligation in a continuing, responsible manner."

ERDA Response:

Each of the States having a commercial waste burial facility located on state owned land has established a program for the perpetual care and maintenance of the site including the acquisition of funds to carry out the program. Kentucky has recently expressed concern about the adequacy of funds being accrued for the Maxey Flats site and plans to reassess the current funding arrangement. We also understand that New York and South Carolina are presently studying their funding arrangements.

Comment 2.C.3. (page 2):

> "Criteria for site selection and evaluation has not been developed well and does not seem to have been uniformly applied. Advances in earth science knowledge have not been applied to full advantage. Predictions and findings in even early site evaluations have, on occasion, been evaluated to such an extent to demonstrate the buried waste will not migrate. On the contrary, waste management experts speak in terms of rate of migration, knowing that movement is inevitable."

ERDA Response:

Commercial low level waste burial sites are evaluated on a case by case basis against a number of criteria to determine that the predicted combination of geological, hydrological, geographical, and topographical aspects of the proposed site are such that the migration of radioactivity from the buried waste is unlikely. The evaluations conducted for the existing sites were conducted during different periods of time and by different individuals. Although the evaluations were conducted using essentially equivalent criteria, the evaluations conducted recently were probably more rigorous and based on the present state-of-the-art concerning the land burial of radioactive waste as a disposal method. The U.S. Geological Survey is currently conducting a 5 year study to develop further criteria for the evaluation of waste disposal sites and predictive models for waste transport over extended periods of time.

Comment 2.C.4. (page 2):

> "An oral report of migration from one such site was made to the AEC by representatives from an Agreement State as early as October, 1974. Information was reportedly made available to the AEC on migration from at least two sites much earlier, perhaps in 1972 or 1973."

ERDA Response:

The Kentucky Department of Human Resources Report concluded (pg. 17) that

"(1) The radioactive waste disposal site at Maxey Flats, Kentucky is contributing radioactivity to the environment. The activity detected in the environment does not create a public health hazard. However, the level of activity detected demonstrates the need to intensify current monitoring activities to provide additional information to determine to what possible extent migration of radioactive material is occurring at the site and for assessing the long range significance of the findings.

(2) The movement of radioactivity from the facility could be through four major routes:

(a) Surface water run-off.
(b) Atmospheric fallout from the evaporator plume.
(c) Migration through geologic formation fissure systems.
(d) Lateral migration through the soil zone."

Kentucky first reported the results of their study to AEC regulatory staff personnel (now NRC personnel) in October, 1974. We also recently learned that water in trenches at the West Valley, New York site is contributing to the movement of radioactivity from the trenches to the surface waters and also some limited migration of tritium in the soil adjacent to the trenches has been detected. We have received no other reports concerning the movement of radioactivity from burial trenches at any of the other sites. We know of no earlier reports of migration during 1972 or 1973 at the commercial low level waste burial areas.

Comment 2.C.5. (page 3):

"(1) If waste disposal operations by burial is required to halt... Significant radiation safety problems could be generated..."

(2) "Removal of previously buried waste would be an astronomically expensive operation...."

(3) Some earth scientists seem to be very skeptical of the success of grouting operations.

(4) 'Other such procedures...' are likely to remain undefined, undefinable and would unquestionably be exceedingly expensive."

ERDA Response:

Contingency plans have been developed for the commercial low level waste burial areas. It is difficult to develop a contingency plan which is appropriate for use at all sites. Each plan must be related to the particular geology, hydrology, geography and topography of the site. When implementing the plan it must also be related to the type of material migrating and mode of migration. Certain contingency actions may be accomplished with relatively little expense (recapping and sealing of trench covers to keep water out) whereas others would be quite expensive (removing buried waste).

Comment 2.C.6. (page 3):

"...Fences and guards have not been sufficient to prevent apparently deliberate diversion of stored waste, including plutonium."

ERDA Response:

We know of no case where there has been apparent deliberate diversion of stored waste, including plutonium. Access to the site is controlled to prevent the potential exposure of unauthorized personnel to radiation from radioactive waste at the site.

Comment 2.C.7. (page 3):

"...Evidence indicates that both container and geological integrity of the site has been inadequate in retaining tritium waste. Certain burial procedures have also been approved when the waste is contained in DOT approved packages. DOT container approval is based on relatively short-term transportation hazard potential, not long-term content retention considerations necessary of disposal by burial..."

ERDA Response:

Packaging can and does provide a primary containment barrier to the buried waste. However, no credit is taken for the containment provided by the packaging since it will eventually decay or rupture thereby releasing the contents. The evaluation of a waste disposal site is based on the predicted ability of the geological and hydrological characteristics of the site to retain the buried waste. The purpose of the packaging is to provide ease of handling, minimization of personnel exposure, safety in transportation to the site and to prevent loss of the radioactive material to the surroundings prior to burial.

Comment 2.C.8. (page 4):

> "This description is highly idealized as naive if meant to encompass all existing sites. Based on personal experience with a single site, exceptions were noted in six of the nine paragraphs describing a 'model' site operation compared to actual operations."

ERDA Response:

The "Description of Model Land Burial Facility" in the LMFBR Program Proposed Final Environmental Statement (and Reference 22) were based on information contained in WASH-1143 "Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities." The operator of the site at Maxey Flats, Kentucky has experienced difficulties in the management of water at the site. Problems have been identified in the past relating to record keeping and burial procedures. The site operator and the state have worked closely to correct any deficiencies which may have existed in the operation of the site.

Comment 2.C.9. (page 4):

> "a) Radioactive effluent releases are routine for at least one site.
> b) The total quantity of radioactive material contained in a burial site will be quite large.
> c) Evidence indicates that plutonium can be included in the list of isotopes which have apparently migrated to surface soils and deep wells outside the restricted area of a site."

ERDA Response:

As discussed in the ERDA response to comment 2.A, site operators are not authorized to release radioactive waste to the environment prior to burial. However, at two sites (in New York and Kentucky) environmental releases occur through the operation of treatment systems for the water removed from the burial trenches.

An article in Radiation Data and Reports (Vol. 15, No. 12, December 1974, pp. 759-767) reports the following totals for waste buried at all commercial low level waste burial sites from 1962-1973. Although the volume is large, the activity (ci/ft^3) is relatively low.

Volume	Byproduct Material	Source Material	Special Nuclear Material
(cubic feet)	(curies)	(Pounds)	(Grams)
9,150,000	2,300,000	1,250,000	1,240,000

The Kentucky Department for Human Resources Report states on page 18:

> "Plutonium concentrations measured in certain individual samples collected in the unrestricted environment and test wells exceed ambient levels."

We know of no other case where plutonium has been detected in environmental samples at commercial low level waste burial site which may be attributable to buried waste.

Comment 2.C.10. (page 4):

> "The description is naive, presumptive, idealized and does not speak to very difficult problems in monitoring design and data interpretation. Approval of corrective actions by the AEC or an agreement state may not, in itself, have any effect on advancing on a particular problem when it developes."

ERDA Response:

The section on monitoring was intended to provide a brief non-technical description of the monitoring programs conducted at the sites only. It is not felt that additional detail regarding monitoring is desirable in this particular environmental statement.

Comment (pages 4 and 5):

"The EPA observations touch upon a very critical issue in the commercial waste disposal industry. The major waste generators have been heavily subsidized by publicly funded research and development. Disposal companies have not had the benefit of much of this research for better methods. At the same time, the pressure to accomodate rapidly increasing volumes of waste, in the same manner, and at much the same price, has grown. If disposal companies had been pressured by regulatory agencies to constantly improve on procedures, had enforced long standing receipt and transfer records requirements, disposal methods would be advanced much beyond those now in use. ..."

ERDA Response:

The state-of-the-art for any technology, including the technology for disposal of radioactive wastes, is never static and the impetus for change depends on many factors (economics and cost recovery, health and safety considerations, societal and environmental considerations, and research and development expenditures). The majority of research and development expenditures for the disposal of radioactive wastes has been directed at the disposal of high-level wastes. Until recently, no problems had been identified at the commercial low level waste burial areas and deficiencies which did arise were corrected through normal enforcement procedures and action by the site operators.

Comment (page 5):

"This close inspection and enforcement attitude apparently was not conducted uniformly with at least one large burial site (Kentucky). Inspection gaps of two to four years have apparently occured, with little or no effort to clearly settle deficiencies noted.

"AEC auditors have periodically reviewed the Kentucky (an agreement state) radioactive material regulatory program to verify compatibility with AEC procedures. The first known review of the disposal site was a cursory site visit in 1972. AEC auditors had, on occasion, been asked to review the disposal site inspection, compliance and environmental monitoring files, but had declined."

10

ERDA Response:

We know of no inspection gaps of two to four years and we believe Kentucky has, in almost all cases, taken appropriate action with respect to deficiencies noted during inspections although, on occasion, the State could have taken more prompt action. We do not believe NRC reviewers have declined to review the inspection, compliance and environmental monitoring files. NRC meetings with the Agreement State programs include a review of licensing and inspection actions. A sampling of the new licenses issued by the State since the previous meeting are reviewed and NRC reviews the licensing and inspection files periodically for the larger licensed programs. A review of the Kentucky disposal site's inspection files was conducted in 1971 and 1972 and a review of the licensing and inspections files was conducted during 1974. Earlier NRC meetings with Kentucky involved a discussion of the initial licensing actions, status of the burial site and environmental monitoring program. Site visits were conducted in 1964, 1973 and 1974 by AEC (now NRC) personnel.

Dear Sir:

Please allow me to register with you my distress at the rapidity with which the gov't & public is jumping into breeder reactor programs, esp. the LMFBR. ~~Energy~~ shortages are better responded to ~~by~~ increased conservation and gradual exploration of new sources & improvement of existing ones such as atomic reactors.

Anne Essay
2616 Indiana St.
St Joseph, Mo 64506

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Ms. Anne Esson
2616 Indian Tr.
St. Joseph, Missouri 64506

Dear Ms. Esson:

Thank you for your postcard commenting on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Energy Research and Development Administration (ERDA) has carefully considered all comments received on the Proposed Final Environmental Statement (PFES) for the LMFBR Program as well as the testimony received during the Public Hearing held on May 27-28, 1975 and has taken these views into account in the preparation of the Final Environmental Statement for the LMFBR Program. A copy is enclosed for your information.

ERDA review of the Environmental Statement has led to the conclusion that development of the LMFBR through the research and development and demonstration phases is warranted. Commercial use of the LMFBR will depend upon the successful results of the program. ERDA further concluded that this development should not be accomplished to the exclusion of other reasonable alternatives for energy production, but rather the LMFBR, together with other electrical generation systems and a vigorous conservation program, can help to meet this country's future energy requirements.

Hopefully your reading of the enclosed Environmental Statement will alleviate your concerns. Thank you for your interest on the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

ASSISTANT SECRETARY

APR 17 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and
Environmental Research
Energy Research and Development Administration
Washington, D.C. 20545

Dear Mr. Pennington:

Department of Transportation personnel have reviewed the proposed final environmental impact statement (EIS) for the Liquid Metal Fast Breeder Reactor Program. The statement was sent to us for comment on February 7, 1975.

Our review focused particularly on the transportation aspects of the statement. On these matters, the statement appears to be in accord with current Department of Transportation, Nuclear Regulatory Commission and Energy Research and Development Administration requirements for transportation of radioactive materials. Responses to comments received relative to transportation appear to be consistent with the philosophy of all three agencies. As a consequence, we find the transportation section of this EIS to be acceptable.

Sincerely,

Benjamin O. Davis, Jr.
Assistant Secretary for Environment,
Safety, and Consumer Affairs

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Benjamin O. Davis, Jr.
Assistant Secretary for Environment,
Safety, and Consumer Affairs
Department of Transportation
Washington, D. C. 20590

Dear Mr. Davis:

Thank you for your letter of April 17, 1975 commenting on the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. We note that your review focused particularly on the transportation aspects of the statement and that, on these matters, you found that the Statement appears to be in accord with current Department of Transportation (DOT), Nuclear Regulatory Commission (NRC) and Energy Research and Development Administration (ERDA) requirements for transportation of radioactive materials. We are pleased that you found that the transportation section of the Proposed Final Environmental Statement was acceptable and that responses to comments received relative to transportation appear to be consistent with the philosophy of the DOT, NRC and ERDA.

Thank you again for your comments. Copies of the Final Environmental Statement are enclosed for your information.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program (6 copies)

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230

April 16, 1975

Mr. W. H. Pennington
Assessment and Coordination Officer
Division of Biomedical and
Environmental Research
Energy Research and Development
Administration
Washington, D. C. 20545

Dear Mr. Pennington:

The proposed final environmental impact statement for "WASH-1535-Liquid Metal Fast Breeder Reactor Program (LMFBR)," which accompanied your letter of February 11, 1975, has been received by the Department of Commerce for review and comment.

We have reviewed the statement and offer the following comments for your consideration.

Based upon our review, we believe the proposed final environmental impact statement satisfies the requirements for such a statement established pursuant to the National Environmental Policy Act of 1969. Furthermore, we have no information which would lead us to disagree with the major conclusion of the environmental impact statement, i.e. that the LMFBR can be developed as a safe, clean, reliable and economic electric power generation system and that the advantages of developing the LMFBR as an alternative energy option far outweigh the attendant disadvantages.

Utilization of the LMFBR would involve several significant environmental problems pertaining to the processing and transporting of plutonium, and the safeguarding of nuclear materials and facilities against theft or sabotage, and the disposal and storage of radioactive wastes. These problems are extensively discussed in the environmental statement.

The electrical energy needs of the Nation are likely to grow to such an extent that existing or developing methods of energy production will not be sufficient to meet the requirements. All reasonable options need to be pursued if the Nation is to be assured of a secure electrical energy supply.

Commercial application of the LMFBR would extend the energy stores of our low-cost uranium resources from decades to centuries and reduce the total environmental impact from the generation of electricity. It would also reduce occupational injuries and fatalities associated with energy supply and provide substantial economic benefits. As part of the preparation of the environmental impact statement, the cost-benefit study for the program was updated. It continues to show, even under extremely conservative assumptions, that the presence of a viable breeder industry in this country will provide benefits far in excess of the investments required to bring it to commercial development.

Within the past year there have been several major independent reviews and assessments of the LMFBR program which support it. Early last year, AEC (now ERDA), as part of a continuing assessment of the program, requested and received input from the program laboratories, private industry, the utilities, and senior consultants. The reviewers indicated strong support for continuing the LMFBR program and stressed the urgency of reaching, at an early date, the goal of a competitive, multi-vendor industry. A further review of the LMFBR program was commissioned by AEC last fall and involved a review of the program, particularly with respect to the role of the demonstration plant (Clinch River Breeder Reactor presently under site preparation) as a logical step in the path to LMFBR commercialization. The report concluded that the government should proceed expeditiously to develop the breeder to assure the continued long-term (1990's and beyond) availability of the nuclear fission power option.

In addition to the conclusions reached by these reviews and studies, successes in the French and British LMFBR programs continue to support their decision to place a high priority on the development of the LMFBR. The U.S. program is expected to gain through technical exchange arrangements with these countries in the LMFBR development. However, it is crucial that one recognize that the breeder reactor is only one of several options potentially available to the U.S. The development of the current nuclear industry as well as past domestic and overseas breeder development has brought the breeder closer to commercial fruition than other advanced systems, but further development effort is still necessary before commercial viability for the U.S. is established.

One must also recognize that support for developing commercial breeder reactor technology does not commit the U.S. to widespread use of breeder reactors. The development effort serves to consolidate one option. By

the time that a successful commercial-sized breeder is developed and demonstrated, some of the present imponderable uncertainties relating to environmental safeguards and the growth rate of the demand for electricity will be better understood and/or partially resolved.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving two copies of the final statement.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Sidney R. Galler
Deputy Assistant Secretary for
Environmental Affairs
U.S. Department of Commerce
Washington, D. C. 20230

Dear Mr. Galler:

Thank you for your letter of April 16, 1975 commenting on the Proposed Final Environmental Statement (PFES) on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The conclusions resulting from your review, which are generally in accord with those set forth in the PFES, are gratifying.

The PFES had been prepared under the auspices of the Atomic Energy Commission prior to the reorganization which led to the formation of the Energy Research and Development Administration (ERDA). ERDA has assumed the responsibility for conducting the LMFBR Program and accordingly has independently reviewed the PFES in the light of its charter for developing all feasible energy technologies, non-nuclear as well as nuclear. Written comments received on the PFES have been reviewed as was the testimony presented at a Public Hearing held on May 27-28, 1975. The Administrator has concluded that continuation of research, development and demonstration of the LMFBR concept is warranted and that continuation of the program will not constitute commitment to widespread commercial deployment of the LMFBR at this time. A decision on widespread deployment will await definitive resolution of several environmental issues on which research, development and demonstration have not as yet been completed. These issues include aspects of nuclear safety, waste management, safeguards and uranium resource availability. The Administrator has also concluded that continuation of the LMFBR

Program will not be at the expense of alternative power generation and conservation concepts which must be developed on a priority basis.

The PFES has been incorporated as Section II into the Final Environmental Statement, copies of which have been enclosed herewith for your information. Thank you again for your review of the PFES and your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement
LMFBR Program (12 copies)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

APR 21 1975

Mr. James L. Liverman
Assistant Administrator for
Environment & Safety
Energy Research and Development
Administration
Washington, D.C. 20545

Dear Mr. Liverman:

In response to your letter to Mr. Nathaniel B. Cohen, Director, Office of Policy Analysis, dated January 17, 1975, NASA personnel have reviewed the proposed final environmental statement, "Liquid Metal Fast Breeder Reactor," WASH-1535.

By way of introduction, I should note that NASA presently has no direct programmatic responsibility for terrestrial energy research and development. We were given responsibility for work in solar and geothermal energy research and development by Public Laws 93-409, 93-410, and 93-473; however, NASA's functions under those acts were transferred to the Energy Research and Development Administration (ERDA) earlier this year. NASA is presently working with ERDA and others in applying aerospace technology to terrestrial energy needs, and we do have some expertise in certain of the alternative technologies considered in the proposed statement. Our review gave particular attention to these areas and our comments are as follows:

1. Energy Demand Projections

With respect to the projection of future energy demand, we defer to agencies having relevant special responsibilities or expertise for comment on the validity of the various demand projections used in the analyses, including consideration of such factors as price and income elasticity of demand

and effects of conservation programs. However, the demand projections are sometimes stated in terms of thermal energy input to electrical generating stations and, at other times, in terms of electrical energy output. The thermal efficiencies employed to relate the two are not explicitly defined. This, in turn, makes comparisons difficult. For example, it is not readily apparent that the demand projection of the Department of the Interior (Section 2.1.2.4) is comparable, assuming a conversion efficiency of 33 percent, with the "very small" demand projection of Figure 11.2-5. Because of the importance of demand projections to the results of the analyses, they should be stated in uniform terms throughout the report, with specific reference to the assumed conversion efficiencies where necessary.

2. Alternatives

We found the technical information provided in Section 6 on the alternative technologies in which we have some expertise generally to be accurate, and we have no specific comments on the material presented. However, we believe that the discussions in this section could be improved by additional consideration of logical combinations of energy technologies, each combination comprising an alternative energy strategy.

For example, advanced coal technologies, employing advanced mining techniques, clean fuels, and exhaust gas treatment for reduced environmental effects, could be phased in as they become available for replacement of obsolete installations and to satisfy part, though not necessarily all, of the demand for new generating capacity. The NASA-managed, ERDA/NSF-sponsored, Energy Conversion Alternatives Study, when complete, should contribute information on high efficiency energy conversion techniques to assist in an appraisal of these advanced coal-related technologies. Other advanced energy technologies, such as solar and geothermal, have been shown by studies to have the potential to contribute a significant fraction of the nation's electric energy needs by the year 2000. They could thus be candidates for consideration as supplementary technologies in such an

alternative strategy. It would seem appropriate that the environmental statement should examine logical combinations of alternative systems of this class.

3. Extraterrestrial Disposal of Nuclear Wastes

Section 7.3.5, Radioactive Waste Management, gives consideration to extraterrestrial disposal of nuclear wastes as one potential future alternative for waste disposal. Although the concept is not considered in detail, the discussion does refer to potential environmental effects of launch vehicle operations. NASA has given consideration to the potential environmental effects of the Space Shuttle now under development and has found them not to be significant. In particular, of those you cite, water pollution effects will be negligible, air pollution effects can be avoided through operational constraints or design changes, and launch noise will be negligible (the 115 dB noise levels cited would impinge only on areas under NASA control in the case of launch from our principal launch site, the Kennedy Space Center, Florida). We believe that it would be premature at this time either to rule out or to depend on an extraterrestrial disposal possibility. Certainly the environmental effects associated with Space Shuttle operations will not be a major factor in considering this alternative.

We recognize the extreme difficulty and complexity of conducting an analysis of the anticipated effects of development and operation of a prospective, large-scale source of electric energy still under development. A program environmental statement of this nature is inherently one which undergoes continual reexamination and, if necessary, change as new information becomes available on the system under development and on alternative systems.

We appreciate the opportunity to comment on this proposed final environmental statement and would be happy to discuss our comments with you in more detail as you put the report in final form.

Sincerely,

Willis H. Shapley
Associate Deputy Administrator

cc:
Mr. Russell Peterson, CEQ
Mr. W. H. Pennington, ERDA

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Willis H. Shaply
Associate Deputy Administrator
National Aeronautics and
Space Administration
Washington, D. C. 20546

Dear Mr. Shaply:

Thank you for your letter of April 21, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The three questions which are raised in your letter are discussed in the enclosures.

The Energy Research and Development Administration (ERDA) has reviewed all written comments received on the PFES as well as the testimony received during the Public Hearing held on May 27-28, 1975, and has taken these views into account in the preparation of the Final Environmental Statement for the LMFBR Program. Copies of that Statement are enclosed for your information.

The National Aeronautics and Space Administration's review of the PFES and interest in the LMFBR Program are appreciated.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Responses to
   NASA Comments
2. Final Environmental Statement,
   LMFBR Program (5 copies)

ERDA Responses to Comments of W. H. Shaply, NASA

Comment (pp. 1 and 2):

> Future energy projections do not appear to be presented using a consistent set of units, making it difficult to compare the various projections. Demands are sometimes stated in terms of thermal energy to power plants and sometimes in terms of electrical output. For example, the Department of Interior's projections in Section 2.1.2.4 are in thermal units whereas the data in Fig. 11.2-5 are in electrical units.

ERDA Response:

We agree that consistent energy units are necessary for comparative purposes, and we have attempted to maintain consistency for the same types of energy requirements. The Department of Interior's projections, which you refer to, are for total energy requirements; total energy refers to primary fuel consumption and is normally expressed in thermal units. Figure 11.2-5 contains projections for electrical energy demand. The primary energy required to generate the electrical demand would, of course, depend on the thermodynamic characteristics of the generating system.

Comment (pp. 2 and 3):

> Technical information in Section 6 on specific alternative energy systems appears to be satisfactory, but this section could be improved by considering combinations of energy systems, each combination comprising an alternative energy strategy.

ERDA Response:

Section 11.1.2.2 examines some alternative energy strategies. Nevertheless, in response to comments by you and others, the analysis of alternative energy strategies has been expanded and is presented in Section III F of the Final Environmental Statement.

Comment (p. 3):

> The discussion of extraterrestrial disposal of wastes given in Section 7.3.5 refers to potential environmental effects of launch vehicle operations. Based on studies made by NASA, it is concluded that environmental effects of launch vehicle operation will not be a major factor in considering extraterrestrial disposal.

ERDA Response:

We agree that launch-vehicle-related air and water pollution and noise effects could be made acceptable by proper design and operational constraints. These potential impacts were mentioned in the PFES simply for the purpose of identifying factors that need to be considered. The primary concern is, as noted in the PFES, the impact of an aborted mission.

RD#1 Leader Road
Box 232
Waterloo, New York
April 19, 1975

Dear Mr. Pennington:

Having read of the Liquid Metal Fast Breeder Reactor Program I am shocked and frightened.

Over the last few years I have been keeping up on the different types of nuclear power plants proposed for different areas of the country and also have been hearing and reading of the so called "minor accidents".

How are they going to label a large area wipe out?

Either by a demented person constructing a nuclear bomb out of stolen plutonium or just sabotaging one of the breeder reactors.

I for one, and I'm sure many others will agree would rather do without so called "necessities" of life requiring energy, than have any more such programs.

Please — your children & grandchildren and ours will be the ones to suffer.

Solar energy programs, methane gas, etc. are the answer.

Making use of our weather and the sun must be the answer in this day of shortage of resources. Not a program of eventual disaster and destruction.

Sincerely
Mrs Harold Sondgeroth

P.S. We are considering & studying Methane gas and wind power for our farm eventually and so are some of our neighbors.

V-81-1

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mrs. Harold Sandyrath
R.D. #1 Leader Road
Box 232
Waterloo, New York 13165

Dear Mrs. Sandyrath:

Thank you for your letter of April 19, 1975 presenting your views on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Energy Research and Development Administration has completed a two-year review of the environmental impacts of the LMFBR program which was initiated under the auspices of the Atomic Energy Commission. This review, entitled "Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program" addresses the concerns you express with regard to the safety of LMFBRs, plutonium safeguards and use of alternative energy sources. Please refer to Sections 4.2.7, 7.4 and 6 of Section II for discussions on these questions.

Although the environmental review of the LMFBR Program has led ERDA to conclude that continuation of research, development and demonstration of the LMFBR concept is needed, continuation of the LMFBR Program will not be at the expense of alternative power generation and conservation concepts, which must be developed on a priority basis. Indeed, these other technology options, which are examined in Section II of the Final Environmental Statement, are receiving substantially increased appropriations in the current fiscal year and are proceeding at a pace limited only by the need to build up the new programs efficiently and effectively.

It is hoped that your review of the enclosed Final Environmental Statement will alleviate your concerns. Thank you for your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

Westinghouse Electric Corporation

John W Simpson
Director and
Chairman of the Energy Committee

Westinghouse Building
Gateway Center
Pittsburgh Pennsylvania 15222

April 18, 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental Research
U. S. ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
Washington, D.C. 20545

Dear Mr. Pennington:

Accompanying this letter are the Westinghouse detailed comments on the proposed final environmental statement on the Liquid Metal Fast Breeder Reactor Program, WASH-1535.

We appreciate the opportunity to review and comment on this document. The conclusions reached in WASH-1535 enforce the Westinghouse belief that the LMFBR must be an essential contributor to the nation's future energy needs. It also enforces our contention that we must develop the LMFBR now as a viable and realistic national energy insurance policy that will return benefits well before the turn of the century.

There are some assumptions and figures within WASH-1535 with which we disagree or which have changed since the document was written. We have noted these instances in the attached detailed comments. In most cases, however, these disagreements tend to highlight the conservative nature of the figures used in the document rather than inaccuracies.

Our conclusion is that WASH-1535 is an objective assessment of the impact of the LMFBR on the environment. It is generally well written and well documented, and should be accepted as ERDA's Final Environmental Statement on the LMFBR program.

Sincerely,

John W. Simpson

attachments

Westinghouse
Electric Corporation

Advanced Nuclear
Systems Divisions

J J Taylor
Vice President and General Manager

Nuclear Center
Box 355
Pittsburgh Pennsylvania 15230

ANSD-57

April 18, 1975

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental Research
U. S. Energy Research and Development Administration
Washington, D. C. 20545

Dear Mr. Pennington:

Viewed overall, the Proposed Final Environmental Statement of the Liquid Metal Fast Breeder Reactor Program (WASH-1535) is an impressive and comprehensive document. It takes a realistic and positive approach to the role of the LMFBR in the nation's energy future.

It may appear to some in reading WASH-1535 that the objective of the LMFBR is to eliminate the use of gas and aid in the production of electricity. This is not the case. Rather, the LMFBR is needed to assure an adequate and reasonably priced primary energy source for the future. The exhaustion of the world's reserves of oil and gas is within sight. The LMFBR is the only proven technology that can assure adequate electricity in the latter part of this century and the early part of the next century when the dwindling supplies of oil and gas, and the environmental impact of mining coal and lower grade uranium will become severe.

It is our opinion that WASH-1535 should be accepted as the Final Environmental Statement for the Liquid Metal Fast Breeder Program with the following comments.

Uranium Supply

The recent Preliminary National Uranium Resource Evaluation (PNURE) results of 3.45 million tons of uranium available, before shale must be mined, represents the best current estimate that can be used with confidence in planning energy policy. The WASH-1535 base case estimate of four million tons, not including shales, is conservative.

More optimistic estimates of potential uranium resource than the base case in WASH-1535 have been proposed by others. In one such study by the Electric Power Research Institute (EPRI), an estimate of 13.2 million tons of uranium

at less than $100 per pound was proposed. This estimate has only a 50% confidence factor. It would not seem prudent to base national energy planning on a resource estimate which has only a 50/50 change of being correct.

Other optimistic estimates have resulted from the misapplication of oil and gas resource estimation techniques to uranium. Since uranium is deposited in a totally different geologic manner than gas or oil, it is debatable whether theoretical world models of uranium resource distribution is a valid basis for estimating national uranium resources.

Environmental Effects

In Section 1.4.3, page 1.4-10, middle paragraph, the value of one-tenth for the transuranic concentration factor in plants is quite conservative. The values used for plutonium are at least two orders of magnitude lower than that.

Radioactive Wastes

Solidification and encapsulation of waste greatly reduce the probability that the radioactive material will be dispersed into the environment. While retrievable surface storage, the method discussed most in the waste management sections of WASH-1535, represents a technically sound approach to the interim storage of high-level radioactive waste, complete public acceptance of nuclear power will probably require the solution of the question of permanent disposal.

Uranium used in fission reactors, especially in breeder reactors, represents a vast energy resource. It is in the long-term national interest that ERDA identify as expeditiously as possible, consistent with public safety, a technique or combination of techniques which represent a good method for the permanent disposal of radioactive waste.

Plutonium Toxicity

A great deal more information is provided in WASH-1535 on the health effects risk estimates compared with that given in the early March 1974 draft. Most of this information enhances the value of the report. However, it is our opinion that the derivation of cancer mortality risk estimates from the BEIR report estimates provide an interpretation of the BEIR report data which is overly conservative, especially with regards to lung, bone and liver cancer risk factors. The data as provided here is based on the assumption that all cancers in the USA result from the background radiation dose. Since there are many other known causes of cancer, we believe it would be more

appropriate to use occupational exposure data or the Hiroshima-Nagasaki atomic bomb casualty data (see Table f-2, page 152 from the BEIR report). If this data is utilized, the risk factor range is reduced from 16-110 per million person-rem as given in Table IIG-24 to 0.2-1.8 per million person-rem. Similarly, the bone cancer risk factor is reduced from 2-17 per million person-rem to 0.11-0.96 per million person-rem based on occupational exposure (page 129, BEIR report).

Plutonium Safeguards

WASH-1535 provides an objective and comprehensive treatment of the potential risks associated with diversion or theft of special nuclear materials as well as a good description of the security measures that have already been implemented and those that are being considered for the future. The Staff attempt to quantify the potential radiological consequences of assumed acts of diversion or sabotage should add credibility to the WASH-1535 analysis of this sensitive subject and should provide the public with some perspective of the risks involved.

WASH-1535 describes the present ERDA/NRC philosophy on Safeguards to protect against current and future risks from diversion or theft of special nuclear materials. We would like to stress the importance of a safeguards program based on guidelines that will permit a nuclear fuel cycle facility to develop security measures which are best suited for its particular situation.

Among the interruption activities under consideration to reduce the probability of successful adversary action (Section 7.4.8), a key feature of an effective safeguards program is considered to be the ability of reserve law enforcement and/or military units to provide a timely response force. The number of security personnel at fixed sites and accompanying shipments (limited by practical considerations) could effectively delay an organized effort to steal nuclear material but prompt assistance would generally be required to insure that attempted theft is not successful. The viability of this important countermeasure is not clearly demonstrated in WASH-1535. It is recognized that appropriate steps are being taken to define and describe the interagency security system in more detail such that the public can be assured of the feasibility and effectiveness of such assistance.

Alternate Technology - LWR, HTGR

This section states that the HTGR requires only about one-half of the uranium ore requirement of the LWR. This appears to be an excessively large estimate. While the HTGR does require less uranium ore than the LWR, it is closer to a 30% savings rather than a 50% savings. Also, Westinghouse estimates indicate

that the HTGR requires significantly greater (approximately 25%) quantity of enrichment work (SWU's) than the LWR. It should be recognized that the future requirement for enrichment capacity may be larger than projected in WASH-1535.

Alternate Technology - CTR

This section of WASH-1535 minimizes the problems yet to be solved and provides an overly optimistic portrayal of the prospects for early practical application of fusion for commercial power production. The section conveys the misleading impression that fusion power plants, whether of the magnetic confinement or inertial confinement varieties, are just around the corner. This can lead to a misinterpretation that fusion is competitive with the LMFBR from the standpoint of the time frame of commercialization. Although Westinghouse encourages a vigorous and urgent development of fusion power, national policy cannot be based on its early realization because the scientific feasibility of magnetically as well as inertially confined controlled fusion is yet to be demonstrated. Furthermore, developmental work on some of the requisite technology is yet to be started, let alone completed, even though the lead times are long and one assumes eventual success.

Alternate Technology - Non-Nuclear

Geothermal - With the following exceptions, this section is very well done and is highly recommended as a primer on the subject.

We feel that too much credibility is attributed to the Hickel report for its estimates of resource base electricity production and research and development costs. The National Petroleum Council estimate of geothermal potential is given but scarce mention in WASH-1535. Yet, it is the most realistic of all the estimates by acknowledgement of experts in the field including Pat Muffler of the U.S. Geologic Survey.

It is true as stated in 6A.4.1.3, 6A.4-11 that the well spacing at the geysers may be a minimum of five acres, but it does not state that the desired spacing is more like forty acres.

It should also be noted that WASH-1535 overlooks the fact that environmental opposition has held up the licensing of unit 12 at the geysers for over three years with no end yet in sight.

Solar - In general, we feel that this section was written so as to give every benefit of doubt to the various solar energy possibilities. Despite this

favorable treatment, WASH-1535 reaches two conclusions with which we agree.

1. Solar energy will probably provide some useful space heating in this century which will replace some fossil fuel which might otherwise be used.

2. There probably will be no significant economic production of electrical power from solar energy sources in this century.

There is no indication in the data that solar power can do the job which the LMFBR will do in supplying base loaded electrical power plants.

Conservation of Energy

The statement that electricity is a much less efficient means of energy utilization requires qualification.

1. To deliver one BTU of heat to a home requires:

   (a) 2.2 BTU of gas at the processing plant

   (b) 3.2 BTU of nuclear fuel or fossil fuel at the generating plant when electric resistance heating is used

   (c) 1.6 BTU of nuclear fuel or fossil fuel at the generating plant when using the heat pump.

   Thus, an electrically driven heat pump is more energy efficient than gas.

2. With natural gas supplies falling rapidly, and the national need to reduce consumption, there will be a shift to coal and nuclear, both being used to supply heat directly and in the form of electricity. Correspondingly, energy efficiency and energy availability become important considerations, not energy efficiency alone.

Energy Storage Devices

WASH-1535 correctly points out that efficiencies in electrical energy conversion above 40% will only come about through the development of advanced systems. Insufficient emphasis is given in this section on the need to develop coal conversion processes simultaneously with the development of advanced conversion systems. Without coal gasification and liquefaction capability, we will be seriously hampered in our efforts to utilize advanced

gas turbine - steam turbine cycles, fuel cells and MHD (magnetohydrodynamic) generators. Since each of these systems has the potential of more than 40% fuel conversion efficiency, it is imperative that a fuel option based on coal be available.

The technology base for efficiencies of 45% is available now. For example, there is ample evidence to suggest that using a combined steam-gas turbine cycle as the basic generating unit, a 45% efficient power plant can be developed by 1985. Accelerating developments now underway, followed by a demonstration unit, is the logical technical plan. Thus, it is not necessary to rely on the more speculative fuel cell system or MHD plant to achieve higher efficiencies. The data given in Table 1.8-2 in the Summary, Volume 1, of WASH-1535 could reflect higher efficiency plants in assessing fossil fuel usage. WASH-1535 is likely to be more credible if the breeder reactor is compared to the technology that is likely to be available in the late 1980s, rather than considering a technology which is representative of 1975.

The use of electrochemical energy storage will enhance the position of nuclear power plants, in general, and definitely improve the position of the breeder. The lower the fuel cost, the more favorable are the economics of storage systems. A battery storage system will also provide for the most efficient use of the base load nuclear system. Thus, the capital investment in the nuclear plant will be better utilized. It can be concluded that research and development on electrochemical storage should be encouraged since batteries will complement LMFBR plants in the future.

Environmental Costs vs. Benefits

The information in this section is consistent with the assessment contained in the Clinch River Breeder Reactor Plant Environmental Report. Both documents indicate a net positive factor associated with the utilization of the LMFBR as a major contributor to the production of electrical energy.

WASH-1535 does not, however, take full credit for advances made in systems designs, for instance, the recycling capability of the CRBRP Radioactive Argon Processing System, the redundant liquid processing systems or the low-pressure, low leakage systems.

Licensing and Environmental Effects

Concurrent with the design of the Clinch River Plant and the Commercial Prototype, close liaison must be maintained with the newly designated Nuclear Regulatory Commission (NRC) to ensure that the plant will meet the necessary

safety requirements. Licensing and successful operation of those plants will provide precedent for rapid licensing of future commercial LMFBR plants. Environmental effects of the plant, including both local effects and effects during the entire fuel cycle must be continuously analyzed and reviewed with the appropriate agencies. Development of long-term, permanent disposal of the radioactive wastes must continue and must provide a suitable waste management scheme in time to handle the wastes produced by the nuclear power industry.

Cost/Benefit

The Cost/Benefit portion of WASH-1535 is a careful and comprehensive study. The fundamental thrust of the Cost/Benefit analysis was to obtain a conservative estimate of the dollar benefit to be obtained from the LMFBR. In order to be conservative, estimates of future costs and trends were made which were, in fact, quite detrimental to the LMFBR. For example, the separative work cost was assumed to be 36 $/swu throughout the study, while the current separative work price is over 40 $/swu and rising. Also, the U_3O_8 price was assumed to be considerably lower than current trends would indicate. Furthermore, the growth rate for electrical energy was assumed to be a decreasing function of time in all cases, and the discount rate of 10% is probably inordinately high. However, even with these conservative assumptions, the LMFBR produced substantial dollar benefits for all realistic cases. For example, the dollar benefit in the base case was 20 billion dollars.

Using the results from the parametric calculations presented in the document, one can estimate the dollar benefit to be obtained from the LMFBR for a more realistic set of assumptions. For example, suppose one assumes a separative work price of 75 $/swu, a U_3O_8 price of approximately 40 $/lb. with two million tons of U_3O_8 consumed, an electrical energy growth rate of approximately 4% per year in the year 2020, and a discount rate of 7.5%. Then, using the principle of superposition, which should hold in a linear analysis, the benefit due to the LMFBR can be estimated to be 80 billion dollars. Though this value is only approximately estimated, it may in fact be a more accurate indication of the dollar benefit to be obtained from the LMFBR. This more realistic estimate is consistent with the most recent and comprehensive cost/benefit analysis titled "An Assessment of Economic Incentives for the Liquid Metal Fast Breeder Reactor" by T. R. Stauffer, R. S. Palmer and H. L. Wyckoff. In this analysis, their base case benefits for the LMFBR are estimated at 76 billion dollars.

The essential point to keep in mind is that the nation should not close off what appears to be a viable electric energy option for the latter part of this century.

The Westinghouse position is that the LMFBR has the least detrimental effect upon the environment of all economic power generation methods that will be available in significant quantities in the decades ahead. It is the only way that the nation can insure the minimum possible power generation costs to the public and at the same time conserve our precious national resources.

Sincerely,

WESTINGHOUSE ELECTRIC CORPORATION

J. G. Taylor/c

J. G. Taylor
Vice President and General Manager
Advanced Nuclear Systems Division

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. John W. Simpson
Director and Chairman
of the Energy Committee
Westinghouse Electric Corporation
Gateway Center
Pittsburgh, Pennsylvania 15222

Dear Mr. Simpson,

Thank you for your letter of April 18, 1975 and the accompanying Westinghouse detailed comments on the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program. We appreciate the favorable comments on the Statement, and agree with your observation that the few disagreements listed by Westinghouse largely result from the conservative assumptions used in the Statement. As you are probably well aware highly conservative assumptions were used in many cases in view of the many uncertainties involved in making projections decades into the future.

In the first enclosure, we offer responses to some of the points raised in the Westinghouse detailed comments. We have also enclosed a copy of the Final Environmental Statement. We appreciate the time you have taken to comment on the Proposed Final Statement.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses
to Westinghouse Comments
2. Final Environmental Statement,
LMFBR Program

ERDA Staff Responses to Westinghouse Comments

Note: ERDA staff is in complete or substantial agreement with the Westinghouse comments captioned Uranium Supply, Radioactive Wastes, Conservation of Energy, Energy Storage Devices, Environmental Cost vs. Benefits and Licensing and Environmental Effects, for which no discussion appears necessary.

(Comment p. 2):

"Environmental Effects
In Section 1.4.3, page 1.4-10, middle paragraph, the value of one-tenth for the transuranic concentration factor in plants is quite conservative. The values used for plutonium are at least two orders of magnitude lower than that."

ERDA Response:

ERDA agrees that the value of one-tenth for the plutonium concentration factor in plants is quite conservative, and, together with other assumptions, probably lead to an overestimation of the amount entering man through ingestion, as stated on the referenced page. This value perhaps is less conservative when considering americium and curium, however, or when chelates are present in the soil. These assumptions and the relevant data are discussed in Volume II, Section 4.7.4, page 4.7-8, and in greater detail in Appendix II.G, Section II.G.3, page II.G-26.

(Comment pp. 2, 3):

"Plutonium Toxicity
...it is our opinion that the derivation of cancer mortality risk estimates from the BEIR report estimates provide an interpretation of the BEIR report which is overly conservative ... The data as provided here are based on the assumption that all cancers in the USA result from background radiation dose. Since there are many other known causes of cancer, we believe it would be more appropriate to use occupational exposure data or the Hiroshima-Nagasaki atomic bomb casualty data ...."

ERDA Response:

While ERDA agrees that there is room for discussion with respect to the degree of conservatism contained in risk estimates based upon the BEIR report, it must be pointed out that the BEIR estimates are not based upon the assumption stated, but are in fact based upon a

linear extrapolation from the data of: a) Hiroshima-Nagasaki atomic bomb survivors, b) patients irradiated therapeutically, and c) groups occupationally exposed (BEIR report, page 2). Use of the BEIR report and its applicability to risk estimates of plutonium toxicity are discussed in Volume II, Section 4.7.6, page 4.7-14, and Appendix II.G., Sections II.G.5.4 and II.G.5.5, pages II.G-59 and II.G-64, respectively.

(Comment pp. 3, 4):

> "Alternate Technology - LWR, HTGR
> This section states that the HTGR requires only about one-half of the uranium ore requirement of the LWR. This appears to be an excessively large estimate. ... it is closer to a 30% savings rather than a 50% savings. Also Westinghouse estimates indicate that the HTGR requires significantly greater (approximately 25%) quantity of enrichment work (SWU's) than the LWR."

ERDA Response:

Westinghouse is correct - the U_3O_8 savings is closer to 30% than to 50%. However, based on data given in WASH-1139(74) page 24, over a nominal service life of 30 years, the HTGR requires less separative work than does the "average" LWR, unless one makes the assumption that over half of the LWRs operate with plutonium recycle over their service lives.

(Comment pp. 4, 5):

> "Alternate Technology - CTR and Non-Nuclear
> This section of WASH-1535 minimizes the problems yet to be solved and provides an overly optimistic portrayal of the prospects for early practical application of fusion for commercial power production.
>
> "Solar was written so as to give every benefit of doubt to the various solar energy possibilities."

ERDA Response:

In general, alternative technologies were given every benefit of doubt in the PFES. Nevertheless, many critics thought the treatment to be pessimistic and self-serving. The report of the Internal Review Board to the Administrator made the observation:

"...while the PFES is unswervingly optimistic concerning the resolution of technical difficulties with regard to the LMFBR, its view of the development of other technologies is often unduly pessimistic."

(Comment p. 7):

"Cost/Benefit
In order to be conservative, estimates of future costs and trends were made which were, in fact, quite detrimental to the LMFBR. For example, the separative work cost was assumed to be $36/SWU throughout the study ... the U_3O_8 price was ... considerably lower than current trends would indicate. Furthermore, the growth rate for electrical energy was assumed to be a decreasing function of time in all cases, and the discount rate of 10% is probably inordinately high."

ERDA Response:

The assumptions used in the cost-benefit analysis were, admittedly, very conservative, but - as Westinghouse points out - still led to substantial LMFBR benefits in most cases considered. A few cases were run to test the sensitivity of the results to more realistic parameters. Some additional cases using more realistic separative work and uranium costs are discussed in Section III F of the Final Environmental Statement.

April 17, 1975

W.H. Pennington
Assessment Officer
Division of Biomedical & Environmental Research
U.S. ERDA
Washington D.C. 20545

Dear Mr. Pennington:

It has come to my attention and to the attention of the Energy Conservation Organization of Eugene (Oregon) that U.S. policy on the breeder reactor is not yet set and that this is the time to express opinion regarding the development of this program.

I hold with Dr. Edward Teller when he says, "I do not like the hazard." I am opposed to nuclear fission in general for two main reasons: 1) I don't feel that any more radioactive waste should be produced before some truly effective way is found for dealing with it and for storing it for the thousands of years that it will be poisonous to the environment; 2) perhaps even more immediately critical is the question of security of plutonium. I don't feel that plutonium is, or can be, adequately protected against theft or dispersal through accident. 95% security is not enough. Only 100% is satisfactory, and that, I believe, is beyond the ability of mortal people.

In addition to these general objections, I must add, in the matter of breeders, the hazard of a full-scale bomb-like explosion which would scatter fission by-products all over a vast geographical area with attendant poisoning of people and environment as occurred in the Japanese cities in 1945.

Please, for all these reasons, shut down the breeder development program and divert the funds into research for solar, tidal, wave, methane, and other alternatives.

Thank you for your attention.

Sincerely,

Peter Bergel

Peter Bergel
Energy Conservation Organization, 1059 Hilyard
Eugene, Ore. 97401

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Peter Bergel
Energy Conservation Organization
1059 Hilyard
Eugene, Oregon 97401

Dear Mr. Bergel:

This is in response to your letter of April 17, 1975 commenting on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Energy Research and Development Administration has completed a comprehensive review of the environmental impacts of the LMFBR Program and has published a Final Environmental Statement on the subject. A copy is enclosed for your information.

With regard to your first concern, that of radioactive waste disposal, a number of points are pertinent. As discussed in detail in Section II, 4.6 of the Final Environmental Statement, ERDA is studying permanent disposal concepts which would make long term surveillance unnecessary. The evaluation of promising geological formations and sites leading to a pilot geological repository, which in turn could lead to a permanent disposal system, is a major part of the ERDA radioactive waste program. At present, ERDA plans further study of several promising geologic formations other than bedded salt, including study of specific promising sites, to bring the state of knowledge of these other formations up to the same level as that of bedded salt. The goal of this further study is to permit a comparative evaluation of these formations and the selection of the optimum formation or formations for pilot plant operations.

Your second point, the question of provision of security for plutonium is extensively addressed in Section 7.4 and Appendix IX.A of Section II of the Final Environmental Statement. Section III C presents a review of the safeguards program being conducted to assure that the increased amounts of plutonium expected to arise from the widespread deployment of the LMFBR will be adequately protected against theft or dispersal.

Finally, there is no scientific basis for assuming that LMFBR's are subject to the "... hazard of a full-scale bomb-like explosion." The configuration of the core material, the oxide composition and the relatively low enrichment all militate against the possibility of a

full-scale explosion. In addition, the stringent safety design criteria, high quality assurance practices, independent licensing review and extensive operator training limit the risk and consequences of any LMFBR accident to a level below that of any other major U.S. industry.

Although our environmental review of the LMFBR Program has led ERDA to conclude that continuation of research, development and demonstration of the LMFBR concept is needed, continuation of the LMFBR Program will not be at the expense of alternative power generation and conservation concepts, which must be developed on a priority basis. Indeed, these other technology options, which are examined in Section II of the Final Environmental Statement, are receiving substantially increased appropriations in the current fiscal year and are proceeding at a pace limited only by the need to build up the new programs efficiently and effectively.

It is hoped that your review of the enclosed Final Environmental Statement will alleviate your concerns. Thank you for your interest in the LMFBR Program.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 23 1975

OFFICE OF THE
ADMINISTRATOR

Mr. W.H. Pennington
Assessment and Coordination Officer
Division of Biomedial and
Environmental Research
U.S. Energy Research and Development
Administration
Washington, D.C. 20545

Dear Mr. Pennington:

In accordance with our responsibilities under NEPA and Section 309 of the Clean Air Act, as amended, the Environmental Protection Agency has reviewed the Atomic Energy Commission's proposed final environmental statement (PFES) on the Liquid Metal Fast Breeder Reactor (LMFBR) Program (Wash-1535), issued January 16, 1975. Our enclosed detailed comments are offered for consideration prior to completion of the anticipated ERDA environmental statement on this program.

Environmental impact statements often include consideration of factors not strictly environmental, particularly to the extent that these factors have relevance to, or an effect on, the environmental impacts. The overall economics and cost/benefit aspects of the LMFBR program are such factors, and they were assessed by the AEC staff in the PFES. Therefore, EPA's review and comments encompass these aspects as well as specific environmental issues.

As was directed by the courts, the PFES addressed (as did the March 14, 1974, draft statement) the impacts of both the developmental program and the possible ultimate commercialization of LMFBR-type plants. We agree that this approach was and is appropriate, and we commend the AEC for its exhaustive efforts to explore the broader aspects of this evolving technology. After review of the PFES, we have concluded that (with the exception of those matters discussed in our enclosed detailed comments) the AEC has addressed the impacts and economic aspects of the overall LMFBR program about as well as can be expected, given the state of presently available information. In addition,

this programmatic environmental statement is beneficial in that it tends to highlight areas of uncertainty and informational gaps--thereby aiding in focusing or redirecting research and developmental programs to provide needed answers. The PFES has generally served this purpose. However, the absence of definitive information in certain key areas restricts present impact analyses and, thus, severely limits the effectiveness of the PFES. It is this problem that is of most concern to EPA.

We believe the developmental portion of the LMFBR program can probably be conducted without any unacceptable adverse impacts on the environment. Nonetheless, there is some uncertainty surrounding the safety aspects of the Clinch River Breeder Reactor (CRBR) since there is a present lack of detailed design information. We realize that some of this information will be developed in the course of the necessary planning and design work and can be evaluated when the specific environmental statement and other documents are issued by the Nuclear Regulatory Commission in conjunction with the licensing of this facility. The PFES indicates that the general approach, as with light-water reactors, will be to utilize conservative design and siting practices to minimize safety risks. We agree that this will probably provide an adequate basic level of safety at the CRBR. Also, we are confident that, as new information is developed relative to safety, changes in plant design will be incorporated as necessary to ensure that the lowest practicable risk levels are maintained.

With respect to the commercialization aspects of the LMFBR program, our review of the PFES indicates that current information is inadequate to predict the ultimate environmental impacts with any certainty. Much of the information needed to make such predictions will come from ongoing and planned research and development. Similar uncertainty, in our opinion, clouds the evaluation of the economic and cost/benefit aspects of LMFBR commercialization. We have concluded from our review that overall LMFBR benefits are highly sensitive to variations in the assumed future electrical demand and uranium resource availability, neither of which is reliably known at this time. Thus, it is not currently possible to make accurate cost/benefit predictions regarding the program.

In spite of the existing environmental and economic uncertainties, EPA has not uncovered any evidence of unresolvable environmental problems which might preclude LMFBR commercialization. Thus, we see no reason for abandoning present and planned developmental efforts. However, in order to preserve flexibility for future energy decisions, we encourage ERDA to

continue (and expand where necessary) substantive exploration of feasible alternatives so that these will be in a sufficiently advanced state of development, should LMFBR commercialization not be possible.

The PFES anticipates a developmental program that progresses rapidly to commercialization in order to capture the assumed benefits of breeder technology. However, in our opinion, the LMFBR would not be rendered significantly less economic relative to other energy alternatives should problems delay the onset of commercialization. Recent downward trends in energy demand projections, in particular, appear to reduce the possible adverse effect of delay on program benefits. For example, using the latest demand projections of Project Independence, our preliminary analyses indicate that a delay of 4 to 12 years might be accommodated without significantly reducing the uranium conservation value of the breeder. This should not be construed as indicating that EPA is necessarily advocating a delay, but that sufficient evidence exists to warrant reexamination of LMFBR timing assumptions.

If it is established that additional time is indeed available for ERDA to consider LMFBR decisions, consideration should be given to the merits of program rescheduling. Present scheduling indicates what we believe to be highly optimistic assumptions concerning the time and effort needed for adequate resolutions of environmental and safety problems. If the developmental program were not tied to the earliest possible date for commercialization, additional time would be available to seek the best solutions to these problems and to optimize the overall program by utilizing new and possibly changing information relative to future uranium supply and energy demand. Further, although the PFES adequately considers possible nuclear and non-nuclear alternatives (based on current information), additional time could be used to advantage to refine such considerations and, thus, possibly improve environmental protection.

As was indicated previously, although the AEC has assessed projected impacts about as well as can be expected utilizing present information, the absence of information in certain key areas severely limits the PFES. We would encourage ERDA to

reexamine the environmental aspects of the program to the extent possible and appropriate as new environmental and environmentally related information becomes available. If you or the ERDA staff have any questions concerning our comments, we would be happy to discuss them with you.

Sincerely yours,

Sheldon Meyers

Sheldon Meyers
Director
Office of Federal Activities

enclosure

PF-AEC-A00106-00

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

April 1975

COMMENTS ON PROPOSED FINAL ENVIRONMENTAL STATEMENT

Liquid Metal Fast Breeder Reactor Program

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INTRODUCTION AND CONCLUSIONS

EPA has reviewed the Proposed Final Environmental Statement (PFES) prepared by the U.S. Atomic Energy Commission on the Liquid Metal Fast Breeder Reactor Program and issued January 16, 1975. In our review we have emphasized the AEC responses to our comments on the draft environmental statement (DES). Our major conclusions are summarized as follows.

In general, we believe the PFES has assessed the environmental impacts of the LMFBR program about as well as can be expected, given the state of present information. However, our review also indicates that some important unknowns and uncertainties still exist, in the areas of reactor safety, transportation safety, radioactive waste disposal, and plutonium toxicity, which limit the accuracy with which environmental impacts can be forecast. Consequently, we were unable to conclude, on the basis of the information presented in the PFES, that commercial development of the LMFBR program can be accomplished without causing future unacceptable environmental impacts. Conversely, neither were we able to identify any unresolvable problems that would preclude LMFBR commercialization. In addition, for a limited number of demonstration facilities (such as may be required to develop the LMFBR technology), we believe an adequate level of safety can probably be provided utilizing conservative design and siting criteria.

In proceeding with the developmental effort, there may be a buildup of inertia from governmental and industrial investment to follow through deployment of commercial LMFBRs. Since the environmental impacts of a single commercial LMFBR cannot presently be predicted with certainty (much less those of full deployment), we would question a decision, based on the PFES, to fully commit to LMFBR commercialization. In our judgment, such a decision should be made after an evaluation of information generated in the ongoing and planned research and development program, as it becomes available.

Our review of the cost/benefit analyses indicates that the LMFBR benefits presented are highly sensitive to variations associated with the assumed future electricity demand and uranium resources, neither of which is reliably known at this time. Therefore, it is not currently possible to make accurate cost/benefit predictions regarding the program.

In our opinion, the time needed to resolve the environmental and safety questions associated with the LMFBR program may be greater than that provided in present scheduling. It appears, however, that additional time for such problems might be available. In view of the most recent energy demand projections by Project Independence, our preliminary analyses have led us to believe that a delay of four to twelve years in the commercialization of the LMFBR might be accommodated without significantly reducing the uranium conservation value of the LMFBR. This should not be construed as indicating that EPA is necessarily advocating a delay, but that sufficient evidence exists to warrant reexamination of LMFBR timing assumptions.

We encourage ERDA, in order to preserve flexibility for future energy decisions, to continue (and expand where necessary) substantive exploration of feasible alternatives so that these will be in a sufficiently advanced state of development, should LMFBR commercialization not be possible.

BENEFIT COST ANALYSIS

INTRODUCTION

Our primary concern in reviewing the proposed final environmental statement (PFES) has been the adequate treatment of the potential environmental and safety impacts associated with the LMFBR program. We believe that the costs of avoiding or incurring these potential adverse environmental effects should be at least offset by the potential net economic benefits of the program. It is because of this critical balancing between potential environmental and economic effects that we have devoted our attention to the economic as well as the environmental aspects of the PFES. We want both to be presented as adequately as is possible in order to increase the likelihood that the proper balancing will be made.

The proposed final environmental statement (PFES) responds satisfactorily to all but two of the detailed EPA criticisms of the benefit-cost analyses presented in the draft environmental statement (DES). One area in which the PFES analysis is deficient is in the presentation of the results of the sensitivity analysis requested by EPA. In its comments, EPA requested a sensitivity analysis of the projected benefits of the LMFBR with respect to high and low values for four major conditions: (1) future supply of uranium; (2) capital cost difference between LMFBRs and LWRs; (3) level of future demand for electrical power; and (4) rate of introduction of HTGRs. Full exploration of the effects of these variations would have required the evaluation of 24 alternatives - eight basic "without LMFBR" alternatives and 16 "with LMFBR" alternatives reflecting the total number of combinations possible given two possible values for each of the four conditions that could be varied. Table 1 presents a summary of the 24 cases which would have been explored under the EPA request. In addition, Table 1 includes 12 additional cases that were evaluated and presented by the AEC as part of the sensitivity analysis. These latter cases reflect a pessimistic assumption about the supply of uranium.

The purpose of the sensitivity analysis was to investigate the degree to which the projected benefits of the LMFBR program vary with different assumptions about uncertain future conditions. In particular EPA believed that energy demand in the year 2020 possibly could be some 50% smaller than that projected using the base projection; that the uranium supply could be significantly greater than that projected for the base case; that the capital cost differential between LMFBRs and LWRs could be significantly higher than the base projection; and that the HTGR growth constraints might be overcome by a change in program emphasis.

Most observers would agree that with respect to the base energy demand, capital costs, and HTGR constraints, deviations from the base projections are likely to be in only one direction - definitely downward - given recent population growth and energy demand experience. Such agreement could not be found with respect to the projected uranium supply. AEC correctly supplemented the requested sensitivity analysis with consideration of a pessimistic projection of future uranium supplies. Their pessimistic forecast reflects the belief of many that future uranium supplies will be limited to today's known and potential reserves.

The second area in which the PFES responds poorly to EPA's comments is in the analysis of the effects of a delay in the introduction date of the LMFBR on the anticipated benefits of the program. The analysis presented in the PFES restricts attention to cases that are for the most part unfavorable to any delay, i.e., cases where at most one adverse future condition occurs. In subsequent sections, we have carried out some primitive analyses to establish a context for viewing the possible effects of a delay in the LMFBR introduction date. The PFES would be greatly improved were it to expand its treatment of the question of timing of LMFBR introduction including additional sensitivity analyses using the benefit-cost model.

PROBLEMS WITH THE ANALYSIS OF THE SENSITIVITY CASES

Apparent Incorrect Base for Measuring Benefits

The measure of gross benefits attributable to the LMFBR is basically the cost savings realized by providing energy to meet the projected level of demand with LMFBR's over the costs of meeting the demand by LWR's. In calculating benefits, therefore, the only difference between the reference base case and the LMFBR case should be the presence of the LMFBR. In Table 1, each reference base case has two LMFBR cases for comparison because two levels of LMFBR capital costs have been postulated. Except for the cases including a constraint on HTGR reactor introduction, the conditions for the base cases correctly do not vary from the comparative LMFBR cases with respect to any of the variable conditions.

This correspondence fails in the HTGR constrained cases because the reference base cases assume a constraint on HTGR introduction up to the year 2020 while the comparative LMFBR cases assume constraints only to the year 2000. In Table 1, base cases 13, 16, 22, 31, and 34 suffer from this apparent error. The results for base case 19 comparisons were not presented in Appendix Table IV D-1; it is not known if the same mistake was made there.

The effects of this non-conformity on gross benefits calculation could be highly significant. No base runs including a year 2000 constraint on HTGR introductions were presented in Table IV D-1, however, an indication of the effect of the apparent error is provided by the PFES, Table 11.2-23. According to the data in the first row of the table, the gross benefits of the LMFBR program are $19.4 billion when the HTGR capacity constraints to the year 2020 are imposed for the non-breeder comparison. If the HTGR capacity constraints are applied only to the year 2000 for the non-breeder case and all other assumptions are held constant the gross benefits drop to $14.6 billion.

Footnote "a" in Table 11.2-23 states that the constraints were not "imposed (or needed)" beyond the year 2000 for the cases with the breeder present. This statement implies that the reduction in gross benefits from $19.4 to $14.6 billion can be attributed wholly to the reduction in the present value of the total costs of producing energy in the non-breeder base cases brought about by relaxing the capacity constraints on the HTGR during the period from the year 2000 through 2020.

These data suggest that if the base case 1 in Table IV.D-1 had HTGR capacity constraints imposed only to the year 2000, the energy cost would be $206 billion instead of $210.8 billion. And, more

importantly, the gross benefit of case 3 in Table IV.D-1 would be reduced from $19.4 to $14.6 billion.

The data in Table 11.2-23 are not sufficient to allow a similar evaluation of the benefits estimated for the other cases in Table IV D-1. However, the same inconsistency with respect to the HTGR constraints between the base cases and the comparison LMFBR cases persists for all the estimates. The HTGR capacity constraints are applied up to the year 2020 for the non-LMFBR base cases. The constraints apply only through the year 2000 for the LMFBR comparison cases. If the comparison between cases 1 and 3 in Table IV D-1 is representative, the elimination of the HTGR constraints for the period from the year 2000 to the year 2020 could reduce the estimated value of gross benefits of the LMFBR by about 25 percent.

Certainly, the evidence is sufficiently great to request that the HTGR constrained base cases be rerun with a year 2000 constraint instead of a year 2020 constraint. Depending on the unknown differential effects of the HTGR and the LMFBR, the benefits reported for the HTGR constrained cases could be significantly reduced.

Until this confusion with respect to true benefits is cleared up, the results of the benefit-cost analysis must be questioned. The most direct way to resolve the problem would be to run the HTGR constrained cases for a year 2000 constraint and the comparative cases with a year 2020 constraint. In that way complete estimates of the effects of both the 2020 and 2000 constraints could be evaluated.

Failure to Analyze Several of the Sensitivity Cases

EPA requested a sensitivity analysis of the combined effects of two possible values for four of the major inputs to the benefit-cost analysis. The sensitivity analysis required the evaluation of 16 possible cases (2,3,5,6,8,9,11,12,14,15,17,18,20,21,23, and 24) in Table 1. Table IV D-1 in the Appendix omits results for six of the requested cases (cases 3,8,9,15,20, and 21) in Table 1. The results for cases 3,8, and 9 do appear, however, in graphical form in Figure 11.2-11 of the benefit-cost document. The results for cases 15,20, and 21 were not found anywhere in the report. The circled results presented in the gross benefit column of Table 1 were estimated by interpolation. For the sake of completeness, the document should include analyses of all of the requested 16 cases and the results should all appear in Table IV D-1.

PROBLEMS WITH THE PRESENTATION OF RESULTS OF THE SENSITIVITY ANALYSIS

Summary Results of the Sensitivity Analysis

Table 1 in this document contains 36 cases: 12 base cases and 24 LMFBR cases. The 24 LMFBR cases constitute the sensitivity analyses for 2 values of LMFBR capital costs, 2 assumptions about HTGR's, 2 levels of energy demand, and 3 levels of uranium supply (2x2x2x3 = 24). The 24 cases can be broken down into two 12-case sets according to the presence or absence of a constraint on the introduction of HTGR's. Figures 11.2-10 and 11.2-11 in the PFES purportedly present the results of the sensitivity analysis following this breakdown. Figure 11.2-11 presents the results for the 12 cases with no HTGR constraint. The companion Figure 11.2-10, however, omits three important cases - cases 15,20, and 21 in Table 1 of this document. Inclusion of the results for these three cases would alter the visual impression of Figure 11.2-10. The benefit picture would definitely be less favorable to the LMFBR. Figure 11.2-10 should be modified to include these results for cases 15, 20, and 21 in Table 1.

Interpretation of the Effects of Changing Conditions on the Benefits of the LMFBR

Tables 11.2-23, 11.2-24, and 11.2-25 in the PFES present data to show the independent effects of variation in HTGR constraints, uranium supply, and LMFBR capital costs on the estimated benefits of the LMFBR program. Such a table is not presented for the effects of variation in energy demand. The effect of energy demand is poorly presented in the discussion on pages 11.2-138 through 11.2-142 and in Figure 11.2-38. The tables tend to be confusing in that the data are gross benefit values, and yet the tables' titles refer only to "benefits." Before these benefits can be viewed as net benefits, the $4.9 billion (present worth) cost of the LMFBR program must be subtracted. This feature of the tables should be made clear in ERDA's final environmental statement (FES).

The tables (11.2-23 through 11.2-25) are useful in that they indicate marginal changes. They indicate the size and direction of the effects of variations on the estimated gross benefits of the LMFBR program. Because of their composition, however, they do not provide sufficient information on the range of effects of the various assumptions on the viability of the LMFBR program, i.e., the extent to which variations in the conditions change the estimated value of the benefit-cost ratio of the program. Tables 11.2-23 and 11.2-25, in particular, appear to contain sets of selected cases that display relatively very high levels of gross benefits. An improved way to display the independent effects of variation in each assumed condition would be to present the whole array of the 24 sensitivity cases organized in such a fashion as to elucidate the independent effects better. For example, Table 2 presents the data in a way that emphasizes the partial effects of changes in the

uranium supply given any of the 8 distinct sets of future conditions that are associated with each of the three possible levels of uranium supply.

Table 2 shows the marked effect that the supply of uranium has on LMFBR net benefits - all other conditions being equal. In each of the 8 possible combinations of values for the other three conditions (HTGR constraint, LMFBR capital cost, and level of energy demand), changes in the direction of increased uranium supply tend to cut the perceived net benefits of the LMFBR in half for each incremental change. In view of this volatility of net benefits with respect to uranium supply, it would appear desirable to collect more information on uranium supply before making a total commitment to pursue the net benefits of the LMFBR program.

The last column of Table 2 clarifies an issue which is raised on page 11.3-1 in the PFES conclusions, "The ratio (B/C) falls below one only when two or more large adverse circumstances--each considered unlikely--are assumed to occur in concert." So long as the unconstrained introduction of the HTGR is considered a "large adverse consequence," this statement is true. If the unconstrained HTGR condition is not viewed as unlikely, then the number of adverse conditions for 12 of the cases in Table 2 are reduced by 1 to equal the numbers in parentheses in the last column. Then in two instances the net benefits of the LMFBR program are negative with the occurrence of only one adverse condition--either high LMFBR capital costs or very low demand (cases 3 and 8 in Table 2).

Table 2 points up the significance of the uranium supply assumption with respect to the net benefit estimate. Similar tables could and should be included in ERDA's environmental statement to present more clearly the range of marginal effects of changes in the assumptions about energy demand and LMFBR capital costs.

ADOPTION OF A DECISION RULE FOR DECISION UNDER UNCERTAINTY

There are several combinations of possible future conditions that could result in the benefit-cost analysis yielding negative net benefits (11 of the 24 cases presented in Table 1). The benefit-cost analysis could deal better with implications of these negative benefit cases in terms of the overall assessment of whether the dollar benefits of the LMFBR program exceed the dollar costs.

For example, one way to deal with uncertainty is to assign equal likelihood to a range of many possible futures and then calculate the expected value of gross benefits of the LMFBR program for each possible future. Table 3 presents the results of two such expected value analyses. Expected gross benefits are calculated under two assumptions, first it is assumed that all of the 24 LMFBR cases in

Table 1 are equally likely to occur. Under that assumption, the expected gross benefits of the LMFBR program are $8.4 billion; in the second case, the very low uranium-supply cases have been eliminated. The remaining 16 cases are then considered equally likely to occur. Even under that assumption (adverse to the LMFBR) the expected gross benefits of $5.6 billion exceed the development costs of $4.9 billion.

The expected value, however, is perhaps less appropriate a measure of benefits than some other not so mechanical criterion, such as minimizing the maximum regret. In Table 1, the most adverse conditions with respect to the LMFBR occur in case 12, where HGTR introduction is unconstrained, LMFBR capital costs are very high, energy demand is very low, and the uranium supply is optimal. In that case, the projected net benefit of the LMFBR is -$4 billion; i.e., the nation would end up losing some $4 billion if the LMFBR program were adopted. On the other hand, case 31 in Table 1 contains the conditions most favorable to the LMFBR. In that case the projected net benefits of the program are $26 billion, i.e., the net cost of not developing the LMFBR could be $26 billion. Thus, the maximum regret for developing the LMFBR could be $4 billion; the maximum regret for not developing could be $31 billion. Clearly, maximum regret would be minimized by going ahead with the LMFBR program.

Ultimately, the acceptance or rejection of LMFBR program must be based upon a scheme for dealing with uncertainty that surpasses the discussion in the existing benefit-cost analysis. The method of dealing with uncertainty should be made explicit in the final benefit-cost analysis.

PROBLEMS WITH THE BASE CASE ENERGY DEMAND PROJECTION

Consideration of Project Independence Total Energy Demand Projection

1. Likelihood the Base Projections are High

As part of the Project Independence Report, FEA prepared base case projections for total energy demand as a function of the price of oil over the short-term period from 1972 to 1985. With the price of imported oil at $7 per barrel total energy demand was projected to grow at 3.2 per cent per year. With a price of $11 per barrel total energy demand was projected to grow at 2.7 per cent per year.

Project Independence also projected a long term "Base Case" total demand for energy. According to that projection, total

energy consumption should grow at a rate of about 2.5 per cent per year from 1985 through the year 2020.

Total energy demand for the year 1970 was 67 Btu x 10^{15} according to Table 11.2-7 of the PFES. Similarly, the PFES base 1 case forecast of total energy demand is 359 Btu x 10^{15}. The base case Project Independence projections can be compared to the PFES base case projection by applying the Project Independence growth rates to the 1970 demand as follows:

$$(1) \quad E = 67 \exp(15r) \exp(35 \times .025)$$

where r is the appropriate rate of growth of total energy demand.

The PFES projection for electric energy demand assumed that 65 per cent of the total energy demand in the year 2020 would be met by electric power generation. Applying the same assumption to the Project Independence derived numbers, one gets the following set of projections.

Base Cases	Total Energy Demand, Year 2020	Electrical Energy Demand 2020
$ 7 per barrel oil	260 BTU x 10^{15}	20.3 Kwhr x 10^{15}
$11 per barrel oil	240	18.8
PFES	359	28

These figures indicate that if the base case Project Independence projections are correct, electric energy demand for the year 2020 will be 33 per cent or 28 per cent less than that projected by the PFES base case, depending upon whether the price of an imported barrel of oil is $11 or $7, respectively.

Apparent Inconsistence of Population and Total Energy Demand Projections

The PFES provides its base national energy forecast in Table 11.2-7 on page 11.2-53. According to the text, the "projections of total energy consumption and energy inputs to the electrical sector were made on the basis of their historical relationship to the real Gross National Product (GNP)." The apparent basis for the GNP estimates was the E series population projection of the Bureau of the Census.

Examination of the historical population, GNP, and total energy demand data, however, suggests that the PFES total energy demand and GNP projections may not be consistent with the population projection

at least in terms of past experience:

	1950	1972	Actual Growth Rate 1950-1972	PFES Forecast Growth Rate 1970 - 2020
U.S. Population	151.32 million	208.84 million	1.45%	0.81%
Total Energy Demand	-	-	3.4*	3.4
GNP (1958 dollars)	$355 billion	$789 billion	3.6	3.6

*Rate cited on page 11.2-54 of PFES.

During the period from 1950 to 1972 the U.S. Population grew at an annual average rate of 1.45 per cent per year. During that time, total energy demand and GNP grew at rates of 3.4 and 3.6 per cent, respectively. If there is some relationship between population growth and growth in these other two measures, it seems anomalous to retain such historical high rates of growth in energy demand and GNP while projecting such a reduced rate of growth in population, as has been done for the PFES base case forecast.

The projected rate of growth of population over the period from 1970-2020 is only 56 per cent of the population growth rate over the period from 1950 to 1972. It would be extreme to argue that a comparable reduction in the rate of growth of total energy demand would also occur. An annual growth rate in total energy demand of 2.5 per cent (as projected by Project Independence for the period 1985-2020) would be equal to 74 per cent of the earlier period's 3.4 per cent growth rate. Such a reduced rate would appear more consistent with the projected reduced rate of population growth.

Implication of Project Independence Projections for the Optimal Timing of the LMFBR Introduction Date

On page 80 of EPA's comments on the DES it was suggested that the question of optimal timing for the introduction of the LMFBR ought to be discussed in the PFES. Unfortunately, the PFES analyzes the effects of timing for too few alternatives to make a reasonable evaluation. Table IV D-1 contains information on timing for cases in which at most one adverse assumption is made with respect to the overall base case. Very importantly, the effect of timing given the (-50%) demand projection is not presented under any conditions.

The essential justification for the LMFBR is that it will allow nuclear power to expand with lower costs for fuel. The breeders will decelerate the rate of consumption of lower and lower grade uranium resources at higher and higher prices. On the other hand, development of LMFBR is going to be a costly program. The optimal time for introduction of the LMFBR would, therefore, appear to depend upon a trade off between discounted costs of development and the discounted opportunity cost of having to pay higher prices for nuclear fuel than would be necessary were the breeder available. The speed at which higher prices for uranium will develop is a function of the availability of uranium resources and the rate at which demand for energy grows. It seems logical that either some level of depressed demand or some level of expanded uranium supply or some combination of lowered demand and increased uranium supply would cause the optimal timing for LMFBR introduction to be postponed beyond the 1987 date proposed by the PFES.

The Project Independence projections for total enrgy demand in the year 2020 are 28% and 33% lower than the PFES energy demand projection for the base case. It would be valuable to know if either of these projected demands would alter the optimal timing for LMFBR introduction. Cases 15 and 16 in Table IV D-1 of the PFES indicate that a (-20%) demand would not delay the optimal timing of LMFBR introduction. However, according to Table IV D-1, the discounted total cost of meeting energy demand under the base projection without the LMFBR is $210.8 billion while the discounted total cost for a (-20%) demand would be $188.4 billion. A 20 per cent lower demand in the year 2020 results in a 10.6 per cent reduction in the discounted total costs; but the cost savings of the LMFBR are still great enough to preclude delay of its introduction without opportunity losses in the (-20%) demand case.

The relative values of the figures in Table IV. D-1, however, make one wonder whether the analytical benefit-cost model is constructed in such a way as to accurately assess the effects of timing of the LMFBR introduction date. Under the base demand projections, delay of the introduction date from 1987 to 1991 results in a reduction of gross benefits of $3.0 billion (difference between case 3 and 4 gross benefits). In the (-20%) demand case, the reduction in gross benefits from the same delay is $2.9 billion (cases 15 and 16). In the (+20%) demand case, the reduction is $3.8 billion. The cost of delay in the (-20%) demand case is only 3.3% less than the cost of delay in the base case, whereas the cost of delay in the (+20%) case is 26.7% greater than the cost of delay in the base case. Admittedly, the increasing cost of uranium might make the increased cost of delay in the (+20%) case proportionally greater than the decreased cost of delay in the (-20%) case but the difference between 3.3% and 26.7% appears unexpectedly large.

This anomaly plus the absence of analysis of the effects of timing on gross benefits with the (-50%) demand indicate that the basic model may not deal effectively with variation in timing assumptions. The final impact statement should provide an improved treatment of the timing question with respect to introduction of the LMFBR under the full range of conditions represented by the 16 sensitivity analysis cases, for delays in timing of 5, 10, and 15 years. If the basic model is deficient in dealing adequately with timing, the problem should surface in carrying out the analyses and appropriate adjustments can, if needed, be made in the model.

A Simplistic Approach toward Assessing the Effect of Reduced Demand on the Optimal Timing of LMFBR Introduction

If one ignores the complex linear programming benefit-cost model, it is possible to construct a simple model that provides at least an intuitive notion of the potential effects of reduced demand on optimal timing of LMFBR introduction. The main benefits of the LMFBR derive from its uranium conservation. For example, a full $16.6 of the estimated $19.4 billion of discounted gross benefits of the breeder consist of cost savings on uranium (PFES, Page 11.2-6). The savings represent the avoidance of having to use lower grade and higher cost uranium resources.

According to Figure 11.2-7 on page 11.2-30, it appears that the LMFBR does not begin to have a significant impact on system power costs until the year 2000 even with introduction around the year 1987. Further, it appears that 1987 is the earliest possible time at which the LMFBR could be introduced. Assuming the PFES base case growth in electrical energy demand is realized, the most benefits that can accrue to the LMFBR occur with the 1987 introduction. With such a scenario, most of the nuclear power generated over the period from 1970 to the year 2000 will use enriched natural uranium fuels.

One way to assess, in a simplistic manner, the implications of reduced energy demand on optimal timing of the LMFBR introduction date is to concentrate on the uranium supply picture. The base demand and 1987 introduction date imply the consumption of some fixed quantity of natural uranium - most of which will be consumed during the period from 1970-2000. The 1987 date appears feasible in terms of the cost of uranium supply given base demand. Similarly, then, some introduction date later than 1987 would be feasible in terms of the costs of uranium supply given a reduced growth in energy demand. In particular, the delayed introduction date that requires a cumulative cost of natural uranium at the year 13 years beyond that introduction date which is equal in present value to the cost of natural uranium up to the year 2000 given a 1987 introduction date and base demand, should be feasible.

According to Table 11.2-7, the gross energy inputs to electric utilities will grow from 17 Btu x 10^{15} to 97 Btu x 10^{15} over the period from 1970 to the year 2000. This represents an annual average growth rate of 5.7 per cent per year. If one takes the Project Independence growth rates for total energy demand for $7 and and $11 per imported barrel of oil, calculates the projected total energy demand for the year 2000 and converts these total energy demands to gross energy inputs to electric utilities using the same ratio as that for the base case shown in Table 11.2-7, one obtains comparable growth rates over the same period (1970-2000) of 5.2 and 4.7 per cent per year.

Using these growth rates it is possible to calculate the gross energy inputs to electric utilities in terms of Btu x 10^{15} for each year over the period from 1970 to 2000 for each of the assumed growth conditions using the following formula,

$$EEt = 17 \exp (rt)$$

where r is either 0.057, 0.052, or 0.047, depending on whether the PFES base, or the Project Independence $7, or $11 barrel growth conditions are assumed, respectively.

If one assumes that the amount of expenditures for uranium increases proportionally to the increases in electrical utility energy demand, then cumulative demand for energy can be used as a gross surrogate measure for the cumulative expenditure for uranium. Given these assumptions, it is possible to find the years at which the present value of the cumulative demand for electrical energy under the Project Independence growth rates is equal to the present value of the cumulative demand for that energy in the base case over the period from 1970 to 2000. The year 2000 is associated with the 1987 LMFBR introduction date. Therefore, the number of years beyond 2000 that it takes to reach an equivalent discounted cumulative consumption can, given the assumptions, be assumed to be the number of years that introduction could be delayed without suffering an increased penalty owing to uranium shortage.

Using a discount rate of 10 percent, the present value of cumulative gross energy inputs to electric utilities over the period from 1970 - 2000 under the PFES base case is:

$$C_B = \int_0^{30} 17 \exp(0.057t) \times \exp(-0.10t)\, dt$$

$$C_B = 286.5$$

Given a 5.2 per cent per year estimated growth rate for the $7 per barrel Project Independence projection, an equivalent present value of cumulative electric utility energy consumption would be reached by Y, where Y can be calculated as follows:

$$\int_0^Y = 17 \exp (0.052t) \exp (-0.10t)dt = 286.5$$

$$Y = 34 \text{ years}$$

Similarly, the year Z at which the same cumulative demand would be realized with the $11 per barrel projection is equal to:

$$\int_0^Z 17 \exp(0.047t) \exp(-0.10t)dt = 280.6$$

$$Z = 42$$

Thus we see that with the rates of growth projected by Project Independence, introduction of the breeder might be delayed as much as 4 to 12 years without increasing the present value of expenditures for uranium above those projected for the base case by the PFES.

Given the extremely simplistic and unrefined nature of this exercise, the conclusions must naturally be suspect. Nevertheless, they do reinforce intuition and do indicate that early introduction of the LMFBR may not be so critical as supposed.

Estimated Costs of 9-11 Years Delay Owing to Lower Demand

According to the data in Table IV D.1, the present value of the gross benefits of the LMFBR program under base demand and a 1987 introduction date is $19.4 billion. Delay of the introduction date to the year 1991 reduces this value to $16.4 billion. Four years delay results in a benefit reduction of $3 billion or 15.5%. This averages out to a 3.8% reduction in gross benefits per year of delay.

Similarly, Table IV.D-1 indicates that if the year 2020 demand is 20 per cent less than the base case, then the present value of gross benefits of the program is reduced to $14.2 billion. This 26.8 per cent reduction in benefits averages out to be a 1.3 per cent reduction for every 1 per cent drop in the level of projected demand for the year 2020.

If one calculates the year 2020 demands for the $7 and $11 per barrel Project Independence estimates, they end up being 27.6 and 33.1 per cent lower than the PFES base case projection. With an estimated drop in gross benefits of 1.3 per cent for each percentage drop in demand, the present value of gross benefits for the $7 projection should be 35.9 per cent lower than for the base case and for the $11 case they should be 43.0 per cent lower.

The $7 per barrel projection has the same effect on gross benefits as a 9 year delay in the introduction date; and the $11 projection has the same effect as an 11.5 year delay. One can conclude, therefore, that the risk of a 9-12 year delay in order to insure environmental concerns would be no greater in terms of potential costs than the risk that presently exists that projected benefits will be significantly smaller than for the base case owing to lowered future demand as predicted by Project Independence.

Effect of R & D Costs on the LMFBR Timing Issue

A graduate student at Harvard University has prepared a draft paper describing his ongoing investigation of the LMFBR timing issue.[3] Using a model very similar to that used for analysis in the PFES, Richels attempts to isolate the effects of the timing of LMFBR commercialization on the projected benefits of the program. Unlike the PFES assumption, however, he assumes that research and development costs do not increase as a result of stretch out or delay in the program. Richels finds that if undiscounted R & D costs are independent of LMFBR introduction date, i.e., that the present value of R & D costs declines as the introduction date is pushed back, then the optimal timing for introduction of the LMFBR could be as late as the year 2000 depending upon future conditions. For example, with a 10% discount rate, a high uranium cost curve, a high demand projection, and a $100/kw capital cost differential between LWR's and the LMFBR, the optimal introduction date for the LMFBR is the year 2000.[4]

Richels recognizes that his assumption about the R & D costs is critical to his results. If the AEC's assumption that the discounted R & D cost curve slopes upward as the introduction date is deferred beyond 1987, then he admits that the contention that the LMFBR should be introduced as soon as possible would be correct for most of the future conditions postulated in the PFES.

The AEC assumption about increased R & D costs derives from the notion that the longer a project takes, the longer the program has to keep teams and facilities geared up, and the more it is going to cost. Richels counters that assumption by other experience which shows that it is frequently possible to hold down overhead and other fixed costs by designing the R & D program to run more in terms of sequential than concurrent phasing. He even suggests that, with effective planning, an extension in project completion time can lead to a reduction in undiscounted R & D costs and that if this were the case for the LMFBR, the optimal commercialization date might come even later than the year 2000 in his example case.

The fact of the matter is that a delay in the introduction date of the LMFBR is by no means certain to result in a reduction of the net benefits of the program. Depending upon future demand conditions and the effect of "stretchout" or delay in the R & D program costs, the postponement of introduction could have positive as well as negative impacts on the overall benefit of the program.

REFERENCES

1. Federal Energy Administration, Project Independence Report (Washington, D.C.: U.S. Government Printing Office, November, 1974), p. 26.

2. Ibid., p. 430.

3. Richels, Richard, "The LMFBR Timing Issue," Draft paper, John F. Kennedy School of Government, Harvard University, March 3, 1975.

4. Ibid., p. 12.

Table 1

Sensitivity Cases

Case No.		EIS Case No.	LMFBR	HTGR Constraint	No. of Base Case for Comparison	LMFBR Cap. Cost	Energy Demand	Uranium Supply	Energy Cost	[illegible] Benefit
1	Base Case	30	No	None		-	Base	Base	202.3	-
2		47B	Yes	None	1	Base	Base	Base	190.1	12.2
3		○[1]	Yes	None	1	+100	Base	Base		④[2]
4	Base Case	45	No	None		-	Base	Optimum	197.1	-
5		46	Yes	None	4	Base	Base	Optimum	189.3	7.8
6		54	Yes	None	4	+100	Base	Optimum	195.2	1.9
7	Base Case	○[1]	No	None		-	-50%	Base		-
8		○[1]	Yes	None	7	Base	-50%	Base		⑥[2]
9		○[1]	Yes	None	7	+100	-50%	Base		①
10	Base Case	49	No	None		-	-50%	Optimum	146.8	-
11		50	Yes	None	10	Base	-50%	Optimum	143.8	3.0
12		57	Yes	None	10	+100	-50%	Optimum	145.9	0.9
13	Base Case	1	No	2020		-	Base	Base	210.8	-
14		3	Yes	2000	13	Base	Base	Base	191.4	19.4
15		○[1]	Yes	2000	13	+100	Base	Base		⑤[2]
16	Base Case	5	No	2020		-	Base	Optimum	201.4	-
17		7	Yes	2000	16	Base	Base	Optimum	189.4	12.0
18		55	Yes	2000	16	+100	Base	Optimum	196.6	4.8
19	Base Case	○[1]	No	2020		-	-50%	Base		-
20		○[1]	Yes	?	19	Base	-50%	Base		⑨[2]
21		○[1]	Yes	?	19	+100	-50%	Base		②[2]
22	Base Case	48	No	2020		-	-50%	Optimum	148.1	-
23		52	Yes	2000	22	Base	-50%	Optimum	144.2	3.9
24		58	Yes	2000	22	+100	-50%	Optimum	147.7	0.4
25	Base Case	59	No	None		-	Base	Pessimistic	211.6	-
26		61	Yes	None	25	Base	Base	Pessimistic	192.1	19.5
27		68	Yes	None	25	+100	Base	Pessimistic	200.6	11.0
28	Base Case	63	No	None		-	-50%	Pessimistic	152.8	-
29		65	Yes	None	28	Base	-50%	Pessimistic	145.9	6.9
30		71	Yes	None	28	+100	-50%	Pessimistic	149.4	3.4
31	Base Case	9	No	2020		-	Base	Pessimistic	225.3	
32		11	Yes	2000	31	Base	Base	Pessimistic	194.7	30.6
33		69	Yes	2000	31	+100	Base	Pessimistic	201.5	23.8
34	Base Case	62	No	2020		-	-50%	Pessimistic	157.3	-
35		66	Yes	2000	34	Base	-50%	Pessimistic	146.9	10.4
36		72	Yes	2000	34	+100	-50%	Pessimistic	150.6	6.7

1. Results for these cases do not appear in Table IV. D-1.

2. Values for cases 3,8, and 9 appear in Figure 11.2-11 on page 11.2-19. Values for Cases 15,20, and 21 have been estimated by interpolation.

Table 2

Effect of Variation in Uranium Supply
on LMFBR Net Benefits

Case No.	EIS Case No.	LMFBR	HTGR Constraint	LMFBR Cap. Cost	Energy Demand	Uranium Supply	Net Ben. $ Billion	[3]No. of Adverse Assumptions In Effect	
26	61	Yes	None	Base	Base	Pess.	15	1	
2	47B	Yes	None	Base	Base	Base	7	1	(0)
5	46	Yes	None	Base	Base	Opt.	3	2	(1)
27	68	Yes	None	+100	Base	Pess.	6	2	(1)
3	○[1]	Yes	None	+100	Base	Base	⊖1 [2]	2	(1)
6	54	Yes	None	+100	Base	Opt.	-3	3	(2)
29	65	Yes	None	Base	-50%	Pess.	2	2	(1)
8	○[1]	Yes	None	Base	-50%	Base	⊖1 [2]	2	(1)
11	50	Yes	None	Base	-50%	Opt.	-2	3	(2)
30	71	Yes	None	+100	-50%	Pess.	-2	3	(2)
9	○[1]	Yes	None	+100	-50%	Base	⊖	3	(2)
12	57	Yes	None	+100	-50%	Opt.	-4	4	(3)
32	11	Yes	2000	Base	Base	Pess.	25	0	
14	3	Yes	2000	Base	Base	Base	14	0	
17	7	Yes	2000	Base	Base	Opt.	7	1	
33	69	Yes	2000	+100	Base	Pess.	19	1	
15	○[1]	Yes	2000	+100	Base	Base	⊖1 [2]	1	
18	55	Yes	2000	+100	Base	Opt.	0	2	
35	66	Yes	2000	Base	-50%	Pess.	5	1	
20	○[1]	Yes	2000	Base	-50%	Base	⊖1 [2]	1	
23	52	Yes	2000	Base	-50%	Opt.	-1	2	
36	72	Yes	2000	+100	-50%	Pess.	2	2	
21	○[1]	Yes	2000	+100	-50%	Base	⊖3 [2]	2	
24	58	Yes	2000	+100	-50%	Opt.	⊖4 [2]	3	

1. See Footnote 1, Table 1
2. See Footnote 2, Table 1
3. Adverse Assumptions are those assumptions which reduce the estimated benefits of the LMFBR.

Table 3

Illustrative Expected Value Analyses

Case No.	Gross Benefit	Equal Likelihood Probability	Expected Gross Benefit	Equal Likelihood Prob. Excluding Pess. $U30_8$	Expected Gross Benefit
2	12.2	.0416	.510	.0625	.762
3	4	.0416	.167	.0625	.250
5	7.8	.0416	.325	.0625	.488
6	1.9	.0416	.079	.0625	.119
8	4	.0416	.167	.0625	.250
9	1	.0416	.042	.0625	.062
11	3.0	.0416	.125	.0625	.188
12	0.9	.0416	.037	.0625	.056
14	19.4	.0416	.810	.0625	1.210
15	6	.0416	.250	.0625	.375
17	12.0	.0416	.500	.0625	.750
18	4.8	.0416	.200	.0625	.300
20	6	.0416	.250	.0625	.375
21	2	.0416	.083	.0625	.125
23	3.9	.0416	.163	.0625	.244
24	0.4	.0416	.017	.0625	.025
26	19.5	.0416	.810		5.579
27	11.0	.0416	.460		
29	6.9	.0416	.288		
30	3.4	.0416	.142		
32	30.6	.0416	1.270		
33	23.8	.0416	.990		
35	10.4	.0416	.416		
36	6.7	.0416	.280		
			8.381		

SAFETY

Introduction

In its review of the draft environmental statement for the LMFBR program (DES), EPA commented on several safety related issues. The principal thrust of these comments was that the discussion of LMFBR safety (1) suffered from a lack of quantitative information and (2) did not fully address the unresolved safety questions associated with critical design aspects of the reactor, which relate directly to potential environmental consequences. As a result, we were unable to conclude that the environmental impact of the LMFBR program would be minimal, nor could we determine the approaches that would be taken to ensure satisfactory resolution of important safety questions. We recognize that the programmatic nature of the environmental statement results in possible difficulty or even inability to provide technical details to estimate environmental risks at this time when substantial research and development efforts remain to be accomplished.

Based on our review of the PFES, it is apparent that the AEC expended considerable effort in attempting to address the safety related issues previously raised. We commend their efforts, recognizing that development of much of the detailed information was impossible at this stage of the program. Even though the additional quantitative information significantly improves the description of the design criteria, the AEC design philosophy, and the general intended approaches to ensuring safety, there is still a lack of definitive information that would provide the reader with the status of the principal unresolved safety problems, their current degree of resolution, and the on-going or required research and development needed to achieve the safety objectives.

Our comments on the DES in this regard may have been misinterpreted; however, they were intended to reflect NEPA requirements which were emphasized in the court decision on the LMFBR program DES, i.e., the DES should "...indicate the extent to which environmental effects are essentially unknown." The AEC, in the PFES, has detailed the general requirements for the design and has provided commitments for future designs but there appeared to be limited discussion of the degree of resolution of the safety aspects as a basis for predicting potential environmental effects. Specific examples of this deficiency will be presented subsequently. While we concur with the general commitments and the general approach to ensuring safety as indicated in the PFES, the specific safety problems, their expected solutions and the projected environmental impacts must eventually be publicly detailed and reviewed. We accept the AEC position that at this time the programmatic nature of the PFES made such detailed environmental risk analyses impossible now. However, we believe that some of this information with regard to the status of problem solution can be provided in the FES.

Following our comments on the draft statement, EPA staff were invited to numerous LMFBR safety-related briefings and program review meetings. This participation has been appreciated and has resulted in providing our staff with an improved awareness of the status of the LMFBR program activities. Based on this participation, it is believed that some of the LMFBR safety issues may be much further toward resolution than is reflected in the PFES. In fact it appears that many of the deficiencies of the PFES are a result of incomplete documentation rather than lack of a solution. Specifically, the PFES frequently cites fast reactor follow-on studies as sources of related information. Yet on page 4.2-12 the PFES states, "It must be recognized that those studies were limited in scope and that much of the detailed information to conduct a precise environmental analysis of a commercial LMFBR power plant was not developed." We believe that in view of the experimental and analytical work which has been performed since the completion of the follow-on studies, their content may now largely be outdated.

In summary we conclude that: (1) the PFES does not include design details and, therefore, no quantitative evaluation of the environmental impact of the LMFBR can be made at this time and (2) there are unresolved technical safety problems which are being investigated and for which solutions are believed to exist, at least in part, but are not known with confidence. These conclusions are the focal points of most of our comments on the DES and to the AEC responses in the PFES as indicated in the specific comments which follow.

Specific Comments

1. The PFES (page 4.2-235) provides a review of a panel discussion of LMFBR safety experts where the reported consensus of the probability of a major LMFBR accident was placed at 10^{-7} per year which was concluded to be an acceptable environmental risk. In fact a great deal more design and performance data and analyses are required before the risks of the LMFBR can be evaluated. Risk acceptability is indeed a complex subject which demands technical, social and legal inputs. To our knowledge such conclusions have not yet been reached for the LWR, much less the LMFBR. We commend the AEC's efforts to evaluate (quantify) the risks of the LMFBR. If possible, the FES should provide more amplification on this program effort including the presently limiting factors (information, technical detail, developmental work, etc.) and the anticipated time frame for the completion of the analyses. We believe that this type of effort is paramount to acceptance of a commercial LMFBR.

2. Uncertainties in various important safety related design parameters should be quantified where possible in such a manner to be more comprehensible. (The risk assessment may do this.) For example, there could be substantial uncertainties in the possible structural integrity of the primary coolant system related to a hypothetical core disruptive accident (HCDA). As indicated on page 4.2-163 concerning the

PFES, "At the upper end of the spectrum one could qualitatively argue that the event was so large that the basic structural integrity of the primary system was lost. In this case, massive sodium and fuel expulsion could take place with consequences correspondingly more severe." Unless uncertainties such as these are eliminated or greatly reduced, there will remain, at least in the public's view, a serious concern about the possibility of an environmental disaster due to a major reactor accident. Therefore, wherever such uncertainties can be resolved or addressed, the FES should do so to the extent possible at this time.

3. Two of our original comments in the draft statement dealt with the relative safety of the LMFBR and the LWR. The response to one (which has resulted in the expansion of paragraph 4.2.7.3) is on page VII.53-152 and the response to the other is on page VII.53-154. The main thrust of both of these comments was for a quantifiable comparison of the risks in such a way as to be able to conclude whether the LMFBR is more safe or less safe than the LWR, through the spectrum of the risks from the various conceivable accidents. Paragraph 4.2.7.4 of the PFES does indeed include a comparative table of the features of the LMFBR and the LWR as they pertain to safety. However, quoting from the AEC response on page VII.53-154 "...in view of the lack of design detail, however, it is not possible to quantify comparative characteristics of LMFBR's and LWR's. It is our objective that LMFBR risks be comparable to those of LWR's. Unfortunately, the accomplished attainment of this objective cannot be proved at this time (though it can be attained). Risk studies for LMFBR's will be performed in the future, becoming more specific and more meaningful as design features are set, so that valid comparisons can be made, not only to LWR risks, but to a wide variety of other risks." It is commendable that the AEC has endeavored to bring the LMFBR risks to a scale comparable to those of the LWR, which we accept as a commitment for future designs. On page VII.53-152, the AEC stated that: "One key comparison is the measure of the ability of the LMFBR to measure up against Regulatory requirements for safety." As indicated in the PFES, the initial approach to ensuring a minimum level of LMFBR safety will be through the use of (1) traditional regulatory safety approaches; (2) existing regulatory (NRC) safety requirements and design guides; and (3) existing "interim" CRBR NRC design requirements. While this approach suffices for the short term, if a breeder based energy economy is to be developed, we believe LMFBR specific design, safety and siting criteria must be developed in a timely fashion.

4. One of the most important considerations regarding LMFBR safety is, of course, the HCDA. The central issue is the amount of energy that is possible to be released in the form of mechanical work in case of a large core disruptive accident. The fundamental safety requirements to be met for such an accident are: (1) it will be contained and the risk of leakage of radioactive debris is acceptably small and (2) recriticality will be avoided. The AEC response on the HCDA (pages VII.53-156-157) indicates that there will be no direct environmental consequences from

such incidents, which is supported by encouraging results from recent research and development. However, we find that the energy conversion efficiency is not well defined. TREAT experimental results that indicate a 0.2% energy conversion efficiency need further justification. If 10% conversion efficiency is accepted for analysis (page 4.2-147-153), then vessel integrity may not be achievable. This point needs further elaboration. Section 4.2.7.8 has been expanded considerably to include discussion of the HCDA. However, the PFES is deficient in its discussion of pin structural integrity and fuel motion under conditions of or during progression of HCDA's, post accident heat removal, code validation used for predicting core behavior, and on consequences of core voids on neutron streaming.

Because of the great importance of the HCDA and because some experts seem to have reservations on the ability to accurately predict the behavior of the pressure vessel under conditions of such a core accident, ERDA should continue to make every effort to inform the public and other Federal agencies of the state of the current research and development programs dealing with HCDAs as was presented on pages 4.2-147-149 i.e., "This mode of recriticality appears at least conceptually possible in large reactors; planning has begun to evaluate effects of this mode of recriticality ...it is true that significant uncertainties exist in the analyses of recriticality situations. In large measure, these uncertainties stem from the as yet incomplete research and development program...."

5. One of EPA's comments on the DES dealt with the safety implications of irradiation creep and irradiation swelling of stainless steel used for fuel pin cladding and in the reactor internals. It was recognized in the AEC's response in the PFES (page VII.53-157) that the DES did not "...clearly identify the swelling phenomena as a technical area of considerable interest." The response further stated that the PFES "...includes specific evaluations of swelling and also includes by reference studies of the safety implications of systems with and without swelling (see for example BAW-1365; cited as Reference 111)."

Because of the importance of this subject to safety we believe that the treatment of irradiation creep and irradiation swelling could be expanded, since we were unable to locate the "specific evaluation" as indicated in the response. The information in the PFES does not include any quantifiable information which would indicate the status of the problem of fuel cladding creep and swelling on core performance and safety as related to potential environmental impacts. Likewise, the information in the PFES does not adequately discuss the safety and economic implications of prospective solutions, such as core clamping, frequent replacement of control rods, etc.

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RADIOACTIVE WASTE DISPOSAL

Interim Storage and Ultimate Disposal

On April 10, 1975, the Energy Research and Development Administration (ERDA) announced that they were withdrawing their plans to develop a Retrievable Surface Storage Facility for high-level radioactive wastes. ERDA now plans to emphasize the direct development of ultimate waste disposal facilities. We concur with the emphasis on the development of permanent disposal techniques, as we indicated in our comments on commercial high-level waste management (WASH-1539).

Validation of Commercial Burial Grounds

In the PFES and in the AEC's response to our comments, the AEC stated that "...to date, there have been no reports of migration of radioactive material from commerical burial sites." This is in error, since radioactivity has been reported to have migrated off-site from burial facilities in Kentucky and New York State. The reported results of an extensive, six-month investigation by the Kentucky Department for Human Resources (KDHR)[5] clearly indicate that the radioactive waste disposal site at Maxey Flats is contributing radioactivity to the environment.

It was concluded by KDHR that the concentrations of radioactivity detected in the off-site environment do not yet constitute a public health hazard; however, the evidence of off-site movement clearly shows that there is a need to intensify current monitoring activities to determine the possible extent and amount of radioactivity which is moving from the site and to assess its long-term significance.

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[5] Project Report, Six Month Study of Radiation Concentrations and Transport Mechanisms at the Maxey Flats Area in Fleming County, Kentucky, KDHR Bureau for Health Services, December, 1974.

Additional environmental studies supported by EPA, in cooperation with KDHR, support the KDHR findings, and studies of the site hydrogeology by the U.S. Geological Survey (USGS) have identified pathways and mechanisms for this off-site movement of radioactive materials. In December 1974, the KDHR made public a report[5] of their work and a number of local, state, and national news articles about the KDHR report and the migration of radioactivity at Maxey Flats were published in December 1974, and January 1975.

Recent reported findings by the New York State Department of Environmental Conservation have also shown radioactivity levels in surface waters from the Nuclear Fuel Services burial site near West Valley, New York. This site was recently closed by the operator because of this condition.

Additional Investigations Needed

The EPA is conducting preliminary field investigations at two waste burial facilities in cooperation with the state agencies and the USGS. It has also reviewed available reports on investigations which have been conducted at the other four waste burial facilities. On the basis of this information, we must disagree with the AEC's statement (p.4.6-46) that sufficient analyses have been performed at the burial facilities which demonstrates that "...buried radioactive waste will not migrate from the site." To the contrary, radiochemical analyses from samples collected at the New York and Kentucky burial sites indicate that radioactive wastes have moved from the burial trenches at both sites and, as noted earlier, have moved off-site in Kentucky after only ten to twelve years of burial operations. These two sites were initially licensed under the assumption that they would have the ability to contain the wastes buried therein for hundreds and even thousands of years. Since they are not performing as predicted, we believe that additional investigations are required to determine the ability of of all of the present sites to comply with the criterion of no off-site migration.

In the six-months investigation conducted by the KDHR, plutonium was detected in the soil and in monitoring wells in Kentucky. The exact mechanism by which it moved from the trenches has not been determined yet but the important fact is that it has migrated from the trenches in which it was buried, less than twelve years ago. It may be that additional investigations in this area are urgently needed. We believe this is particularly important for any nuclear fuel cycle, such as the LMFBR, which will generate large quantities of plutonium.

Classification of Wastes

We appreciate the AEC's efforts in clarifying and reorganizing the classification of radioactive wastes within Section 4.6 of the PFES. However, the AEC apparently did not understand our basic concern about their proposed system of classification. The category other-than-high-level (OTHL) wastes and its sub-categories still do not give sufficient information on the activity, content, and hazard potential of the waste. The classification only indicates (1) that a waste is not high-level waste, (2) whether or not it contains a certain level of alpha contamination, and (3) whether it comes from a certain functional area of the fuel cycle.

A more detailed, explicit classification system is needed to enable reviewers to evaluate the potential environmental impact from the OTHL wastes. Such a system would also be of great assistance to EPA as well as others, such as burial site operators and the state agencies which regulate them. We realize that developing a radioactive waste "classification" system which meets the needs of everyone will be difficult and not necessarily a part of an LMFBR development program. However, we believe that this is an important effort since as shown in a recent EPA report [6] on land burial activities, the problem is expected to grow in the future.

Other Comments

In Section 4.6.2.1, the PFES states that, "Radioactive materials in the coolant will consist of fission products and neutron-activated structural materials that are released to the coolant by corrosion processes." This statement does not consider the potential for transuranic radionuclides leaking into the coolant from the $Pu-UO_2$ fuel elements, or the possible disposal difficulties which may arise if the OTHL waste, expected to be disposed of at land burial sites, is found to contain transuranics in concentrations which prohibit its disposal in that manner.

In Section 4.6.3, the PFES states that "The technology and facilities established for management and disposal of radioactive waste from the LWR nuclear power industry will be directly applicable to the management of radioactive waste generated by the LMFBR and its fuel cycle." It has not been adequately demonstrated by the PFES that the technology and facilities established for the processing, management, storage, and/or disposal of waste from the LWR industry will be directly applicable to managing LMFBR fuel cycle waste. It appears that the following areas in waste management may be unique to the LMFBR fuel cycle and may require the application or development of new technologies:

[6] Radiation Data and Reports, Vol. 15, No. 12
EPA Office of Radiation Programs, December 1974

a. transuranic contamination in the LMFBR low-level waste streams;

b. organic solvents in the LMFBR liquid waste cleanup system;

c. radioactive sodium wastes, containing large quantities of radioactive fission products, transuranics, and activation products from neutron activation of sodium structural components, due to the high neutron flux levels in the LMFBR; and

d. increased quantities of transuranic contaminated low-level waste at the LMFBR fuel fabrication and reprocesssing sites.

PLUTONIUM SAFEGUARDS

The PFES has been greatly expanded in the area of safeguards. The general approach to development of the required safeguards program is explicitly stated, as are a number of safeguards requirements and subproblems. In general we believe that these changes, along with other refinements in the treatment of safeguards, show a great improvement over the presentation in the DES. The PFES includes a substantial amount of information on safeguards costs - information that was omitted in the DES. This effort can only be viewed as a first approximation of costs; nevertheless, it provides an explicit, intelligent estimate of the safeguards costs. We recognize that making this evaluation involved considerable effort, which was justified, however, by the importance of this aspect of the program.

Costs for safeguards will be high, involving many millions of dollars in capital and operating costs. However, when reduced to a percentage of corresponding total costs for a large "module" of 80,000 MWe capacity, these costs do not represent an excessively high fraction of the total cost, i.e., less than 1% of fuel cycle capital costs and less than 2% of total operating costs. This is perhaps the best way of looking at these costs. However, it must be recognized that before LMFBR deployment reaches the scale of this module, the corresponding safeguards costs, when expressed as fractions of operating and capital costs, could be considerably higher.

In view of the recent division of the AEC into ERDA and NRC, we strongly recommend that ERDA's FES indicate explicitly which agencies are assigned specific areas of responsiblity and authority for safeguards. The safeguards program is of the utmost importance. Difficulties and possible gaps in the development of the program can be avoided by an explicit assignment of responsibility and authority from the start. Additionally, ERDA's FES also should indicate the organizational structure within each of these agencies where these duties reside.

PLUTONIUM TOXICITY

The PFES recognizes that with respect to plutonium toxicity the answers to some important questions concerning the impact on public health are not available. It is recognized by EPA and the AEC that in many cases there are reasonable differences of opinion on the health implications that might be inferred in the absence of definitive data. While it is agreed that animal toxicity experiments, and not the meager human exposure data, should serve as a guide, the discussion of animal data is not sufficient to allow a judgment to be made on plutonium toxicity in man. The differences of opinion on the significance of animal data extrapolated to man are unresolved.

Although the toxicity of plutonium may be underestimated by an order of magnitude, adjusting the adverse health effects estimates upwards by

an order of magnitude would not significantly change the total health impact of the LMFBR program as estimated by the AEC in the PFES. This is because the projected releases of plutonium are so small. As new data become available during the development of this technology, any significant changes that may occur in the assumed probability and magnitude of plutonium releases into the environment from the LMFBR fuel cycle would require a re-evaluation by the EPA on the health impacts due to the LMFBR program. Health effects have been forecast on the basis of what is essentially a zero release operating philosophy. It remains to be seen whether near zero release is technologically possible and whether all important plutonium releases, such as those due to sabotage, have been properly considered.

TRANSPORTATION SAFETY

The PFES does not provide the bases for the quantification of the risks associated with transportation accidents, which EPA previously requested; rather, risk values were based on assumptions and judgments. To our knowledge, the relationship between packaging test requirements and the survival (or maintenance of integrity) of such packages under various accident conditions has not been established. This consideration applies to transportation of all types of radioactive material.

Although we failed to address this issue in our comments on the DES, we note that AEC suggested that the doses estimated from spent fuel transportation accidents could be compared to the "accident guidelines" set forth in 10 CFR Part 100. The stated purpose of 10 CFR Part 100 was to provide criteria to guide the nuclear industry in evaluating the suitability of proposed sites for LWR's, and the AEC indicated that its use of the values of 25 rem to the whole body and 300 rem to the thyroid is not intended to imply that these values constitute acceptable limits for emergency doses to the public under accident conditions. In our opinion, it would be more appropriate to compare the transportation accident doses to the LD 50/60 dose-response curve.

CONSIDERATION OF NUCLEAR ALTERNATIVES

Alternatives to the LMFBR were presented in Section 6 of the PEIS. These alternatives are, in most cases, treated in an even-handed manner for comparison with the LMFBR. However, this section needs to have included in its summary a side-by-side comparison of the more viable alternatives, perhaps in tabular form. This comparison should emphasize the significant advantages and disadvantages of the alternatives (e.g., apparently the principal disadvantage of the GCFR is its later introduction date).

FWPCA PERMIT CONSIDERATIONS

EPA will be responsible for issuance of discharge permits for the proposed (LMFBR) power plants, under the National Pollutant Discharge Elimination System (NPDES) -- Section 402 of the Federal Water Pollution Control Act of 1972, as amended (FWPCA). Issuance of the permits will be based upon review and analysis of all relevant information supplied by the Applicants. Consideration will be given to requirements of Section 301 and 316(b), and all other provisions of the Act.

Section 301 of the FWPCA stipulates that effluent limits for various point source discharges to navigable waters shall require the application of "Best Practicable Control Technology Economically Achievable" no later than July 1, 1977, and "Best Available Technology Economically Achievable" no later than July 1, 1983. The levels corresponding to these terms were defined in EPA's Steam Electric Power Generating Point Source Category Effluent Guidelines and Standards, Federal Register, of October 8, 1974. Section 316(b) of the FWPCA requires that "...the location, design, construction, and capacity of cooling water intake structures reflect the best technology available to minimize adverse environmental impact."

Section 306 of the Act further modifies effluent limits for new point sources requiring that "...discharge of effluent reduction which the Administrator determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives including, where practicable, a standard permitting no discharge of pollutants." "New source" means any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance under this section which will be applicable to such source, if such standard is thereafter promulgated in accordance with this section. The term "source" means any building, structure, or facility from which there is or may be the discharge of pollutants. An exception to these new point sources is any construction work contracted prior to publication of the new proposed regulations.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Sheldon Meyers, Director
Office of Federal Activities
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Meyers:

Thank you for your letter of April 23, 1975 forwarding Environmental Protection Agency comments on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Staff responses to the EPA comments on the PFES are enclosed.

We appreciate the time taken by EPA staff in their extensive review of both the Draft and Proposed Final Statements. Copies of the Final Environmental Statement are enclosed for your information.

Sincerely,

James L. Liverman

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific EPA Comments
2. Final Environmental Statement, LMFBR Program (10 copies)

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

ERDA Staff Responses to EPA Comments

EPA Comment (page 3):

> "The proposed final environmental statement (PFES) responds satisfactorily to all but two of the detailed EPA criticisms of the benefit-cost analyses presented in the draft environmental statement (DES). One area in which the PFES analysis is deficient is in the presentation of the results of the sensitivity analysis requested by EPA."

ERDA Response:

EPA initially requested a series of 16 cases with the LMFBR available, and 8 cases without the LMFBR, to test "synergistic" effects of combinations of assumptions. Five of these coincided with cases already performed for the Draft Environmental Statement.

The EPA cases requested involved "optimistic" and "base" assumptions of uranium ore reserves. The AEC countered with a proposal that the cases consider "optimistic" and "pessimistic" uranium assumptions, and that values for "base" assumptions be arrived at by interpolation. This procedure was agreed to by the EPA representative reviewing the cost-benefit study. Comparison of the cases requested by EPA and those proposed by AEC are shown in Table I.

Of the 12 EPA-requested cases considering base uranium assumptions, three coincided with cases already run. One additional case (47B) was included in the PFES, and four others were run as "calibration" cases to assist in interpolating; although they were not reported in the PFES, their results were used therein. The four remaining cases involved constrained HTGR and LMFBR capacities, and can be interpolated from "optimistic" and "pessimistic" cases. In summary, all EPA-requested cases were either calculated or obtained through interpolation of calculations that closely bracketed the requested cases. Accordingly, we believe the PFES complied with EPA's request.

EPA Comment (pages 3-4):

> "Most observers would agree that with respect to the base energy demand, capital costs, and HTGR constraints, deviations from the base projections are likely to be in only one direction - definitely downward - given recent population growth and energy demand experience. Such agreement could not be found with respect to the projected uranium supply. AEC correctly supplemented the requested sensitivity analysis with consideration of a pessimistic projection of future uranium supplies. Their pessimistic forecast reflects the belief of many that future uranium supplies will be limited to today's known and potential reserves."

TABLE I

COMPARISON OF ADDITIONAL CASES: EPA AND AEC

U_3O_8 Supply	LMFBR Capital Cost (after 2000)	Electrical Demand	HTGR & LMFBR Constrained?	EPA* Case No.	AEC Case No.
Optimistic	+$100/kw	-50%	No	1	57
Optimistic	+$100/kw	-50%	Yes	2	58
Optimistic	+$100/kw	Base	No	3	54
Optimistic	+$100/kw	Base	Yes	4	55
Optimistic	Base	-50%	No	5	51
Optimistic	Base	-50%	Yes	6	52
Optimistic	Base	Base	No	7	47
Optimistic	Base	Base	Yes	8	7
Optimistic	(none)	-50%	No	(unnumbered)	49
Optimistic	(none)	-50%	Yes	(unnumbered)	48
Optimistic	(none)	Base	No	(unnumbered)	45
Optimistic	(none)	Base	Yes	(unnumbered)	5
Base	+$100/kw	-50%	No	9	(57B)
Base	+$100/kw	-50%	Yes	10	--
Base	+$100/kw	Base	No	11	(54B)
Base	+$100/kw	Base	Yes	12	--
Base	Base	-50%	No	13	(51B)
Base	Base	-50%	Yes	14	--
Base	Base	Base	No	15	(47B)
Base	Base	Base	Yes	16	3
Base	(none)	-50%	No	(unnumbered)	(49B)
Base	(none)	-50%	Yes	(unnumbered)	--
Base	(none)	Base	No	(unnumbered)	30
Base	(none)	Base	Yes	(unnumbered)	1
Pessimistic	+$100/kw	-50%	No	--	71
Pessimistic	+$100/kw	-50%	Yes	--	72
Pessimistic	+$100/kw	Base	No	--	68
Pessimistic	+$100/kw	Base	Yes	--	69
Pessimistic	Base	-50%	No	--	65
Pessimistic	Base	-50%	Yes	--	66
Pessimistic	Base	Base	No	--	61
Pessimistic	Base	Base	Yes	--	11
Pessimistic	(none)	-50%	No	--	63
Pessimistic	(none)	-50%	Yes	--	62
Pessimistic	(none)	Base	No	--	59
Pessimistic	(none)	Base	Yes	--	9

*Cases in parentheses were run for calibration purposes but were not included in PFES tables.

ERDA Response:

Deviations from the base assumptions in energy demand, capital costs, and HTGR constraints are not necessarily likely to be only in the direction which decreases benefits from LMFBR introduction. Deviations in this direction were emphasized in the study since it was felt to be more appropriate to test the LMFBR's ability to produce benefits under combinations of adverse conditions. Some conditions tending to increase benefits from the breeder have a high likelihood of occurring. For example, costs for uranium enrichment used for most cases in the study were taken at $36 per separative work unit (SWU). Actual charges now in effect range upward to $53 per SWU. It is expected that the price for a SWU will be at least $75 when provided by private industry. In cases 73 through 76 of the PFES (Table IVD-1) the current and forecast enrichment charges were included; this single charge increased base discounted benefits by 50 percent. Additional cases corresponding to increased enrichment charges, lower energy demand projections and higher uranium prices have been analyzed and are presented in Section III F of the FES.

EPA Comment (page 4):

> "The second area in which the PFES responds poorly to EPA's comments is in the analysis of the effects of a delay in the introduction date of the LMFBR on the anticipated benefits of the program. ... The PFES would be greatly improved were it to expand its treatment of the question of timing of LMFBR introduction including additional sensitivity analyses using the benefit-cost model."

ERDA Response:

Of the 76 cases present in the PFES cost-benefit analysis, 24 involved the effects of delay in the LMFBR introduction date, and 8 more (cases 37-44) involved restrictions on post-introduction commitment of the LMFBR. Ample information is given in these cases to permit extrapolation to other conditions.

Compliance in full with this request of EPA would require that a large number of additional cases be calculated, with minimal additional gain of information. In comments on the draft environmental statement, EPA requested an expansion of the discussion on effects of delays in the LMFBR introduction date; the cases in the PFES comply with this. However, those comments did not request additional calculations as is now inferred by EPA.

EPA Comment (pages 5-6):

> "... the evidence is sufficiently great to request that the HTGR constrained base cases be rerun with a year 2000 constraint instead of a year 2020 constraint. Depending on the unknown differential effects of the HTGR and the LMFBR, the benefits reported for the HTGR constrained cases could be significantly reduced.
>
> "Until this confusion with respect to true benefits is cleared up, the results of the benefit-cost analysis must be questioned. The most direct way to resolve the problem would be to run the HTGR constrained cases for a year 2000 constraint and the comparative cases with a year 2020 constraint. In that way complete estimates of the effects of both the 2020 and 2000 constraints could be evaluated."

ERDA Response:

In the constraint rationale, constraints for both the HTGR and the LMFBR prior to the year 2000 were applied consistent with the capacity projections of WASH-1139(72). For differing energy projections, the ratios of HTGR and LMFBR capacity to total nuclear capacity were taken to be the same as in the WASH-1139(72) projection. For cases when the LMFBR was assumed not to be available, the additional required capacity was divided proportionately between LWR's and HTGR's.

Beyond the year 2000, constraints were not applied to LMFBR's; the capacity of HTGR's was constrained to not more than 1/3 the capacity of LWR's. As a matter of practicality in the calculations (as is indicated in the footnote of Table 11.2-23 of the PFES), HTGR constraints were "not imposed or needed" in cases with LMFBR's available, since in those cases economic factors limited the introduction of HTGR's. In any case where the LMFBR is economically attractive, it promotes the economic desirability of reactor types (LWR's) which furnish it plutonium fuel during its introductory years. As a corollary, the introduction of HTGR's is depressed. This same effect has been repeatedly observed, not only in these studies but in evaluations of different reactor types using a completely different computer model.

As an illustration of this effect, a variant of Case 3 of the PFES study was calculated in which HTGR constraints remained imposed until 2020. Table II indicates the comparative development of a reactor mix for this case, for the "standard" Case 3 (constraints imposed only until 2000) and for the unconstrained Case 47B. As is seen, the Case 3 variants are identical; even the completely unconstrained case shows only minor differences. Costs of power, also, are identical for the Case 3 variants.

TABLE II

EFFECT OF HTGR CONSTRAINTS ON REACTOR MIX (LMFBR INTRODUCTION 1987)

(Base Energy, Base U_3O_8 Supply)

GW Operating at Beginning of:

		1975	1980	1990	2000	2010	2020
HTGR Constrained to 2020; LMFBR Constrained to 2000 (Case 3 Variant)	LWR	51	147	369	655	635	861
	HTGR	-	2	40	90	98	69
	LMFBR	-	-	13	369	1378	2342
HTGR, LMFBR Constrained to 2000 (Case 3)	LWR	51	147	369	655	635	861
	HTGR	-	2	40	90	98	69
	LMFBR	-	-	13	369	1378	2342
HTGR, LMFBR Unconstrained (Case 47B)	LWR	51	147	330	523	552	842
	HTGR	-	2	80	123	122	85
	LMFBR	-	-	13	469	1435	2346

EPA Comment (page 6):

"EPA requested a sensitivity analysis of the combined effects of two possible values for four of the major inputs to the benefit-cost analysis. The sensitivity analysis required the evaluation of 16 possible cases (2,3,5,6,8,9,11,12,14,15,17, 18,20,21,23, and 24) in Table 1. Table IV D-1 in the Appendix omits results for six of the requested cases (cases 3,8,9,16,20, and 21) in Table 1. The results for cases 3,8, and 9 do appear, however, in graphical form in Figure 11.2-11 of the benefit-cost document. The results for cases 15,20, and 21 were not found anywhere in the report. The circled results presented in the gross benefit column of Table 1 were estimated by interpolation. For the sake of completeness, the document should include analyses of all of the requested 16 cases and the results should all appear in Table IV D-1."

ERDA Response:

As was shown earlier, all EPA-requested cases were actually calculated except three LMFBR cases and one case without the LMFBR. All four of these cases involved "base" uranium assumptions and low energy demand (50% below the base demand in the year 2020). However, the corresponding cases were shown using both "pessimistic" and "optimistic" uranium supply assumptions. As might be expected with the lowered energy demand, results for these cases differed only slightly between the optimistic and pessimistic uranium assumptions. Therefore, the intermediate values for the base assumption may be readily arrived at by interpolation, and the added calculations were not felt to be warranted.

The results for cases 15, 20 and 21 are given in Table 11.2-24. Table IV D-1 presents the results only of calculated cases. We believe it simplifies matters to limit presentation of interpolated cases to the section on results (Section 11.2.4).

EPA Comment (page 7):

"Summary Results of the Sensitivity Analysis

"Table 1 in this document contains 36 cases: .... Figures 11.2-10 and 11.2-11 in the PFES purportedly present the results of the sensitivity analysis .... Figure 11.2-11 presents the results for the 12 cases with no HTGR constraint. The companion Figure 11.2-10, however, omits three important cases - cases 15, 20, and 21 in Table 1 of this document. Inclusion of the results for these three cases would alter the visual impression of Figure 11.2-10.

The benefit picture would definitely be less favorable to the LMFBR. Figure 11.2-10 should be modified to include these results for cases 15, 20, and 21 in Table 1."

ERDA Response:

Figures 11.2-10 and 11.2-11 in the PFES do not purport to follow the breakdown in EPA's Table 1, but they follow the modified AEC schedule shown herein in Table I (which was agreed to by EPA) plus the additional cases as shown in the table.

While Figure 11.2-10 does not display results for the three disputed cases, it does show the corresponding cases for "optimistic" and "pessimistic" uranium assumptions. It is not at all clear that display of the mid-range base case results would influence this figure to the detriment of the LMFBR. This is certainly not true in the comparison in Figure 11.2-11, which shows the corresponding cases without constraints applied to reactor types.

EPA Comment (pages 7-8):

"Interpretation of the Effects of Changing Conditions on the Benefits of the LMFBR

"Tables 11.2-23, 11.2-24, and 11.2-25 in the PFES present data to shown the independent effects of variation in HTGR constraints, uranium supply, and LMFBR capital costs on the estimated benefits of the LMFBR program. Such a table is not presented for the effects of variation in energy demand. The effect of energy demand is poorly presented in the discussion on pages 11.2-138 through 11.2-142 and in Figure 11.2-38. The tables tend to be confusing in that the data are gross benefit values, ...

"In view of this volatility of net benefits with respect to uranium supply, it would appear desirable to collect more information on uranium supply before making a total commitment to pursue the net benefits of the LMFBR program (emphasis added).

".... 'The ratio (B/C) falls below one only when two or more large adverse circumstances--each considered unlikely--are assumed to occur in concert.' So long as the unconstrained introduction of the HTGR is considered a 'large adverse consequence,' this statement is true. If the unconstrained HTGR condition is not viewed as unlikely, then the number of adverse conditions for 12 of the cases in Table 2 are reduced by 1 to equal the numbers in parentheses in the last column...."

8

ERDA Response:

The intent of the EPA comments is not clear in the statements that the effects of energy demand are "poorly" shown. The graphical data in Figure 11.2-38 are comparable to the tabular data given in Tables 11.2-23 through 25, but are shown in graphical form (in response to the request of another commentor) for "greater clarity."

Gross benefit numbers are used consistently throughout this report. These are the values used both in determining cost-benefit ratios and in rate-of-return analyses. Program costs are also prominently displayed. The reader may convert to net benefit values easily if he wishes.

Tables 11.2-23 through 11.2-25, along with other tables and figures in the report, were designed to show the trends of effects of changing key parameters. The multiplicity of tables and figures were used principally to avoid complicated comparisons such as that shown in EPA's Table 2 and make the relationships more understandable to the reader (the data in Table 2, by the way, are given in very similar form in Table IVD-1 of the PFES).

As regards the "volatility" of benefits with respect to uranium supply, ERDA is carrying out programs to assess domestic uranium resources and improve technology for discovery, assessment, and production of these resources. Preliminary results of this program, however, indicate that uranium supplies may be less plentiful than is assumed in the "base" reserves consideration. Recent projections of uranium ore supply by ERDA, the U.S. Bureau of Mines, and the National Science Foundation all tend to be more conservative than the "base" assumption.

As regards the relevance of capacity constraints applied to the HTGR and their relationship to "large adverse circumstances"--the rationale for imposition of these constraints was set forth in the PFES. The logic of using such a constraint mechanism is confirmed by recent data on comparative capital costs and fuel cycle costs of HTGR's and LWR's, which indicate that the HTGR may have inadvertently been given an unwarranted economic advantage over the LWR via input data used in the study.

EPA Comment (pages 8-9):

"ADOPTION OF A DECISION RULE FOR DECISION UNDER UNCERTAINTY

"There are several combinations of possible future conditions that could result in the benefit-cost analysis yielding negative net

benefits (11 of the 24 cases presented in Table 1). The benefit-cost analysis could deal better with implications of these negative benefit cases in terms of the overall assessment of whether the dollar benefits of the LMFBR program exceed the dollar costs...."

ERDA Response:

The reviewer is in error in stating that 11 of his 24 EPA cases in Table 1 indicate negative net benefits (i.e., benefit/cost ratios less than 1). Only seven of these cases show these results, and they represent some of the most adverse assumptions considered in the study.

Several errors appear in Table 1:

(1) In cases 5, 11 and 20 the wrong PFES cases were selected for comparison. The cases selected imposed capacity constraints on the LMFBR but not on the HTGR.

(2) In several cases rounded-off approximations in the summary section of the PFES in Chapter 11 were used rather than more precise data given elsewhere in the chapter.

(3) Benefit values for EPA cases 20 and 21 were taken from the incorrect table in the summary section. The referenced cases utilize capacity constraints on HTGR's and LMFBR's; the benefits listed, and the table referenced, are for unconstrained cases.

The logic of the remainder of this section appears to confirm strongly our results showing a decided benefit from early LMFBR introduction. However, the reviewer's comments must be weighed in light of the fact that sensitivity cases in the cost-benefit study were selected to emphasize adverse conditions, and in light of subsequent information that (1) uranium reserves may in actuality be less than assumed in the base projection; (2) the HTGR may have been given an unintended economic advantage in the study; and (3) assumed uranium enrichment costs were definitely too low. While the alternate techniques of LMFBR evaluation suggested are interesting, they are not required to confirm the favorable benefit/cost position of the LMFBR.

EPA Comment (pages 9-10):

"1. Likelihood the Base Projections are High

"As part of the Project Independence Report, FEA prepared base case projections for total energy demand as a function of the

price of oil over the short-term period from 1972 to 1985. With the price of imported oil at $7 per barrel total energy demand was projected to grow at 3.2 per cent per year. With a price of $11 per barrel total energy demand was projected to grow at 2.7 per cent per year."

ERDA Response:

EPA places heavy emphasis on results from the Project Independence study. Project Independence was nearly totally concerned with short-range (1975-1985) forecasts and evaluations, and made only cursory long-range forecasts using simplified modeling techniques. The short-range studies, although they covered essentially all potential energy sources and uses, were concerned mainly with energy use and conservation practices affecting petroleum and natural gas. The long-range studies, carried out on a much lower key, are heavily qualified by FEA themselves in the Project Independence report. EPA's extending of FEA short-range forecasting methods into longer range forecasts is particularly inappropriate: the price of oil, in particular, is all-important in short-range forecasts, but in the longer range may merely mean less oil is used -- or more energy uses are shifted to alternate sources, including electricity.

Many energy forecasts have been made in the past few years; some are lower than the PFES base case, and some are higher (the PFES cost-benefit study, in fact, considers eight separate energy forecasts).

A supplemental cost-benefit analysis utilizing updated assumptions is included in the Final Environmental Statement. The base assumption for energy demand in this analysis utilizes recent ERDA projections which approximate the FEA value.

EPA Comment (pages 10-11):

"Apparent Inconsistence of Population and Total Energy Demand Projections

"....The projected rate of growth of population over the period from 1970-2020 is only 56 per cent of the population growth rate over the period from 1950 to 1972. It would be extreme to argue that a comparable reduction in the rate of growth of total energy demand would also occur. An annual growth rate in total energy demand of 2.5 per cent (as projected by Project Independence for the period 1985-2020) would be equal to 74 per cent of the earlier period's 3.4 per cent growth rate. Such a reduced rate would appear more consistent with the projected reduced rate of population growth."

11

ERDA Response:

The crux of the comments on this section appear to be the nature of the relationship between population growth and growth in the GNP. Use of an average over the years 1950-1972 masks important trends. Analysis of historic trends on a year-to-year basis shows growth in GNP accelerating relative to population growth, because of increases in productivity. As is mentioned on page 11.2-53 of the PFES, the historic productivity increase rate of 2.6% per year was chosen as representative of the long-term rate of change in productivity, and was used to project GNP.

An additional factor not taken into account by EPA is the historic fact that, since about 1965, the ratios of consumption of both total energy and of electricity relative to real (inflation-free) GNP, have increased relative to trends in prior years.

In similar manner. EPA's averaging of projected rates of population growth over a 50-year period (1970-2020) masks the fact that present low birth rates will not appreciably affect the productive sector of the population until the 1990's at the earliest.

EPA Comment (pages 11-12):

> "Implication of Project Independence Projections for the Optimal Timing of the LMFBR Introduction Date
>
> "On page 80 of EPA's comments on the DES it was suggested that the question of optimal timing for the introduction of the LMFBR ought to be discussed in the PFES. Unfortunately, the PFES analyzes the effects of timing for too few alternatives to make a reasonable evaluation. Table IV D-1 contains information on timing for cases in which at most one adverse assumption is made with respect to the overall base case. Very importantly, the effect of timing given the (-50%) demand projection is not presented under any conditions."

ERDA Response:

The effects of delay in the LMFBR introduction date are presented, in 24 of the 76 cases in the PFES, as affected by changes in energy demand, availability of uranium ores, and availability of advanced LMFBR designs. Extrapolations can readily be made for other assumed conditions via the other cases considered and reported in the PFES study.

The "optimal" time for LMFBR introduction, at any rate, is the earliest feasible date. As is explained in detail in the PFES, delay in LMFBR

introduction results in added expenditures for uranium ore and for separative work which are not recoverable in any future years. While the net penalties for delay vary for different assumptions of energy demand, uranium costs, etc., the losses definitely occur.

It is also noted that a delay in the introduction of the breeder delays the time when the nuclear power industry is self-generating all the fissile fuel that is required for new and operating reactors. At this time of fuel self-sufficiency the industry essentially does not require mined uranium and as a result the fuel cycle costs of converter reactors are stabilized at a low value, perhaps as low as 1 mill per Kwhr. Hence, delaying the breeder can have a large impact on the fuel cycle costs of the large number of converter reactors expected to be operating about the turn of the century.

Further details on the economic impact of delaying the breeder are provided in ERDA-38, "The LMFBR-Its Need and Timing", and the Statement of Saul Strauch before the Subcommittee to Review the National Breeder Reactor Program, Joint Committee on Atomic Energy, Congress of the U.S., on July 10, 1975.

EPA Comment (pages 12-13):

> "The relative values of the figures in Table IV.D-1, however, make one wonder whether the analytical benefit-cost model is constructed in such a way as to accurately assess the effects of timing of the LMFBR introduction date. ...
>
> "... the basic model may not deal effectively with variation in timing assumptions. The final impact statement should provide an improved treatment of the timing question with respect to introduction of the LMFBR under the full range of conditions represented by the 16 sensitivity analysis cases, for delays in timing of 5, 10, and 15 years."

ERDA Response:

On Page 12, the worth of the model used in the cost-benefit study is questioned. The same question was raised by EPA following publication of the Draft Statement. Subsequently, the structure and operation of the model were explained in detail to the EPA representative, who agreed that it was adequate for the study. In the present case, the reviewer apparently fails to account for the fact that the added costs incurred due to delay in LMFBR introduction accrue, not only for the interval of delay, but for as long as uranium consuming nuclear plants

continue to operate. For cases involving high energy demands or high priced uranium, these increases in cost can be substantial.

As requested by EPA in its comments on the Draft Statement, a comprehensive discussion of the effects of varying the introduction date of the LMFBR was included in the PFES.

EPA Comment (pages 13-15):

> "A Simplistic Approach toward Assessing the Effect of Reduced Demand on the Optimal Timing of LMFBR Introduction
>
> "If one ignores the complex linear programming benefit-cost model, it is possible to construct a simple model that provides at least an intuitive notion of the potential effects of reduced demand on optimal timing of LMFBR introduction. The main benefits of the LMFBR derive from its uranium conservation. ...
>
> "If one assumes that the amount of expenditures for uranium increases proportionally to the increases in electrical utility energy demand, then cumulative demand for energy can be used as a gross surrogate measure for the cumulative expenditure for uranium. Given these assumptions, it is possible to find the years at which the present value of the cumulative demand for electrical energy under the Project Independence growth rates is equal to the present value of the cumulative demand for that energy in the base case over the period from 1970 to 2000. ...
>
> "Thus we see that with the rates of growth projected by Project Independence, introduction of the breeder might be delayed as much as 4 to 12 years without increasing the present value of expenditures for uranium above those projected for the base case by the PFES.
>
> "Given the extremely simplistic and unrefined nature of this exercise, the conclusions must naturally be suspect. Nevertheless, they do reinforce intuition and do indicate that early introduction of the LMFBR may not be so critical as supposed."

ERDA Response:

The assumption that expenditures for uranium are monotonically proportional to energy generation is not correct. This relationship would hold only if very large amounts of uranium were available at

constant price. Actually, uranium costs are projected to increase rather steeply as more resources are consumed.

The analysis presented by EPA purports to be a calculation of optimum timing for introduction of the LMFBR. In our view, it is merely a simplified formula which estimates, all other things being equal, the time span required for power generation costs to equal those calculated in the PFES base case, when the rate of increase in power demand is varied. This is an apples-and-oranges comparison which bears no relation to the question of optimum timing of LMFBR introduction.

As was shown in the PFES, penalties for delay in introduction of the LMFBR are unique and predictable for each set of circumstances. These penalties have been calculated for a wide range of conditions, and may be estimated for other conditions from data given in the PFES.

EPA only considers changing or emphasizing assumptions that might reduce benefits of the LMFBR. Consideration is given to lower energy demand projections or emphasizing the assumption that only HTGRs will eventually be built in the no-breeder cases. No consideration is given to higher separative work prices or higher uranium prices. The price for separative work became $53.35 per SWU on August 20, 1975 for fixed commitment contracts whereas $36 per SWU was the base assumption used in the PFES. Recent contracts for U_3O_8 provide for a price of $40 per lb of U_3O_8 for delivery in the early 1980s.

EPA is correct in noting that more than 80% of the breeder's benefits are due to savings in uranium and separative work requirements. Hence, it is important not only to consider updating energy projections but also uranium and separative work price projections. Updated cost-benefit calculations which utilize updated assumptions for energy demand and also uranium and separative work price projections are reported in Section III F of the FES. These calculations indicated substantially increased benefits for the breeder and an increased need for early introduction of the breeder.

EPA Comment (page 15):

"Estimated Costs of 9-11 Years Delay Owing to Lower Demand

"According to the data in Table IV D.1, the present value of the gross benefits of the LMFBR program ... averages out to a 3.8% reduction in gross benefits per year of delay.

"Similarly, Table IV.D-1 indicates ... a 1.3 per cent reduction for every 1 per cent drop in the level of projected demand for the year 2020.

"If one calculates the year 2020 demands for the $7 and $11 per barrel Project Independence estimates, they end up being 27.6 and 33.1 per cent lower than the PFES base case projection. ...

"The $7 per barrel projection has the same effect on gross benefits as a 9 year delay in the introduction date; and the $11 projection has the same effect as an 11.5 year delay. One can conclude, therefore, that the risk of a 9-12 year delay in order to insure environmental concerns would be no greater in terms of potential costs than the risk that presently exists that projected benefits will be significantly smaller than for the base case owing to lowered future demand as predicted by Project Independence."

ERDA Response:

The estimates made by EPA as to the relative decreases in benefits for lowered energy demands and for delayed LMFBR introduction are basically correct. The decrease in benefits from a decrease in energy demand to a 2020 demand about 30% below the base demand would indeed be approximately the same as that resulting from a delay of about 10 years in LMFBR introduction, under base demand conditions.

There is, of course, a high likelihood that actual electric power demand up to the year 2020 will differ from that assumed as the base demand in the study. Depending on future events, it may be either higher or lower than the base demand -- but would not necessarily be that predicted by Project Independence; in that study primary attention was focused on the 1975-1985 interval, as was previously stated. If actual demand is lower than the base demand, benefits from 1987 LMFBR introduction will be lower than those calculated in the base case. However, delay of LMFBR introduction beyond 1987, at any one level of power demand, will produce a real, calculable decrease in benefits relative to those from 1987 introduction. These added costs of deferred LMFBR introduction can be predicted and, by prudent planning of the development program, can be avoided. It is not at all clear that "environmental concerns" would dictate a 9-12 year delay as inferred by EPA. The loss of benefits due to deferral gives a definite incentive for resolving any such "concerns" to allow timely introduction of the LMFBR, and any prudently planned development program will take this into account.

EPA Comment (page 16):

> "A graduate student at Harvard University has prepared a draft paper describing his ongoing investigation of the LMFBR timing issue.[3] ...
>
> "The AEC assumption about increased R&D costs derives from the notion that the longer a project takes, the longer the program has to keep teams and facilities geared up, and the more it is going to cost. Richels counters that assumption by other experience which shows that it is frequently possible to hold down overhead and other fixed costs by designing the R&D program to run more in terms of sequential than concurrent phasing. He even suggests that, with effective planning, an extension in project completion time can lead to a reduction in undiscounted R&D costs and that if this were the case for the LMFBR, the optimal commercialization date might come even later than the year 2000 in his example case.
>
> "The fact of the matter is that a delay in the introduction date of the LMFBR is by no means certain to result in a reduction of the net benefits of the program. Depending upon future demand conditions and the effect of 'stretchout' or delay in the R&D program costs, the postponement of introduction could have positive as well as negative impacts on the overall benefit of the program."

ERDA Response:

EPA fails to take into account several basic differences in the assumptions made in Richels' study and those used in the PFES cost-benefit study. Richels' "high" uranium cost curve is roughly comparable to the base curve in the PFES, and his "high" demand projection is equivalent to the PFES "low" (-20%) projection. Furthermore, in the case referenced by EPA, Richels assigns the LMFBR, upon introduction, a capital cost disadvantage of $250/KWe as compared to the LWR; its cost "after learning" is $100/KWe higher than the LWR. Further, in many of Richels' cases, the LMFBR must compete in later years with an undefined "advanced technology" plant which has no fuel costs, has capital costs equal to those of the LWR, and is assessed no introductory "learning" penalty. Thus, in his scenario, introductory penalties for learning are applied uniquely to the LMFBR, and not to any other new technology.

Richels' treatment of the LMFBR introductory penalty is itself questionable. He assumes that undiscounted R&D costs for the LMFBR are constant, no matter what the introduction date. It would seem reasonable, then, to

assume that the same degree of "learning" should be required no matter when the LMFBR became available. Yet, Richels decreases the introductory penalty, linearly with time, for later dates of LMFBR availability, until by the year 2006 there is no "learning" penalty. Little wonder his model shows greater benefits for later dates of LMFBR availability!

In addition, there appears to be an error in Richels' discounting procedures. His assumption of constant undiscounted R&D costs, regardless of availability date, would result in the schedules of discounted costs for different availability dates which he shows in his paper only if the R&D costs were considered to be paid in one lump sum at the date of availability. Actually, of course, R&D costs occur and are paid on a year-by-year basis. The discounted sum of a series of equal year-by-year payments--a much more reasonable assumption--would differ considerably less with varying availability dates of the LMFBR than is indicated by Richels.

The assertion of Richels that "sequential rather than concurrent phasing" can minimize R&D costs is certainly true, but must be taken in the context of overall program requirements.

The LMFBR development program is very heavily involved with the development and testing of large pieces of equipment, and the construction of large facilities for testing and for demonstration. In activities such as these, the optimum schedule is that in which the components of each major project are scheduled sequentially--for example, detailed design of Project 2 is started as the design for Project 1 begins to tail off from peak effort. Scheduling such as this is aimed at maintaining a roughly constant level of effort for the design team, the equipment fabricators, and the construction industry. Acceleration of a program from the optimum would increase costs from added burdens on one or more of these sectors. Stretching out of the program would also incur higher costs because of the fluctuation in effort. These added costs would result from (1) reductions of force, followed by hiring and training of new personnel; (2) requalification of nuclear equipment fabricators following a lull in effort; and (3) maintaining essential fabrication and construction facilities in standby or at less than design capacity.

Some phases of R&D effort, of course, if they were independent of other efforts, could be conveniently stretched out without appreciable penalty; however, these phases must in reality be scheduled so that results are available when needed for the controlling, "sequenced" projects.

One major objective of management of a complex R&D program such as the LMFBR program is to maintain the schedule as near the optimum as

possible. Delays in scheduling--even deliberate stretchouts—can easily increase costs.

EPA Comment (Page 21):

> "Even though the additional quantitative information significantly improves the description of the design criteria, the AEC design philosophy, and the general intended approaches to ensuring safety, there is still a lack of definitive information that would provide the reader with the status of the principal unresolved safety problems, their current degree of resolution, and the on-going or required research and development needed to achieve the safety objectives."

ERDA Response:

Information along the lines requested is provided in Section III B of the Final Environmental Statement. It should be emphasized, however, that the safety approach as described in Section 4.2.7 of the PFES provides sufficient flexibility considering both the safety R&D program and the design approach of utilizing multiple levels of defense such that safety problems which currently exist or are anticipated can be accommodated by design options for future LMFBR plants if not fully resolved by the R&D program for early plants. There are no major problems or uncertainties not amenable to orderly and planned resolution by the safety R&D program.

Increasing size from the demonstration plant to full-sized commercial plants will require considerable engineering development for the scale-up of components and in other areas. We believe that it is currently feasible for LMFBRs to be designed, licensed, and operated with adequate safety margins.

EPA Comment (Page 22):

> "Risk acceptability is indeed a complex subject which demands technical, social and legal inputs. To our knowledge such conclusions have not yet been reached for the LWR, much less the LMFBR. We commend the AEC's efforts to evaluate (quantify) the risks of the LMFBR. If possible, the FES should provide more amplification on this program effort including the presently limiting factors (information, technical detail, developmental work, etc.) and the anticipated time frame for the complétion of the analyses."

ERDA Response:

ERDA is funding some exploratory and investigatory work in the development of risk methodology for LMFBRs. If successful, it is believed that such methods, properly utilized, will aid in establishment of priorities for safety R&D efforts. It will also help identify the relative contributions to overall plant risk of various systems, subsystems, and components as well as the effect of design variations of those components. It is believed that this kind of effort can be useful in the early stages of the development of the LMFBR program. With the buildup of a sufficient data base, the methods can be quantified and the uncertainty bands reduced. This will assist even more the decision-making process concerning safety options in the LMFBR program. Present limitations rest primarily with the lack of a specific methodology tailored to LMFBRs and a detailed understanding of in-core phenomena and the lack of a large data base. Early analyses should be completed in the next few years; a tentative goal of the development of an acceptable risk assessment methodology by mid-1985 has been established.

EPA Comment (Page 22):

> "Uncertainties in various important safety related design parameters should be quantified where possible in such a manner to be more comprehensible. (The risk assessment may do this.) For example, there could be substantial uncertainties in the possible structural integrity of the primary coolant system related to a hypothetical core disruptive accident (HCDA)."

ERDA Response:

It is not clear what uncertainties are being referred to or how they might be quantified. With regard to the particular one cited, we expect that R&D efforts will, in the not-very-distant future, provide a basis for the conclusion that core disruptive accidents resulting in the generation of significant amounts of mechanical energy are physically unrealizable. Nevertheless, the safety and licensability of LMFBRs do not have to await this R&D result since it is possible to contain significant amounts of mechanical energy from a disruptive accident (e.g., the FFTF design). Once the anticipated R&D confirmation is obtained, design features of subsequent plants may change significantly.

EPA Comment (Page 23):

> "As indicated in the PFES, the initial approach to ensuring a minimum level of LMFBR safety will be through the use of (1) traditional

regulatory safety approaches; (2) existing regulatory (NRC) safety requirements and design guides; and (3) existing "interim" CRBR NRC design requirements. While this approach suffices for the short-term, if a breeder based energy economy is to be developed, we believe LMFBR specific design, safety and siting criteria must be developed in a timely fashion."

ERDA Reponses:

We agree, and both NRC and ERDA are actively pursuing this matter.

EPA Comment (Pages 23 and 24):

"The AEC response to the HCDA (pages VII.53-156-157) indicates that there will be no direct environmental consequences from such incidents, which is supported by encouraging results from recent research and development. However, we find that the energy conversion efficiency is not well defined. ...

"Because of the great importance of the HCDA and because some experts seem to have reservations on the ability to accurately predict the behavior of the pressure vessel under conditions of such a core accident, ERDA should continue to make every effort to inform the public and other Federal agencies of the state of the current research and development programs dealing with HCDAs..."

ERDA Response:

As indicated previously, we expect that R&D efforts to further define energy conversion efficiencies will show that an HCDA of high mechanical energy is not physically possible. More specific information on the LMFBR safety R&D program is provided in Section III B of the Final Environmental Statement. ERDA recognizes the need to keep all interested parties informed of the current status of this program and is attempting to do so within the constraints of reporting and publishing lag times.

EPA Comment (Page 24):

"Because of the importance of this subject to safety we believe that the treatment of irradiation creep and irradiation swelling could be expanded, since we were unable to locate the 'specific

evaluation' as indicated in the response. The information in the PFES does not include any quantifiable information which would indicate the status of the problem of fuel cladding creep and swelling on core performance and safety as related to potential environmental impacts. Likewise, the information in the PFES does not adequately discuss the safety and economic implications of prospective solutions, such as core clamping, frequent replacement of control rods, etc."

ERDA Response:

Specific evaluations were not, in fact, presented. With regard to economic implications, the analyses in the cost-benefit section of the PFES (as noted in Volume IV, page 11.2-13) assumed that the stainless steel swelling phenomenon will not be a factor in the "advanced oxide" core design, which is assumed to be available in 1991.

Irradiation-enhanced creep and void swelling are important physical phenomena which must be treated quantitatively in the design of fast reactor cores. The design of the FFTF and CRBR core systems have included explicit consideration of these phenomena. This design analysis has been conducted in a manner which is similar to and consistent with that used for the more conventional engineering properties of core materials in designing for the effects of the thermal, mechanical, chemical and neutronic environment of the reactor. Current design relationships for creep and swelling are published in the Nuclear Systems Materials Handbook.

The design relationships which consider irradiation effects are necessarily based, in part, on projection beyond current experience in as much as we have not yet reached the design goal exposures of FFTF or CRBR in our irradiation testing programs. However, developmental programs are in place which will establish the effects of neutron irradiation on the properties and behavior (including creep and swelling) of the reference core materials at FFTF goal exposures in the EBR-II prior to reaching those levels in FFTF, and to CRBR goals in FFTF prior to reaching those levels in CRBR. Also, there is continuing surveillance monitoring of EBR-II reactor components which are subject to these phenomena, and there will be a comprehensive component surveillance program in FFTF to monitor the predicted performance of core components.

In regard to safety, we know of no explicit safety issues which are a consequence of the phenomena of irradiation creep and void swelling. This statement is based upon the fact that the phenomena are explicitly

treated in the design of the reactors. Of course, if a system were designed in ignorance of these or any other critical phenomena, scenarios could be developed which might lead to safety issues; however, such is not the case.

In regard to the more general issue of LMFBR core performance, the phenomena of creep and swelling are important; and, for certain core components and certain design conditions, these phenomena are indicated in design analysis to be performance limiting factors. However, for the same components (e.g., fuel pins) under other conditions, other more conventional material properties (e.g., stress rupture strength) are indicated as the performance limiting factors. We have major materials program activities underway in the development of advanced alloys and to a lesser extent in the optimization of our current reference alloy with the objective of raising or eliminating the various material performance limits as we now understand them. For example, we have significant data which indicate that the void swelling "problem" has a metallurgical solution. Quantitative consideration of the economic or technical impact on overall LMFBR performance of design options relative to creep, swelling or other material properties requires extensive design analysis of specific systems. We anticipate that these kinds of tradeoff studies will be carried out in the planning of the pending "commercial" LMFBR development.

EPA Comment (page 25):

> "On April 10, 1975, the Energy Research and Development Administration (ERDA) announced that they were withdrawing their plans to develop a Retrievable Surface Storage Facility for high-level radioactive wastes. ERDA now plans to emphasize the direct development of ultimate waste disposal facilities. We concur with the emphasis on the development of permanent disposal techniques, as we indicated in our comments on commercial high-level waste management (WASH-1539)."

ERDA Response:

We appreciate EPA's concurrence as to the importance of developing permanent radioactive waste disposal techniques. As stated in the ERDA Fiscal Year 1976 budget proposal to Congress, we want to increase the level of effort on the geological disposal of both high-level waste and transuranium-contaminated waste. We believe that continuation of present studies in southeastern New Mexico will lead to proposal of a pilot geological disposal project for transuranium-contaminated waste in the FY 1978 budget.

However, EPA's statement that on April 10, 1975, ERDA "announced that they were withdrawing their plans to develop a Retrievable Surface Storage Facility for high-level radioactive wastes" is not entirely accurate. On that date, ERDA did announce the withdrawal of draft environmental statement WASH-1539, issued in September 1974 on the waste repository development program, so that it could be replaced with a statement which would be expanded in scope to cover a number of regulatory issues raised by commentors. Because of the nature of these issues, the Nuclear Regulatory Commission (NRC) was asked to join in preparation of the new statement. At the same time, a construction line item for the RSSF was withdrawn from the FY 76 ERDA budget proposal, since it would now be impossible to prepare both the final generic repository statement and the follow-up site-specific RSSF environmental statement within that fiscal year.

The proposed ERDA budget still includes operating funds identified for RSSF work such as conceptual design of a site-independent nature, safety studies, and evaluation of alternative sites. Therefore, it is not correct to state or imply that the concept of an RSSF has been completely withdrawn or discontinued. It is quite true that if good progress is made in the geological disposal program during the period of delay imposed by expanding the scope of the generic waste management environmental statement, and possible other delays in commercial spent fuel processing, the need for an RSSF might be eliminated.

EPA Comments (pages 25 and 26):

> "In the PFES and the AEC's response to our comments, the AEC stated that '...to date, there have been no reports of migration of radioactive material from commercial burial sites.' This is in error, since radioactivity has been reported to have migrated off-site from burial facilities in Kentucky and New York State. The reported results of an extensive, six-month investigation by the Kentucky Department for Human Resources (KDHR)[5] clearly indicate that the radioactive waste disposal site at Maxey Flats is contributing radioactivity to the environment."

ERDA Response:

We agree with these EPA comments. The staff responsible for preparing the LMFBR Program PFES had no knowledge of the migration of radioactivity from these burial grounds prior to publication of the PFES (December 1974).

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[5] Project Report, Six Month Study of Radiation Concentrations and Transport Mechanisms at the Maxey Flats Area in Fleming County, Kentucky, KDHR Bureau for Health Services, December, 1974.

The following information was received from the U.S. Nuclear Regulatory Commission regarding these EPA comments.

"Conclusions 1 and 2 of the report prepared by the Kentucky Department for Human Resources state:

'(1) The radioactive waste disposal site at Maxey Flats, Kentucky, is contributing radioactivity to the environment. The activity detected in the environment does not create a public health hazard. However, the level of activity detected demonstrates the need to intensify current monitoring activities to provide additional information to determine to what possible extent migration of radioactive material is occurring at the site and for assessing the long range significance of the findings.

(2) The movement of radioactivity from the facility could be through four major routes:

(a) Surface water run-off.

(b) Atmospheric fallout from the evaporator plume.

(c) Migration through geologic formation fissure systems.

(d) Lateral migration through the soil zone.'

"The New York State Atomic Energy Council has reported to us that liquids in certain trenches at the West Valley, New York low level waste burial site have seeped out of the trench cover. The seepage was principally limited to onsite areas near the trenches although some seepage drained to the surface water courses at the site. The State has determined that the radioactivity levels in the seepage constitute no hazard to the public health and safety. The site operator has decided to close the site until the details for further studies to assess conditions at the site and procedures for operation of the site are resolved.

"We do not know of the details of the results of the additional studies mentioned by the EPA. We understand the U.S. Geological Survey is conducting a 5 year study of 2 commercial low level waste burial areas to develop further definitive guidelines for evaluating sites and predictive models to assess the possibility for the transport of waste in various geological formations. We also understand the EPA is conducting environmental studies at the Maxey Flats site. Kentucky has established a committee of Federal and State representatives to design further environmental studies for the Maxey Flats site. New York State has retained consultants and plans to work closely with the site operator in carrying out further studies at the West Valley site. However, we are not aware of any similar problems at any of the other commercial low level waste burial areas."

Additional information on the migration of radioactivity from burial grounds is located in Section III D, 4.6S.

EPA Comment (page 27):

"We appreciate the AEC's efforts in clarifying and reorganizing the classification of radioactive wastes within Section 4.6 of the PFES. However, the AEC apparently did not understand our basic concern about their proposed system of classification. The category other-than-high-level (OTHL) wastes and its sub-categories still do not give sufficient information on the activity, content, and hazard potential of the waste. ...

"A more detailed, explicit classification system is needed to enable reviewers to evaluate the potential environmental impact from the OTHL wastes. Such a system would also be of great assistance to EPA as well as others, such as burial site operators and the state agencies which regulate them. We realize that developing a radioactive waste 'classification' system which meets the needs of everyone will be difficult and not necessarily a part of an LMFBR development program. However, we believe that this is an important effort since as shown in a recent EPA report[6] on land burial activities, the problem is expected to grow in the future."

ERDA Response:

As stated on page 4.6-1 of the LMFBR Program PFES, regarding other-than-high-level wastes-

"This category has been further subdivided for purposes of waste management considerations into beta-gamma solid wastes, alpha solid wastes, and noble gas wastes."

Following EPA's suggestions on the LMFBR Program Draft Environmental Statement, information on the activity of these wastes was included in the PFES as shown in Table 4.6-6 of the PFES.

The beta-gamma wastes were further subdivided into "normal" beta-gamma wastes, tritium, iodine and sodium, as shown on pages 4.6-44 and 4.6-45 of the PFES.

We are unable to provide a more detailed or explicit classification system than we have already provided in the LMFBR Program PFES. We agree with the general intent of the last two sentences in this EPA comment, but do not believe that categorization is a desirable goal if it is intended as a replacement for hazards analysis of specific waste management operations.

EPA Comment (page 27):

"In Section 4.6.2.1, the PFES states that, 'Radioactive materials in the coolant will consist of fission products and neutron-activated structural materials that are released to the coolant by corrosion processes.' This statement does not consider the potential for transuranic radionuclides leaking into the coolant from the Pu-UO_2 fuel elements, or the possible disposal difficulties which may arise if the OTHL waste, expected to be disposed of at land burial sites, is found to contain transuranics in concentrations which prohibit its disposal in that manner."

ERDA Response:

If LMFBR coolant waste is found to contain sufficient alpha activity from transuranic radionuclides to prohibit disposal at land burial sites, it will be sent to an alpha waste storage facility (see Section 4.6.3.2.2 of the PFES).

EPA Comment (pages 27 and 28):

"In Section 4.6.3, the PFES states that 'The technology and facilities established for management and disposal of radioactive waste from the LWR nuclear power industry will be directly applicable to the management of radioactive waste generated by the LMFBR and its fuel cycle.' It has not been adequately demonstrated by the PFES that the technology and facilities established for the processing, management, storage, and/or disposal of waste from the LWR industry will be directly applicable to managing LMFBR fuel cycle waste. It appears that the following areas in waste management may be unique to the LMFBR fuel cycle and may require the application or development of new technologies:

a. transuranic contamination in the LMFBR low-level waste streams;

b. organic solvents in the LMFBR liquid waste cleanup system;

c. radioactive sodium wastes, containing large quantities of radioactive fission products, transuranics, and activation products from neutron activation of core structural components, due to the high neutron flux levels in the LMFBR; and

d. increased quantities of transuranic contaminated low-level waste at the LMFBR fuel fabrication and reprocessing sites."

ERDA Response:

We agree with this comment regarding items a. and b. and that part of c. dealing with radioactive sodium wastes. We fail to see how handling of either products from neutron activiation of LMFBR core structural components or increased quantities of transuranic contaminated low-level wastes will require the development of new technologies. It is our opinion that the technologies developed for LWR wastes in these areas will be adequate for LMFBR wastes.

In any event, the technology for dealing with the LMFBR low-level wastes, including the liquid and sodium wastes, was discussed in Section 4.2.3.2.4 of the PFES. The discussion in Section 4.6.3 was intended to cover only the handling of radioactive wastes after they had been treated, packaged and shipped from LMFBRs and associated fuel cycle facilities.

EPA Comment (page 29):

> "In view of the recent division of the AEC into ERDA and NRC, we strongly recommend that ERDA's FES indicate explicitly which agencies are assigned specific areas of responsibility and authority for safeguards. The safeguards program is of the utmost importance. Difficulties and possible gaps in the development of the program can be avoided by an explicit assignment of responsibility and authority from the start. Additionally, ERDA's FES also should indicate the organizational structure within each of these agencies where these duties reside."

ERDA Response:

Information on ERDA and NRC responsibilities and authority for safeguards is provided in Section 7.4.8.1.3S of the Supplemental Material in the Final Statement, with particular emphasis on those activities that pertain to the development, demonstration and application of safeguards for a future commercial LMFBR fuel cycle.

Within ERDA, the development and demonstration of safeguards for application to future fuel cycles are the responsibility of the Division of Safeguards and Security, under the Assistant Administrator for National Security. Safeguards development and demonstration activities involving the use of a government-owned, contractor operated facility are coordinated with the ERDA division having overall responsibility for the faciltiy. Safeguards activities involving the use of a facility subject to NRC licensing are coordinated with NRC.

Within NRC, the "Energy Reorganization Act of 1974" delegates to the Office of Nuclear Material Safety and Safeguards, under Section 204.b.1, "principal licensing and regulation (functions) involving all facilities and materials, licensed under the Atomic Energy Act of 1954, as amended, associated with the processing, transport, and handling of nuclear materials, including the provision and maintenance of safeguards against threats, thefts, and sabotage of such licensed facilities, and materials." Section 161(i) of the Atomic Energy Act provides that NRC may prescribe such regulations and orders as may be necessary to "guard against the loss or diversion of special nuclear material...and to prevent any use or disposition thereof which the Commission may determine to be inimical to the common defense and security." Section 204.b.2.B of the Energy Reorganization Act also charges the Office of Nuclear Material Safety and Safeguards with "developing, in consultation and coordination with the Administration (ERDA), contingency plans for dealing with threats, thefts, and sabotage relating to special nuclear materials, high-level radioactive wastes and nuclear facilities resulting from all activities licensed under the Atomic Energy Act of 1954, as amended."

EPA Comment (pages 29 and 30):

"The PFES recognizes that with respect to plutonium toxicity the answers to some important questions concerning the impact on public health are not available. It is recognized by EPA and the AEC that in many cases there are reasonable differences of opinion on the health implications that might be inferred in the absence of definitive data. While it is agreed that animal toxicity experiments, and not the meager human exposure data, should serve as a guide, the discussion of animal data is not sufficient to allow a judgment to be made on plutonium toxicity in man. The differences of opinion on the significance of animal data extrapolated to man are unresolved.

"Although the toxicity of plutonium may be underestimated by an order of magnitude, adjusting the adverse health effects estimates upwards by an order of magnitude would not significantly change the total health impact of the LMFBR program as estimated by the AEC in the PFES. This is because the projected releases of plutonium are so small. As new data become available during the development of this technology, any significant changes that may occur in the assumed probability and magnitude of plutonium releases into the environment from the LMFBR fuel cycle would require a re-evaluation by the EPA on the health impacts due to the LMFBR program. Health effects have been forecast on the basis of what is essentially a zero release operating philosophy. It remains to be seen whether near zero release is technologically possible and whether all important plutonium releases, such as those due to sabotage, have been properly considered."

ERDA Response:

ERDA agrees that both experimental animal data and data from the limited human exposures need to be utilized in estimating potential health consequences; both of these sources of information, and their applicability and limitations, are summarized and discussed in the PFES. The estimates of health consequences in the PFES are derived from analysis of both human and animal data and, in the absence of relevant data, upon conservative assumptions; ERDA continues to be of the opinion that this approach results in a soundly based upper limit estimate of potential health effects. Uncertainties in these estimates will be reduced as additional experimental and human data become available. It is expected that additional information will permit reduction of the degree of conservatism introduced by assumptions made in the absence of data and consequently of the estimates of potential health consequence. The conservative nature of the estimates makes it improbable that the PFES underestimates the potential health consequences arising from the anticipated exposures.

As was discussed in the PFES (pages VII.53-116 to 118 and VII.53-127, and references referred to therein), ERDA beleives that potential human health effects caused by the transuranic elements will be qualitatively similar to those health effects observed in animals.

EPA Comment (page 31):

> "...To our knowledge, the relationship between packaging test requirements and the survival (or maintenance of integrity) of such packages under various accident conditions has not been established. This consideration applies to transportation of all types of radioactive material."

ERDA Response:

The ERDA staff acknowledges that the relationship between packaging test requirements and the survival (or maintenance of integrity) of packages under accident conditions has not yet been fully established. Research is underway to better establish such relationships. Preliminary results indicate that many types of packages designed to hold significant amounts of radioactivity maintain their integrity under conditions more severe than those likely to be encountered in transportation accidents. In addition, after more than 25 years of experience in a wide variety of transportation accidents, these package types have demonstrated excellent structural survival without loss of integrity.

EPA Comment (page 31):

> "Although we failed to address this issue in our comments on the DES, we note that AEC suggested that the doses estimated from spent fuel transportation accidents could be compared to the 'accident guidelines' set forth in 10 CFR Part 100. The stated purpose of 10 CFR Part 100 was to provide criteria to guide the nuclear industry in evaluating the suitability of proposed sites for LWR's, and the AEC indicated that its use of the values of 25 rem to the whole body and 300 rem to the thyroid is not intended to imply that these values constitute acceptable limits for emergency doses to the public under accident conditions. In our opinion, it would be more appropriate to compare the transportation accident doses to the LD 50/60 dose-response curve."

ERDA Response:

We agree that 10 CFR Part 100 "accident guidelines" may not be acceptable limits for public radiation doses following transportation accident releases. However, we feel that the LD 50/60 doses would not be appropriate either as they are relatively too high.

Until acceptable transportation "accident guidelines" are developed, comparisons should probably not be made. Efforts are underway to develop such "guidelines." For example, the AEC Ad Hoc Task Group on Transportation, in their October 10, 1974 report, "Safety in Transportation of Radioactive Material," suggested the following "accident guidelines."

"Limits on the contents of individual packages and standards for designs of packages should assure that (a) the probability that a release of radioactive materials or an increase in radiation levels would occur in transport is less than 1 for each 10^4 packages shipped; and (b) the probability that an individual would receive a dose or dose commitment greater than 15 rem from accidental releases of radioactive material or increases in radiation levels in transport in a year is less than 1 in 10^7."

It should be noted that these "accident guidelines" are only the recommendations of the Task Group and are not ERDA (or NRC) policy.

EPA Comments (page 33):

> "EPA will be responsible for issuance of discharge permits for the proposed (LMFBR) power plants, under the National Pollutant Discharge Elimination System (NPDES) -- Section 402 of the Federal Water Pollution Control Act of 1972, as amended (FWPCA)...."

ERDA Response:

We agree with these EPA comments regarding the implementation of these regulations.

GLENDALE TAXPAYERS' ASSOCIATION
INCORPORATED

A Civic Organization Serving Glendale for Over 50 Years

HENRY REICHERT, *President*
79-56 - 77th Road, Glendale, N. Y. 11227
Telephone: 821-9031

MRS. LILLIAN B KOLIN, *Secretary*
71-22 - 68th Street, Glendale, N. Y. 11227
Telephone: 821-4154

April 19, 1975

37

W. H. Pennington, Assessment Officer
Division of Biomedical and Environmental Research
U. S. ERDA, Washington, D.C. 20545

Dear Sir:

Residents of our community are greatly concerned over the proposed program that would permit the shipment of Liquid Metal Fast Breeder Reactor through residential areas. According to reports, LMFBR involves two dangerous and difficult to control substances; plutonium fuel in quantities and molten sodium which flames on contact with water or air. The superheated fast reactions can lead to explosions, and we fear the shipping of this material through populated areas could in case of accident, such as explosions, cause destruction and lose of life.

Research has also shown that invisible hot particles, suspended in the air, if inhaled can incite cancer of the lung and due to the fact that plutonium has a half-life of many years, once it is admitted to the environment, it will be virtually forever pervasive.

We, therefore, urge that the program of shipping LMFBR be suspended until other ways and means of shipping this material could be found. We would appreciate your giving our thoughts every consideration.

Very truly yours,

Glendale Taxpayers' Assn, Inc.

Executive Secretary

hr/lbk

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mrs. Lillian B. Kolin
Secretary
Glendale Taxpayers' Association
71-22 68th St.
Glendale, New York 11227

Dear Mrs. Kolin:

Thank you for your letter of April 19, 1975 commenting on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The concerns you raise with regard to the safety of transporting LMFBR materials and the toxicity of plutonium have been carefully examined during the preparation of the Proposed Final Environmental Statement (PFES) on the LMFBR Program (WASH-1535). Please refer to Sections 4.5 (and Appendix II.A) and 4.7, respectively of the PFES which has been incorporated as Section II of the Final Environmental Statement (FES).

A copy of the FES is enclosed herewith for your information. It is hoped that your review of the Statement will alleviate your concerns. Thank you for your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

Office of Planning and Budget
Executive Department

James T. McIntyre, Jr.
Director

GEORGIA STATE CLEARINGHOUSE MEMORANDUM

TO: Mr. W. H. Pennington
Assessment and Coordination Officer
Division of Biomedical and Environmental Research
Energy Research and Development Administration
Washington, D. C. 20545

FROM: Charles H. Badger, Administrator
Georgia State Clearinghouse
Office of Planning and Budget

DATE: April 21, 1975

SUBJECT: RESULTS OF STATE-LEVEL REVIEW

Applicant: Energy Research and Development Administration

Project: Proposed Final Environmental Impact Statement

State Clearinghouse Control Number: 75-02-20-01 (WASH 1535)

The State Clearinghouse has completed a coordinated State-level review of the above-referenced proposed final environmental impact statement. As a result of that review process the State of Georgia is opposed to the further development of the Liquid Metal Fast Breeder Reaction Program (LMFB) for the following reasons:

The State of Georgia is opposed to the further development of the Liquid Metal Fast Breeder Reactor Program (LMFB) for a number of reasons. Briefly, those reasons are:

Environmental and health hazards related to nuclear development are not adequately understood to permit development of adequate safeguards to protect the public.

The length of time necessary for the wastes to degrade beyond their hazardous State is estimated at more than 25,000 years, greatly increasing the problem of leakage from the storage facility into the environment during the hazardous life of the material.

There is no adequate program to insure security of wastes during processing, transportation or storage to prevent theft by subversive elements.

The economic viability of the LMFB program is highly questionable in that estimates of costs of construction are increasing rapidly with no slowdown in increases anticipated. Final costs of the program are impossible to predict, raising questions as to feasibility of this approach.

In accordance, with the provisions of the National Environmental Policy Act, the foregoing comments and enclosures to this memorandum should be addressed in the final environmental statement prepared for the project.

Enclosure - Review comments prepared by the Department of Natural Resources, dated April 9, 1975.

cc: Ray Siewert, DNR
Omi Walden, OPB
Gary Midkiff, OPB

Department of Natural Resources

OFFICE OF PLANNING AND RESEARCH
270 WASHINGTON ST., S.W.
ATLANTA, GEORGIA 30334
(404) 656-5160

Joe D. Tanner
COMMISSIONER

Charles M. Parrish, III
DIVISION DIRECTOR

April 7, 1975

M E M O R A N D U M

TO: Chuck Badger, Administrator
State Clearinghouse

FROM: Bruce MacGregor

ISSUE: Final EIS, Liquid Metal Fast Breeder Reactor Program

The State of Georgia does not choose to respond at this time to the technical information contained in the seven volume page Final Environmental Impact Statement. However, the State has a great interest in and a great concern for ramifications of nuclear power.

First, we feel that the decision, in 1970, to proceed with the development of the breeder reactor was short sighted, politically motivated and made without public input. Even by nuclear power advocates the breeder reactor was never intended to be anything more than a stop-gap measure on the road to the development of nuclear fusion. Had the research money spent on the breeder reactor during the past five years been applied to nuclear fusion research, the nation would probably be very close to development of the safer fusion reactor.

The summary sheet supplied with the final EIS is inadequate. The summary statement appears to be written more as a project justification than as a summary of the environmental impact of the project. In fact, the first sentence states... "This Proposed Final Environmental Statement is issued in support of the AEC's programs..." The summary statement states that environmental problems would "...not be significantly different from those inherent in other nuclear fuel cycles." In addition to being questionable, this statement overlooks two important issues; first, existing LWR plants have experienced substantial environmental and safety problems. Second, the magnitude of these problems will be multiplied many times with a breeder reactor.

ISSUE: Final EIS, Liquid Metal Fast Breeder Reactor Program
April 7, 1975
Page Two

Overall, we feel that the LMFBR program should NOT be continued. Reasons for this position include:

(a) The program will produce large amounts of plutonium, one of the deadliest substances known to man.

(b) The transportation and storage of radioactive wastes will involve undue and unnecessary risks to the general public.

(c) The program's economic feasibility is questionable. Costs have risen dramatically and continually.

(d) The costs of LMFBR research diverts money from other nuclear research, such as fusion, and from other energy source research, such as solar.

The overall health, safety, environmental and security problems pose an unacceptable risks for the limited short term benefits gained. Plutonium has a half life of over 25,000 years. Regardless of statements to the contrary, there has been no acceptable method of handling, transporting and especially disposing of this material. Safe guarding radioactive wastes over such a time span would assume societal tranquility of a time span which has never yet occurred and probably will not occur.

BM:eh

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Charles H. Badger, Administrator
Georgia State Clearinghouse
Office of Planning and Budget
270 Washington Street, S.W.
Atlanta, Georgia 30334

Dear Mr. Badger:

Thank you for the Georgia State Clearinghouse Memorandum, dated April 21, 1975 concerning the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. It is noted from the memorandum enclosed therewith that "The State of Georgia does not choose to respond at this time to the technical information contained in the seven volume page Final Environmental Impact Statement." It is further noted that "The State of Georgia is opposed to the further development of the Liquid Metal Fast Breeder Reactor Program (LMFBR) for a number of reasons." The reasons cited are: the environmental and health hazards of nuclear development, the problems of long-term waste disposal, the problems of safeguarding wastes, and questions regarding the economic viability of the LMFBR.

These issues are extensively discussed in the PFES and are further amplified in the Final Environmental Statement (FES). Your attention is invited to the sections listed below:

Environmental and health hazards: Sections 4.2, 4.3, 4.4, 4.5, 4.7 and Appendices, especially Appendix II.G of the PFES. Section III G of the FES.

Waste Disposal: Section 4.6, 5.4.2.2, 7.2.5, 7.3.5, 8.2.5, 9.1.2 of the PFES. Section III D of the FES.

Safeguards: Section 7.4 of the PFES. Section III C of the FES.

LMFBR Economics: Sections 11.1 and 11.2 of the PFES. Section III F of the FES.

We trust study of the information therein will alleviate your concerns regarding the LMFBR program.

We do not view the breeder as a "stop-gap measure on the road to the development of nuclear fusion." Dr. Seamans, Administrator of the Energy Research and Development Administration (ERDA), recently submitted "A National Plan for Energy Research, Development and Demonstration," (ERDA-48) to the President in which he concluded that both the breeder and nuclear fusion must be vigorously pursued if we are to meet the energy needs of the next century. The breeder has the potential to provide a major portion of the energy needs of the Nation for centuries to come. Furthermore, the development of fusion power is in its early stages and there are significant uncertainties concerning the timely availability of substantial amounts of electric power from the fusion process even should its technical feasibility be established.

Although our environmental review of the LMFBR Program has led ERDA to conclude that continuation of research, development and demonstration of the LMFBR concept is needed, continuation of the LMFBR Program will not be at the expense of alternative power generation concepts such as fusion. Indeed, these other technology options, which are examined in Section 6 of the PFES are receiving substantially increased appropriations in the current fiscal year and are proceeding at a pace limited only by the need to build up the new programs efficiently and effectively.

The Final Environmental Statement is based on a significant amount of public input. Comments were solicited and a Public Hearing held on the Draft Environmental Statement. Information developed as a result was factored into preparation of the PFES. Similarly, ERDA has carefully reviewed all written comments received on the PFES as well as the testimony received during the Public Hearing held on May 27-28, 1975, and has taken them into account in the preparation of the Final Environmental Statement (FES) for the LMFBR Program. Copies are enclosed for your information.

The Georgia State Clearinghouse Memorandum and its enclosure have been published in the FES along with other responses received in connection with the Proposed Final Statement. In this way, the views expressed therein will be available for consideration by those who use the Final Environmental Statement as a basis for decisions on the future course of the Program.

We regret that you were unable to provide specific comments on the PFES and trust the information provided in this letter and the FES will alleviate your concerns.

We appreciate the candid expression of your views.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program (6 copies)

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

PEP ER 75/133

APR 24 1975

Dear Mr. Liverman:

Thank you for your letter of December 31, 1974, transmitting copies of the proposed final statement for the Liquid Metal Fast Breeder Reactor (LMFBR) Program (WASH-1535).

Our comments are presented according to the format of the statement, or by subject.

General

We note that this statement is programmatic and an additional supplemental statement for each sited plant will be required. While some concerns for fish and wildlife resources are acknowledged in this programmatic statement, fish and wildlife concerns are dependent on the location of specific reactors and, in some instances, may require special consideration for these resources. For the same reasons, we are pleased to note that site-dependent cultural aspects of individual plants will be addressed on a case-by-case basis in subsequent environmental statements for specific plants and sites.

We suggest that this statement may present too strong an impression of the safety of LMFBR technology. Recent events with the present generation of reactors, such as leaks, cracks, and design deficiencies, would appear to call for some caution with the program.

Further, the implication to combine construction and operating permits could be unwise as there appears to be environmental risk associated with issuing a combined construction permit and operating license.

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

Outdoor Recreation

In general, we feel that the proposed final statement adequately addresses the impacts on outdoor recreation. However, we believe that the comment furnished to you about outdoor recreation on the draft statement, dated May 20, 1974, is still justified. That letter indicated that further consideration should be given to the positive recreation impacts that properly planned site areas and transmission lines could provide. For example, transmission corridors offer a significant benefit to hikers and other outdoor recreationists by providing increased access into previously inaccessible land; transmission line planning that recognizes this potential can optimize these benefits without sacrificing design efficiency. We recommend that such a policy be considered.

Radioactive Waste Handling

Waste handling is not adequately discussed. At present, sufficient processing facilities are not available, and there is no prospect that this shortage will soon be remedied. It is conceivable that a storage problem of immense proportions with no immediate solutions in sight could occur. Consequently, we are concerned that the loss of plutonium or any other radioactive wastes by any route appears to be neither adequately guarded against nor discussed.

Fossil Fuels

The data presented in the sections on alternative fossil fuels are out of date; at the minimum, references to the relevant Project Independence Task Force reports should be added. Some sections have the appearance of good literature searches by individuals lacking prior specific knowledge of fossil fuels. In general, the potential contributions of nonatomic energy sources to our economy appear to be understated.

We have the following specific comments to make.

Volume 1, Subsection 1.6.1.2. Increased Use of Current Nonnuclear Energy Production Systems
There are no problems foreseen to limit the use of coal by electric utilities to the extent suggested. The efforts to develop systems to control the environment by the use of coal would appear to be no more formidable than those involving the LMFBR. The use of coal for home heating is currently limited and its use will undoubtedly decline in the future.

Volume 2, Subsection 4.1.2. Availability of Plutonium and Uranium
The Energy Research and Development Administration (ERDA) stockpile of depleted uranium, recently reported to be 220,000 tons in form of depleted UF_6, is not included in Section 4 or in Section 5, although it would be of significance in the LMFBR program. This stockpile represents a large supply of fertile uranium for use in the LMFBR and is approximately equal to the production of depleted uranium, projected in Table 4.1-1, page 4.1-8, for 1973-1984. The maintenance, processing, and transportation of this stockpile material would have significant environmental and economic impact.

Volume 2, Subsection 4.4.1.2. Status of Reprocessing Technology
This Subsection indicates that the reprocessing of spent LMFBR fuels is the subject of a development program that is expected to be successful. However, the reprocessing of spent fuels in the light water reactor program has not been successfully demonstrated on a commercial scale, and a shortage of reprocessing capacity is becoming a serious problem. There is little basis for a prediction that LMFBR fuel reprocessing technology will be developed when needed.

Volume 3, Subsection 6A1.1.2. Extent of Energy Resources
Reserves at cutoff cost of \$8 per pound U_3O_8, and even those at \$10, appear unrealistic in view of price increases leading to a market price of \$16 per pound U_3O_8 in early 1975. Also, it is doubtful that reserves can be mined at the indicated costs because of recent increases in operating costs. The reserve-resource position is changing because of continuing increases in operating costs and market prices.

Volume 3, Subsection 6A1.1.2.3. Estimated Availability and Consumption of Uranium
Requirements of 12,000 tons U_3O_8 per year should be defined as we believe actual needs as first-core and replacement fuels are probably only about half that amount. We suggest the 12,000 tons U_3O_8 may be market commitments or enrichment feedstock demand.

Volume 3, Subsection 6A1.1.2.4. Potential Effect of Advanced Enrichment Process on Resource Conservation
We do not know why gas centrifuge enrichment is not included here, even though the technology is more advanced than that for laser enrichment.

Volume 3, Subsection 6A1.2.2. Extent of Energy Resource
Thorium resources reported in Tables 6A1-15 and 6A1-16 are different from those reported by the Bureau of Mines and the Geological Survey. However, these Tables substantiate the lack of a thorium resource problem.

Volume 3, 6A2. Fossil Fuels for Central Station Electric Power Generation
The Table on the contribution of fossil fuels to our total energy needs contains several errors. Also, the date of the data should be shown. The oil production shown is crude oil only, while natural gas liquids appear to be included in imports. Coal production should exceed coal consumption by the amount of net exports. The natural gas data do not correspond to the Bureau of Mines data for 1972, which otherwise appears to be the data of the Table. The Bureau of Mines data are shown on page 44 of the 1973 Mineral Industry Survey.

Volume 3, 6A2.1.1.3. Status
The Bureau of Mines estimates that 31.6 percent of economically recoverable coal can be obtained from surface mines (see Mineral Industry Survey, "Demonstrated Coal Reserve Base of the United States on January 1, 1974"). Coal production increased from 416 million tons in 1960 to 603 million tons in 1970. Although the number of mines decreased, there was a marked increase in the size of new mines. Competition from cheap natural gas and increased oil importation was not as restrictive on coal demand as is suggested.

Volume 3, 6A2.3. Oil Shales

Page 6A2-54
The statement regarding "one-third mineral matter" should be checked. Oil shale is more nearly 85 percent mineral matter.

Page 6A2-56, toward bottom of page
The 24 million is the figure for metric tons. A more recent figure could be given but a fair indication of growth is indicated in the last part of the last sentence on this page.

Page 6A2-57, middle of page
We suggest mentioning the Mowming shale center in the Province of Kwang Tung, which probably produces more shale oil now than the Manchurian oil shale facilities.

Page 6A2-57, next paragraph
The stated views about oil shale in this paragraph should be deleted unless there is good reason to believe that it is well-founded and that Federal policy would promulgate this viewpoint.

Page 6A2-58, top of page
This sentence, which begins on the preceding page, without any other information to accompany it, especially recent information, does not give an adequate description of shale oil economics

Page 6A2-58, next sentence
Prototype leasing has more than just begun. Four tracts have already been leased. Two others, the Wyoming tracts, were offered but did not attract any bids.

Page 6A2-58, same paragraph, last sentence
It would not be accurate to say that the goal of the leasing program is production of 1 million barrels per day. There is no other leasing program at present.

Page 6A2-62, top of page
It is suggested that "in some retorts" be inserted in connection with the 2200°F.

Page 6A2-62, next paragraph
Some of the gas is recycled, but some is vented from the system.

Page 6A2-65 and Page 6A2-66, toward bottom of page
Cost figures go out of date quite rapidly. It would be better to mention more recent estimates, or in some way acknowledge the rapid escalation. See Project Independence Oil Shale Task Force report.

Page 6A2-67, toward top of page
The sentence describing shale oil as "more than competitive" does not give a proper picture of the economic status of shale oil. We suggest referencing the Project Independence Oil Shale Task Force report.

Volume 3, 6A4. Geothermal Energy
This report overlooks the non-electrical applications which would reduce the demand for electricity as opposed to increasing supply. The emphasis in the last paragraph on the word may, implying that geothermal may not be available in time, is misleading. At best it is a question of timing, for the technical problems are less severe than many which have been faced in the past, the prime example being nuclear energy.

Volume 3, 6A2.2.2. Natural Gas and Oil
The data cited on domestic oil and gas production, consumption, and deficits are all "pre-crisis" and do not reflect current trends. A reference to the Project Independence report would be useful.

The probable cost of Arctic gas now greatly exceeds the $1.10 per Mcf which is cited.

We hope these comments will be helpful to you.

Sincerely yours,

Stanley A. Cremos

Deputy Assistant Secretary of the Interior

Mr. James L. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
Energy Research and Development
Administration
Washington, D. C. 20545

9

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Stanley Doremus
Deputy Assistant Secretary of the Interior
United States Department of the Interior
Washington, D.C. 20240

Dear Mr. Doremus:

Thank you for your letter of April 24, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. You are quite correct in your observation that the Statement is programmatic in nature and that additional statements are required for each sited plant which would address the specific site-dependent environmental issues. Your specific comments are addressed in the enclosed ERDA Staff Responses. In many instances your comments refer to information in the PFES which has become outdated since the material was prepared. This is inevitable in a document of this magnitude which has been in preparation for more than two years. Where it was determined that updating the data was needed it has been included in the revisions and corrections to the text that are listed in Section III A of the Final Environmental Statement (FES).

The FES for the LMFBR Program has been prepared taking into account the written comments received on the PFES and the testimony given at the Public Hearing held on May 27-28, 1975. Copies of the Statement are enclosed for your information. Thank you for your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses
2. Final Environmental Statement,
   LMFBR Program (18 copies)

ERDA Staff Responses to Department of Interior Comments

General

Comment (p. 1):

> "...this statement may present too strong an impression of the safety of LMFBR technology. Recent events with the present generation of reactors, such as leaks, cracks, and design deficiencies, would appear to call for some caution with the program."

ERDA Response:

The PFES provides considerable information on the LMFBR safety R&D program. Additional, more detailed, information is provided in the Final Environmental Statement. It must be emphasized, however, that the safety approach as described in Section 4.2.7 of the PFES provides sufficient flexibility considering both the safety R&D program and the design approach of utilizing multiple levels of defense such that safety problems which currently exist or are anticipated can be accommodated by design options for future LMFBR plants if not fully resolved by the R&D program for early plants. There are no major problems or uncertainties not amenable to orderly and planned resolution by the safety R&D program.

The fact that failures have occurred does not imply that reactors are unsafe. Indeed they are illustrative of the very wide spectrum of possible events which must be taken into account when a reactor is designed so that the reactor can accommodate them safely. Nuclear plants are designed with a multiplicity of protective features and systems so that single and even multiple failures can be accommodated safely. A large proportion of the defects which have occurred in nuclear systems were detected as a result of the extensive testing, inspection, and quality assurance programs applied uniquely to such systems, and probably would not have been detected had they occurred in non-nuclear systems. It is significant in this regard that civilian nuclear power plants have now accumulated over 240 reactor-years of operation without a single radiation-related death or injury to operating personnel or the public.

Comment (p. 1):

> "...the implication to combine construction and operating permits could be unwise as there appears to be environmental risk associated with issuing a combined construction permit and operating license."

ERDA Response:

No such implication was intended; this is a subject outside the responsibilities of ERDA.

Comment (p. 2):

> "In general, we feel that the proposed final statement adequately addresses the impacts on outdoor recreation. However, we believe that ...further consideration should be given to the positive recreation impacts that properly planned site areas and transmission lines could provide...."

ERDA Response:

ERDA agrees that multiple uses of land, including recreation, is desirable where secondary uses do not pose public health and safety questions. The thought that transmission right-of-ways could be used for recreation may have merit and should be examined more thoroughly. It is not clear, however, what specific energy R&D (which, as you know, is ERDA's responsibility) could be undertaken to enhance the prospects for recreational use of right-of-ways.

Perhaps the National Park Service, or some other appropriate agency within Interior, could make an assessment of multiple uses of transmission corridors. ERDA would be pleased to cooperate relative to energy R&D required for such multiple uses.

Comment (p. 2):

> "Waste handling is not adequately discussed. At present, sufficient processing facilities are not available, and there is no prospect that this shortage will soon be remedied. It is conceivable that a storage problem of immense proportions with no immediate solutions in sight could occur. Consequently, we are concerned that the loss of plutonium or any other radioactive wastes by any route appears to be neither adequately guarded against nor discussed."

ERDA Response:

Waste handling was discussed in considerable detail in the PFES. Present waste handling systems were described in Sections 4.5 and 4.6 of Volume II of the PFES and future systems were discussed in Section 7.3 of Volume IV. Additional information on the waste management program is provided in

Section III D of the Final Environmental Statement. It is true that sufficient fully operational fuel reprocessing facilities are not available at the present time. However, it is not strictly correct to state that there is no prospect that this shortage will soon be remedied. It is presently expected that the Allied-General Nuclear Services fuel reprocessing plant near Barnwell, S. C. will begin operation in the near future. In any event, it is expected that sufficient spent fuel storage capacity will be made available using reactor storage basins, expanded if necessary, and existing and projected storage capacity at fuel reprocessing plants (at Morris, Ill., Barnwell, S.C. and West Valley, N.Y.) to preclude a "storage problem of immense proportions with no immediate solutions in sight." See the March, 1975 ERDA report--"1975-1984, LWR Spent Fuel Disposition Capabilities," ERDA-25 for additional information on the storage of spent fuel. The safeguards to prevent the diversion of plutonium or radiaoctive wastes were discussed in Section 7.4 of Volume IV of the PFES and additional information on the safeguards program is provided in Section III C of the FES.

Comment (p. 2):

> "The data presented in the sections on alternative fossil fuels are out of date; at the minimum, references to the relevant Project Independence Task Force reports should be added. Some sections have the appearance of good literature searches by individuals lacking prior specific knowledge of fossil fuels. In general, the potential contributions of nonatomic energy sources to our economy appear to be understated."

ERDA Response:

Concerning your comment on updating information, we are sure you recognize the difficulty of keeping all material current in a publication of the scope and magnitude of the LMFBR Program Environmental Statement. Our approach in preparing the Final Statement was to review any new information, including that in the Project Independence reports, and make an assessment relative to whether it would change the conclusions reached in the PFES. If so, we prepared new material to be published as an addendum; otherwise the effort involved in updating would not seem justified.

With respect to your comment that non-nuclear contributions appear to be understated, you should note that a number of cost-benefit studies were run (see Section 11) including some that assume a phaseout of all nuclear contributions. The results of these studies demonstrated, we believe, the importance of developing a breeder reactor. In all cases examined, non-nuclear energy sources provided at least 65% of our total national

energy need in the year 2000. Additional cost-benefit analyses including alternative energy option strategies are presented in Section III F of the FES.

Specific Comments

Comment (p. 3):

> "Volume I, Subsection 1.6.1.2. Increased Use of Current Nonnuclear Energy Production Systems
> There are no problems foreseen to limit the use of coal by electric utilities to the extent suggested. The efforts to develop systems to control the environment by the use of coal would appear to be no more formidable than those involving the LMFBR. The use of coal for home heating is currently limited and its use will undoubtedly decline in the future."

ERDA Response:

Since the referenced section of the PFES contains no quantitative data on the limits to coal use, we are uncertain as to the source of your objection. The PFES did point out that there are major environmental problems associated with the use of coal and "Research and development efforts that are being intensified to find means for alleviating these problems must be successful if coal is to maintain or increase its current role in the power generation market." We agree that increased use of coal is necessary if we are to meet our short-term and medium-term energy goals; the coal R&D program has good potential for success, but we still believe this success is necessary if coal is to maintain or increase its share of the power generation market. With reference to your comment on home-heating, it would seem likely that the successful development of coal-conversion processes (e.g., pipeline gas) could increase the home-heating market for coal.

Comment (p. 3):

> "Volume 2, Subsection 4.1.2. Availability of Plutonium and Uranium
> The Energy Research and Development Administration (ERDA) stockpile of depleted uranium, recently reported to be 220,000 tons in form of depleted UF_6, is not included in Section 4 or in Section 5, although it would be of significance in the LMFBR program. This stockpile represents a large supply of fertile uranium for use in the LMFBR and is approximately equal to the production of depleted uranium, projected in Table 4.1-1, page 4.1-8, for 1973-1984. The maintenance, processing, and transportation of

this stockpile material would have significant environmental and economic impact."

ERDA Response:

The omission of this stockpile was arbitrary since it is government-owned and is small when compared with the 1,530,186 metric tons of depleted UF_6 projected to be available by the year 2000 as a by-product of the nuclear reactor power program (Table 4.1-1, p. 4.1-8). However, it was noted on p. 4.1-7 of Volume II along with the observation that it could be used for fuel in LMFBRs. The environmental impact of UF_6 in the LMFBR fuel cycle has been assessed in Section 4.3 (Fuel Fabrication) and in Section 4.5 (Transportation) of the Proposed Final Statement. Thus the information required for assessing the environmental impact of this stockpile, if used in LMFBRs, is already available in the Statement. The environmental impact of the fuel cycle is independent of which stockpile is used as a source of fertile material for LMFBRs.

Comment (p. 3):

"Volume 2, Subsection 4.4.1.2 Status of Reprocessing Technology This Subsection indicates that the reprocessing of spent LMFBR fuels is the subject of a development program that is expected to be successful. However, the reprocessing of spent fuels in the light water reactor program has not been successfully demonstrated on a commercial scale, and a shortage of reprocessing capacity is becoming a serious problem. There is little basis for a prediction that LMFBR fuel reprocessing technology will be developed when needed."

ERDA Response:

The reprocessing of spent LWR fuel and of future LMFBR fuel relies on well established technology--the Purex solvent extraction process which has been used successfully in several commercial-scale facilities at the Hanford and Savannah River plants for over 20 years. The first commercial LWR fuel reprocessing plant (Nuclear Fuel Services) used the Purex process in recovering values from 244 metric tons of spent fuel, from which over a ton of plutonium was separated and purified. Several operational difficulties were encountered, which can be corrected if the owners proceed with stated plans to modify and increase the capacity of the plant.

For LMFBR fuel, a head-end process for converting the spent fuel into a feed solution compatible with the Purex process is under development. There is really no question that this can be done, but it will require a careful development and demonstration program to assure that a reliable and maintainable process has been achieved.

Comment (p. 3):

"Volume 3, Subsection 6A1.1.2. Extent of Energy Resources Reserves at cutoff cost of $8 per pound U_3O_8, and even those at $10, appear unrealistic in view of price increases leading to a market price of $16 per pound U_3O_8 in early 1975. Also, it is doubtful that reserves can be mined at the indicated costs because of recent increases in operating costs. The reserve-resource position is changing because of continuing increases in operating costs and market prices."

ERDA Response:

Based on data furnished by the uranium mining industry, ERDA re-assesses its estimates of U.S. uranium reserves annually. The latest assessment is given in the following Table:

Estimated Uranium Ore Reserves, January 1, 1975

Cutoff Costs $/lb U_3O_8	Short Tons U_3O_8
$8	200,000
$10	315,000*
$15	420,000*
$30	600,000*

*Includes the lower cost reserves

Additions to $8 reserves in 1974 contained an estimated 13,000 tons of U_3O_8. However, 12,600 tons of U_3O_8 were mined and shipped to mills, and 77,000 tons were subtracted from the prior year estimate of 277,000 tons and added to higher cost reserves. This adjustment was primarily due to inflation.

Estimated operating and forward capital costs are used by ERDA. Profit and "sunk" costs, such as expenditures for property acquisition, exploration and mine development, are not included. Therefore, the cutoff cost figures do not represent the price at which the estimated reserve would be sold.

Comment (p. 4):

"Volume 3, Subsection 6A1.1.2.3. Estimated Availability and Consumption of Uranium
Requirements of 12,000 tons U_3O_8 per year should be defined as we believe actual needs as first-core and replacement fuels are

probably only about half that amount. We suggest the 12,000 tons U_3O_8 may be market commitments or enrichment feedstock demand."

ERDA Response:

The point is well taken. The sentence should read: "Uranium production in the U.S. is currently at a rate of about 12,000 tons of U_3O_8 per year..." (See revision to text in Section III A of the FES.)

Comment (p. 4):

"Volume 3, Subsection 6A1.1.2.4. Potential Effect of Advanced Enrichment Process on Resource Conservation
We do not know why gas centrifuge enrichment is not included here, even though the technology is more advanced than that for laser enrichment."

ERDA Response:

The gas centrifuge process would evidently not have a significant impact on U-235 conservation in comparison with prospective laser enrichment processes, and so was not discussed in this subsection. The footnote on page 6A.1-21 directs the interested reader to a reference containing information on prospective centrifuge enrichment costs in comparison with those of the gaseous diffusion process.

Comment (p. 4):

"Volume 3, Subsection 6A1.2.2 Extent of Energy Resource
Thorium resources reported in Tables 6A1-15 and 6A1-16 are different from those reported by the Bureau of Mines and the Geological Survey. However, these Tables substantiate the lack of a thorium resource problem."

ERDA Response:

The Bureau of Mines and Geologic Survey figures could easily be used in lieu of those found in other source documents. However, as noted, the intent was merely to point out an apparently adequate resource base for thorium fuels.

Comment (p. 4):

"Volume 3, 6A2. Fossil Fuels for Central Station Electric Power Generation

The Table on the contribution of fossil fuels to our total energy needs contains several errors. Also, the date of the data should be shown. The oil production shown is crude oil only, while natural gas liquids appear to be included in imports. Coal production should exceed coal consumption by the amount of net exports. The natural gas data do not correspond to the Bureau of Mines data for 1972, which otherwise appears to be the data of the Table. The Bureau of Mines data are shown on page 44 of the 1973 Mineral Industry Survey."

ERDA Response:

The Table on p. 6A2-1 of the PFES, taken from ref. 1 (Oct. 1973), was not intended to be a most-current statistical digest reflecting the latest minute changes in the contributions of various primary fuels to the total national energy consumption. The point is that the fuels with the smallest indigenous reserve base, oil and natural gas, have been (and are) jointly supplying about 75% of the total energy consumed in the U.S.

Comment (p. 4):

"Volume 3, 6A2.1.1.3. Status
The Bureau of Mines estimates that 31.6 percent of economically recoverable coal can be obtained from surface mines (see Mineral Industry Survey, 'Demonstrated Coal Reserve Base of the United States on January 1, 1974'). Coal production increased from 416 million tons in 1960 to 603 million tons in 1970. Although the number of mines decreased, there was a marked increase in the size of new mines. Competition from cheap natural gas and increased oil importation was not as restrictive on coal demand as is suggested."

ERDA Response:

As indicated on p. 6A2-4, there is some uncertainty regarding the strippable fraction, and estimates have ranged as high as ~35%. The Bureau of Mines estimates, as reported in Weekly Energy Report, (pp. 6-7, July 15, 1974), gives a total minable reserve of 434 billion tons, composed of 297 billion tons by underground mining and 137 billion tons by surface mining, which corresponds to 31.6% strippable. Of the surface mining component, about 67 billion tons are regarded as economically accessible, which corresponds to 15.4% economically extractable by strip mining. This estimate falls within the 3 to 18% span cited in the PFES.

Your indicated increase in domestic coal production between 1960 and 1970, which corresponds to a compound growth rate of 3.8%/yr., is accurate. The production rate in every year since 1970, however, has been lower. CY 1975 coal production is expected to exceed that for 1970 by about 5% and the net annual production rate will doubtless increase markedly in the future.

We do agree with your last statement. The five factors cited on p. 6A2-4 of the PFES are the reasons, from all available information, for few new coal mines being opened during the 1960's.

Comment (p. 5):

> "Page 6A2-54
> The statement regarding 'one-third mineral matter' should be checked. Oil shale is more nearly 85 percent mineral matter."

ERDA Response:

The statement regarding mineral matter in oil shale should read "generally contains over one-half mineral matter." For 16 samples of Green River oil shales with grades (assays) of 10.5 to 75.0 gallons oil/ton shale, the inorganic mineral content varied from 43% (min.) to 63% (avg.) to 93% (max.); see p. 41 of Synthetic Fuels Data Handbook (Cameron Engineers, Inc., 1975).

Comment (p. 5):

> "Page 6A2-56, toward bottom of page
> The 24 million is the figure for metric tons. A more recent figure could be given but a fair indication of growth is indicated in the last part of the last sentence on this page."

ERDA Response:

Difference between short and metric tons is ~10%, which is probably less than the uncertainty in the cited 1971 Soviet oil shale production.

Comment (p. 5):

> "Page 6A2-57, middle of page
> We suggest mentioning the Mowming shale center in the Province of Kwang Tung, which probably produces more shale oil now than the Manchurian oil shale facilities."

ERDA Response:

We do not know the status of the shale center in Kwang Tung Province. To the best of our knowledge the information in the PFES is accurate.

Comment (p. 5):

"Page 6A2-57, next paragraph
The stated views about oil shale in this paragraph should be deleted unless there is good reason to believe that it is well-founded and that Federal policy would promulgate this viewpoint."

ERDA Response:

The views stated are not necessarily those of ERDA but were reported by Gustafson (ref. 85) and by Welles (ref. 88) and have been expressed by many for decades. This critical viewpoint, which is balanced by the last paragraph on p. 6A.2-57, will be retained.

Comment (p. 5):

"Page 6A2-58, top of page
This sentence, which begins on the preceding page, without any other information to accompany it, especially recent information, does not give an adequate description of shale oil economics."

ERDA Response:

The subject sentence isn't intended to give an adequate description of shale oil economics. It is simply a conclusion reached by Prien in 1971, as stated, and is in the section titled "Historical Aspects and Status."

Comment (p. 5):

"Page 6A2-58, next sentence
Prototype leasing has more than just begun. Four tracts have already been leased. Two others, the Wyoming tracts, were offered but did not attract any bids."

ERDA Response:

The information in the PFES was current at the time it was written. It is true that two additional tracts have since been leased.

Comment (p. 5):

"Page 6A2-58, same paragraph, last sentence
It would not be accurate to say that the goal of the leasing program is production of 1 million barrels per day. There is no other leasing program at present."

ERDA Response:

Your comment is valid. Although the leasing program Environmental Statement considered the impact of producing 1 million barrels per day by 1985, apparently additional leasing programs not covered in the Environmental Statement would be required to accomplish the 1 million barrel/day goal.

Comment (p. 5):

"Page 6A2-62, top of page
It is suggested that 'in some retorts' be inserted in connection with the 2200°F."

ERDA Response:

Regarding the 2200°F, this is already qualified by "local temperatures as high as about..."

Comment (p. 5):

"Page 6A2-62, next paragraph
Some of the gas is recycled, but some is vented from the system."

ERDA Response:

The text wording is already qualified by "usually recycled."

Comment (p. 6):

"Page 6A2-65 and Page 6A2-66, toward bottom of page
Cost figures go out of date quite rapidly. It would be better to mention more recent estimates, or in some way acknowledge the rapid escalation. See Project Independence Oil Shale Task Force report."

ERDA Response:

Cost estimates for shale oil production have indeed risen to approximately four times the costs published in the Fall of 1973. Some recent estimates are ∿$11/bbl. Still later estimates are up to $14/bbl (see Weekly Energy Report, p. 6, April 28, 1975). This tends to strengthen the conclusion that oil from shales will not be an alternative to the LMFBR for power production.

Comment (p. 6):

> "Page 6A2-67, toward top of page
> The sentence describing shale oil as 'more than competitive' does not give a proper picture of the economic status of shale oil. We suggest referencing the Project Independence Oil Shale Task Force report."

ERDA Response:

The subject sentence on p. 6A.2-67 is a quote from Prien (see bottom of p. 6A.2-57 and top of p. 6A.2-58 of the PFES), related to the immediately preceding cost estimate announced by TOSCO in 1971.

Comment (p. 6):

> "Volume 3, 6A4. Geothermal Energy
> This report overlooks the non-electrical applications which would reduce the demand for electricity as opposed to increasing supply. The emphasis in the last paragraph on the word may, implying that geothermal may not be available in time, is misleading. At best it is a question of timing, for the technical problems are less severe than many which have been faced in the past, the prime example being nuclear energy."

ERDA Response:

The PFES notes (see p. 6A.4-31) the potential uses of geothermal energy for other than electricity production including producing: (1) desalted water, (2) commercial minerals and gases, and (3) process or space heat. It is true that no credit for reduced electricity demand as a consequence of these potential applications was considered because this would be minor. The use of geothermal energy for producing desalted water and industrial process heat would displace the fuels normally used in these applications--presently gas and oil. To have a significant impact on electricity consumption for home heating would require that geothermal reservoirs and population centers coincide; this is presently not the case.

Concerning your comment that the word "may" implies that geothermal energy "may not be available in time," we can only note that if the timing of geothermal energy development is on the maximum schedule envisioned by most experts, the development of advanced coal and nuclear energy systems would still be required.

Comment (p. 6):

> "Volume 3, 6A2.2.2 Natural Gas and Oil
> The data cited on domestic oil and gas production, consumption, and deficits are all 'pre-crisis' and do not reflect current trends. A reference to the Project Independence report would be useful.
>
> "The probable cost of Arctic gas now greatly exceeds the $1.10 per Mcf which is cited."

ERDA Response:

Domestic oil and natural gas reserves continue to be depleted and were smaller at the end of CY 1974 (34.3 billion barrels and 237.1 TCF, respectively) than a year earlier.

Concerning Arctic gas, at least $1.10/MCF is the text wording; the probable cost is now ∿$2/MCF and will likely rise to ∿$3/MCF by the time it's made available.

V.88-1

1721-19th Street, N.W.
Washington, D.C. 20009
April 26, 1975

Mr. W. H. Pennington
Assessment Officer
U.S. Energy Research and Development Administration
Washington, D.C. 20545

Dear Mr. Pennington:

I am unalterably opposed to the development of the liquid fast metal breeder reactor because of the emphasis on the use of plutonium and the resulting unconscionable risk to the safety and health of the public and future generations. It would be a legacy fraught with peril and incalculable difficulties, reason of itself to reject the program as a rational answer to our energy needs.

The vulnerability of all segments of the project to sabotage and terrorism will pose security problems that will inevitably threaten our already eroded civil liberties.

Finally, the cost overruns are of a magnitude that would be better applied in the development of non-nuclear energy sources.

Any one of the above arguments should, in my opinion, be sufficient to justify terminating the program. Taken together, they constitute an irrefutable case.

Very truly yours,

Wanda Bollentin

(Ms.) Wanda Bollentin

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Ms. Wanda Bollentin
1721 19th Street, N.W.
Washington, D.C. 20009

Dear Ms. Bollentin:

Thank you for your letter of April 26, 1975 commenting on the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Your comment on "the use of plutonium and the resulting unconscionable risks to the safety of and health of the public and future generations" encompasses a number of issues. These issues have been extensively examined in WASH-1535, "Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program," most specifically in Volume II of that document. WASH-1535 has been incorporated as Section II of the Final Environmental Statement (FES) and supplemental material bearing upon the safety of LMFBR's and the environmental issues relating to waste management and safeguards are provided in Section III of the FES.

Your comment that "The vulnerability of all segments of the project to sabotage and terrorism will pose security problems that will inevitably threaten our already eroded civil liberties," is not supported by the safeguards record of the nuclear industry. From the beginning of the atomic energy program in the United States, the safeguards system has been continuously modified as appropriate to reflect the growth of nuclear activities, both military and commercial, and changes in technology and in social conditions. Although questions have been raised on the adequacy of safeguards, to date there has never been an instance of the theft or disappearance of significant quantities of special nuclear material. Recognizing that safeguards needs continue to change, the Nuclear Regulatory Commission is conducting two comprehensive safeguards studies -- one in connection with the implementation of plutonium recycle and the other concerning the need for a federal guard force to safeguard special nuclear material. In both studies, the civil liberties aspects of proposed safeguards systems are being carefully evaluated.

A copy of the Final Environmental Statement is enclosed for your information. It is hoped that your review of the Statement will alleviate your concerns. Thank you for your interest in the LMFBR Program.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosure:
Final Environmental Statement,
LMFBR Program

FEDERAL ENERGY ADMINISTRATION
WASHINGTON, D.C. 20461

May 1, 1975

OFFICE OF THE ASSISTANT ADMINISTRATOR

FEA 75-34

Mr. James L. Liverman
Acting Deputy Assistant Administrator
for Environment and Safety
Energy Research and Development
Administration
Washington, D.C. 20545

Dear Mr. Liverman:

This is in response to your letter of January 17, 1975, requesting our comments on ERDA's Proposed Final Environmental Statement, WASH-1535 - Liquid Metal Fast Breeder Reactor (LMFBR) Program.

We find that ERDA has presented a comprehensive analysis of the LMFBR's environmental impacts.

Our comments address electrical energy demand projections, LMFBR program element comments, LMFBR safety, and plutonium carcinogenicity.

We find that projections in the EIS for electrical energy demand are based on information existing about a year ago. FEA has under way a number of national conservation and demand management programs which we believe will help reduce the growth of demand in the next 10 years to about 5% per year, and in the period, 1985 to 2000, to about 6% per year. These reduced growth rates, if achieved, would result in electrical demand during the period, 1985 to 2000, which is about 25% lower than the ERDA estimate.

This reduced demand projection may provide additional flexibility in developing our domestic fuel resources. However, even this reduced capacity requirement cannot be fully met by other domestic fuels using current and projected technologies. Therefore, we are dependent on the continued

use of nuclear generated electricity to meet our needs. We must recognize that the viability of the nuclear option beyond the mid-1980's depends on continued availability of nuclear fuels and, in particular, on the demonstration of commercial breeder reactors. For these reasons, and in view of the schedular uncertainties involved in bringing any new and complex technology to the point of commercial application, it is especially important to continue with ERDA's present LMFBR demonstration program.

Whereas we believe it is in the best interest of the Nation to continue the breeder demonstrations, we encourage ERDA to continue the parallel development of direct solar conversion and fusion programs such that they may contribute substantially to our energy base sometime in the next century. However, both of these alternatives have substantial technological problems, and therefore the breeder reactor may prove critical in satisfying the electrical energy demand growth in the first part of the next century.

We suggest that the discussion on the fuel fabrication and reprocessing plants, on the nuclear energy centers, and on the detection of plutonium could have been given more detailed analysis in the statement. These aspects of the program are discussed in more detail in Attachment 1.

We believe there exists additional technical information, discussed in Attachment 2, which could more adequately portray the safety of the LMFBR demonstration plant. Such information, if it were included in the environmental impact statement, would provide a more complete picture, reduce some of the ambiguity, and therefore minimize the uncertainty regarding LMFBR safety in the present statement.

Our final concern relates to the human health effects of plutonium as discussed by Arthur R. Tamplin and Thomas B. Cochran in their comments on the draft environmental impact statement. Our comments on this subject are presented in Attachment 3.

In light of the recognized need to develop energy technologies for the early twenty-first century, we believe ERDA should proceed with the demonstration program. The demonstration of the breeder is a significant and perhaps critical element to the strategy of meeting this Nation's growing demand for electrical energy. At the same time, we are concerned that meeting our future energy requirements not be completely

dependent upon the success of a single concept. We therefore suggest that ERDA continue to give full consideration to developing alternative breeder concepts so that they can either supplement or replace the LMFBR, if needed.

We hope that our comments will be helpful to you in your further consideration of this proposed program.

Sincerely,

Roger W. Sant
Assistant Administrator
Energy Conservation and
Environment

Attachments

Attachment 1

LMFBR Program Element Comments

1. Currently Feasible Alternatives for Fuel Fabrication and Fuel Reprocessing Plants

Sections 7.2.2 and 7.2.3 discuss the Currently Feasible Alternatives for Fuel Fabrication Plants and Fuel Reprocessing Plants. In these sections, and in other sections of the document, statements are made to the effect that current releases are thought to be as low as practicable but that additional measures could be taken which could reduce these releases below what is considered to be as low as practical (Section 4.4.5.3.2). These statements as presented carry two implications:

(a) That the current as low as practical standards are inadequate to protect against unacceptable environmental impacts, and

(b) That measures taken to continually reduce the releases from the fuel recycle plants and the LMFBR powerplant are environmentally desirable.

Other sections of the report (i.e., Section 1.4.2.1) conclude that currently obtainable releases are within presently established environmental and public safety standards. If this is a correct conclusion, the statements such as those in paragraph 2, Section 7.2.2.2, indicating that current releases from the fuel-fabrication plant could be reduced to one ten thousandth of present practice, should be put in perspective to indicate that presently achievable releases are acceptable and that any improvements have off-setting environmental and economical costs.

Implication (b) above tacitly assumes that the measures taken to reduce nuclear plant effluents do not result in any adverse environmental impact. We question this tacit assumption on the grounds that the economic costs alone are indicative of the need for supplies and materials whose production results in environmental impacts from other industries involved.

In addition, upgrading the nuclear facilities to produce these marginal environmental benefits may result in making less energy available to the ultimate consumer. This follows since energy is an essential ingredient to the well-being of our society and actions which impair the supply of adequate amounts of energy could have adverse environmental and health effects upon society.

There obviously is a trade-off between reducing the environmental impact from nuclear facilities at the expense of increasing the environmental impacts by other segments of industry, and settling for a reasonable but less rigorous standard for the nuclear industry with the benefit of reducing the overall environmental impacts from the non-nuclear segments of industry. The need to balance these two opposing factors should have been pointed out in the statement.

2. Nuclear Energy Centers

(a) Need for New Criteria:

Paragraph 1, page 7.2-15, Vol. IV indicates that, "Before nuclear energy centers can be constructed, present nuclear powerplant site criteria will have to be modified somewhat and new criteria developed for application to such centers." Although this statement is not strongly relevant to the subject of the statement, it is important to an evaluation of the viability of nuclear energy centers, and as such relates to the manner in which LMFBR's might evolve. Evaluation studies on nuclear energy centers are underway by several different agencies, i.e., National Science Foundation, Nuclear Regulatory Commission, etc. Hence, it would have been helpful if the basis for this conclusion could have been developed in more specific terms.

(b) Decommissioning - Role of Nuclear Energy Centers:

Nuclear energy centers offer an advantage in the decommissioning of nuclear facilities, in that they provide increased flexibility over dispersed sites for permanent use of the site.

The larger size of these centers would provide greater opportunity for building new facilities on or adjacent to decommissioned facilities, thus minimizing the number of contaminated sites that must be kept under surveillance. Also, should there be an accumulation of ground contamination, the larger centers could accommodate to the situation more easily than smaller dispersed sites.

(c) Attractiveness of Nuclear Energy Centers in Wartime:

The last paragraph of Section 7.4.9.4.2, page 7.4-81 states in effect that the targeting of nuclear energy centers in wartime would be masked by the overall consequence of a massive strategic attack. Accepting the validity of this statement, it nevertheless fails to take into account that nuclear energy centers, because of their large concentrations of electric power and economic resources, are more likely to become strategic targets than would a number of smaller dispersed sites.

3. Detection of Plutonium

Paragraph 1, page 7.4-34 and other parts of the report indicate that portal monitors can detect the passage of 1 gram of unshielded plutonium, in any of the forms in which it could be found in the LMFBR Fuel Cycle. The implication is that this is adequate protection to insure against the unauthorized and clandestine removal of plutonium from the plant. Obviously, one-half gram amounts of plutonium could be taken out of the plant on two different occasions, or one-fourth gram quantities removed in four separate operations, etc., and achieve the same objective as by removing one gram at a time. Thus, there is a need to discuss the possibility of frequent clandestine removal from the plant of small amounts of plutonium which may not be easily detected but which, when accumulated, could produce the larger amounts needed for sabotage and terrorist activities.

Attachment 2

The Safety of LMFBR's

The section on accident analysis (4.2.7) could be improved by directly addressing available alternatives with respect to safety problems of the LMFBR program. It is our conviction that sufficient information is available to make any ambiguity about the safety of this program unnecessary.

The following sentences illustrate the sense of uncertainty and ambiguity to which this observation refers: Page 4.2.135 - "It is an objective of the development program to provide a protection system of sufficient sensitivity to assure that appropriate corrective action can be taken to prevent a minor defect from developing into a major leak." Page 138 - "Work is under way to develop an improved experimental and analytical basis for assessing the consequences of potential sodium fires and design features to mitigate such events." Page 143 - "This program, together with other efforts on preventing or providing early detection and control of possible events that could lead to core disruption, should provide a sound basis for decisions on treatment of core disruptive accidents in commercial LMFBR's." Page 156 - "Extensive programs are under way to develop and confirm designs of effective and reliable plant protective systems."

It is our opinion that, after many years of research and development, there exist practical answers to a number of questions sufficient to allow the establishment now of quite clear designs for at least the construction and operation of a demonstration plant.

There is little question that core disruption is likely to occur if power is lost to the primary pumps while the reactor is at full power, and if the reactor is not shut down by control rod action. Since this kind of accident is a central issue for public acceptance of LMFBR's, the EIS should more accurately reflect the fact that design features can and will be included in the demonstration plant to mitigate its consequences.

1. Safety Research

If failure-to-scram is postulated, in conjunction with such low-probability events as loss of forced coolant circulation, reactivity will rise and the core must inevitably be at least partially disassembled. (This point is made in Section 4.2.7 of the statement.) Given the postulated scram failure, the question then is how violent could the disassembly become?

At this point, it seems to us, a fundamental distinction should be made between probability, as it is used in the evaluation of risks, and uncertainty, as it affects the analysis of HCDA's in LMFBR's. In the latter case, uncertainty means lack of knowledge. The spectrum of HCDA scenarios of varying severity that is associated with a particular initiating event does not represent a collection of real possibilities, each with some likelihood of occurrence; rather it suggests a range of conceivable trajectories, some one of which is the real one that the system will follow, given the postulated initial conditions--but we don't yet know which one. The problem in hand is not whether a nuclear excursion of some particular magnitude is sufficiently unlikely (in addition to the low probability of the postulated initiating event) to pose an acceptable low risk to the public. The problem instead is to show that this conceivable event, given the initial conditions, will occur (in which case the system must be able reliably to accommodate it) or it will not occur (in which case it can be ignored altogether). (The preceding is admittedly somewhat oversimplified, in order to underscore what we believe to be an important aspect of the current status of LMFBR safety analysis.)

This situation is discussed fully in a recent report to ERDA (ERDA-1) dated December 13, 1974, of an LMFBR Program Review Group established in October 1974 by the Atomic Energy Commission. It is the conclusion of this study group (pp. 57-58 and p. 4 of Attachment 10) that there is a reasonable expectation that within the next few years (quite possibly before the review of the CRBR for an operating license) sufficient advances will be achieved in LMFBR safety technology to preclude altogether the more severe core disruptive accidents that could challenge the adequacy of presently proposed containment techniques. It seems to us that it is the strong expectation that this will be the outcome of further LMFBR safety research that largely justifies the continuing forward march of the program, including the timing of the heavy investment in the demonstration reactor. This expectation is not based only on the progress of the last few years, which has eliminated some of the older extreme postulates; it arises also from

the recognition of specific phenomena which, when better understood and more quantitatively described, will probably alter substantially the calculated behavior of the system. These include the so-called frothing phenomenon, which is expected to modify the behavior of molten fuel in such a way as to limit possible rates of reactivity addition and perhaps to prevent achievement of prompt criticality.

2. Safety Design Features

Pending the results of the presently vigorously-pursued safety research program, there are other steps which could be taken now to adopt firm design features. We believe that there do exist practical answers sufficient at least for the establishment of clear design features for the construction of a first demonstration plant and that emphasizing these features in the EIS would improve public acceptance of the program. We suggest that the following two elements be included.

(a) Protection Against a Core Disruptive Accident

A core disruptive accident is the accident most feared by the public and should be faced in a straightforward manner. Sections 4.2.7.6.1 through 4.2.7.8.2 provide a good summary of the current status of the R&D program on LMFBR safety and fairly represent the differing opinions on individual facets of the safety program. However, Annex B (pp. 4.2-206 to 4.2-229), giving a discussion of safety criteria for the first demonstration plant, indicates a desire to avoid any serious consideration of the HCDA. Options are to be left open for later inclusion of such accidents should the project be forced to consider them, but this hypothetical event which is on every critic's mind is avoided as a subject of discussion. In contrast, on pp. 4.2-160-161, it is pointed out that reactor studies by Atomics International and Babcock and Wilcox had as a design basis the criterion that the HCDA should be accommodated.

The core disruptive accident is likely to occur if power is lost to the primary pumps while the reactor is at full power and if the reactor is not scrammed by control rod action. The first of these if's is a possible occurrence,

so the second must be made extremely unlikely. Annex D, page 4.2-234 gives the following conclusion by a panel of experts who met last April: "There was a general consensus that all design approaches should assure positive termination of any nuclear chain reaction. This should be achieved by use of independent and diverse shutdown systems, and should include both diverse and independent trip signals, information channels, and neutron absorbers." This is a simple statement and should represent the minimum design criterion and should be reflected in the EIS. In contrast, Annex B, dealing with the CRBR, says simply, "Two independent shutdown systems will be provided," and remarks that failure of either system is highly unlikely. The latter statement is not borne out by experience, and experts believe that it will be extremely difficult to assure the required reliability and independence of two systems. This should be clarified to indicate how the problem of leak detection and prevention would be handled in such a case.

(b) Natural Convection Heat Removal System

For one final example, there is a paragraph on page 4.2-108 that discusses the desirability, and possibility, of designing reactors in which the decay heat can be removed by an independent natural convection system. This is a very attractive feature of the LMFBR, for it basically means that if the reactor can be shut down by getting one set of control rods in, then the further safety of the system is assured without the necessity of continued operation of any of the normal components. For example, loss of power to the sodium pumps could be tolerated. While the CRBR Project has stated their intention to provide for removal of decay heat by natural circulation, the EIS leaves uncertainty as to whether the design feature will indeed be adopted. We believe that a stronger postion could and should be taken with respect to decay heat removal by natural circulation noting particularly that CRBR will have this capability as have the FERMI, FFTE and EBR-II designs.

In conclusion, we believe that the discussion of LMFBR accidents is lacking in several respects. It should have been a clear statement of (a) the achievements already made in the past 20 years of safety research in the definition and projected course of possible accidents, (b) the character and significance of present uncertainties in the analysis of LMFBR accidents, (c) the anticipated impact of further LMFBR safety research in clarifying the need - or lack of need - for various protective devices, and the reason for optimism concerning the outcome of this research, and (d) the adoption of design features for safety available now which is capable of removing a number of unnecessary uncertainties in the current situation. .

Attachment 3

Plutonium Carcinogenicity

Arthur R. Tamplin and Thomas B. Cochran made the following comments in response to the draft EIS comment request. Their comments are reprinted in Volume V, pp. V. 6-1 through V. 6-61 of the proposed final environmental statement.

> "On November 13, 1973, and December 26, 1973 we submitted for consideration in the preparation of this Draft Environmental Statement on the LMFBR Program, our comments relative to the carcinogenic hazard of plutonium. Subsequently, on February 14, 1974, we submitted a petition to AEC and EPA asking for radiation protection standards that would be 115,000 fold more restrictive than the present standards when insoluble alpha-emitting hot particles were involved. In support of this petition and for consideration in the Draft EIS, we submitted a 50-page report detailing the scientific bases for the requested modification of the standard (1).
>
> "Upon receipt of copies of the Draft Environmental Impact Statement we were appalled at the treatment of the problem in Particle Lung Dose Effects, Volume II, Part 2, pages 4.G-89 to 4.G-105. These pages are shallow, self-serving and not supportive of the conclusion that the average lung dose is appropriate for estimating the health consequences from hot particles."

In light of available scientific facts it is mandatory that these comments by Tamplin and Cochran be fully assessed. Their position is based on two unsubstantiated and highly questionable assumptions:

a. Presence of a "critical particle activity" for plutonium exposure, and

b. Extrapolation of rat skin data to plutonium exposure in the human lung.

1. "Critical Particle Activity"

The concept of a "critical particle activity" by Tamplin and Cochran (1-p.32) is very central and essential to their "hot particle" theory, which suggests that a specific level of tissue damage must occur before the carcinogenic response occurs. It is apparently based primarily on the induction of cancer by alpha-irradiation of rat skin by Albert and his associates (2, 3, and 4). However, such is not analogous to lung exposure to plutonium and cannot be so extrapolated with any degree of validity. Results of studies with rats vary with rat strains, and results of comparable studies of irradiated mouse skin have not given results identicial to the rat experiments. Since the "critical particle activity" concept is crucial to the Tamplin and Cochran thesis, the lack of appropriate biological supportive data would put the whole analysis in doubt. As a matter of fact, Tamplin and Cochran themselves admit that particles less than this critical size can be considered on the basis of an average dose to the lung.

Between the part in Section IV-B (page 14) of the Tamplin and Cochran Report (1), where it is stated that "it will be shown that biological data strongly suggests that for such particles we should use a DF=1 grossly underestimates the DE for Pu," no biological data is presented in support of the thesis. Some data is indirectly referenced by quoting general summary statements to support such a conclusion.

Consideration of mechanisms of radiation carcinogenesis suggests that there has been no change in direction or strength of data which would compel departure from the concept that average lung dose for alpha particles provides a reasonable and conservative base for protection. In support of the above, it is interesting to note that the referenced work of Bair (5, and 6) in beagles are used by Bair, Richmond, and Wachholz (7-p. 39-42) to show "that the mean dose to lung from Pu particles is a biologically reasonable basis for expressing the quantitative relationship between tumor incidence and alpha-radiation dose."

2. Human Skin Lesions From Plutonium Exposure

In discussion of human dermal lesion from accidentally implanted plutonium, Tamplin and Cochran (1-p. 27) quote directly from Lushbaugh and Langham (8) as follows, "The autoradiographs showed precise confinement of alpha-tracks to the area of the epidermis; where epithelial changes typical of ionizing radiation exposure were presented. The cause and effect relationship of these findings, therefore, seem obvious. Although the lesion was minute, the changes

in it were severe. Their similarity to known precancerous epidermal cytologic changes, of course, raised the question of the ultimate fate of such a lesion should it be allowed to exist without surgical intervention." However, Tamplin and Cochran omitted the following sentences from the same paragraph of Lushbaugh and Langham (8), "Although no malignancies of the skin of man have ever been shown autoradiographically to be associated with such alpha-emitting foreign bodies, the changes here would seem to indicate that the development of such a lesion is possible." Although the average radiation dose within the lesion was estimated to be an incredible 75 million rad over the 4 1/4 years exposure period, there was no malignant cellular transformation as required for the diagnosis of cancer. No such cytological changes have ever been found next to "hot particles" in human tissue.

Tamplin and Cochran (1-p. 28) describe a supposed plutonium particle induced cancer in a worker, but such is not a proved positive example of plutonium exposure. It's categorization as such is conservatively justified from a legal viewpoint in the face of circumstantial indicators. But it would not seem to be a firm foundation on which to base exposure criteria. Tamplin freely admits that the case is not "clear-cut."

3. Human Inhalation Exposure to PuO_2

Mann and Kirchner (9) reported on an October 1965 fire in a plutonium fabrication plant resulting in a large-scale spread of plutonium oxide. The Rocky Flats body counter was used to measure the plutonium in the lungs of all employees working in the area, and, of approximately the 400 employees counted, 25 were found to have enough plutonium in their lungs to deliver a dose of 15 rem per year or greater (i.e., at least 0.016 uCi). Of the above 25 people, two had burdens as high as 0.16 uCi, a factor of 10 above the current maximum permissible lung burden. Of those workers available for follow-up, most are measured for retained activity several times a year. Thus far, 9 years after exposure, there is no evidence of cancer or other pathology.

Tamplin and Cochran (1) discredit 14 of the 25 Los Alamos Manhattan Project (10) workers as possible "hot particle" cases because their exposure was due to the inhalation of a plutonium solution rather than an aerosol of PuO_2 particles. It is claimed that only the latter is capable of setting up a "hot particle" situation. However, there still remain 11 workers who meet their "hot particle" standard. It is now more than 27 years after their PuO_2 exposure--well after the period in which cancers should start to appear if such

were going to develop. If the cancer risk for such "hot particles" were 5 x 10^4 per particle, as postulated by the Natural Resources Defense Council report (Tamplin and Cochran-1), the 4 x 10^5 particles present should yield about 200 cancers per man. The observed lung cancer incidence for these workers after almost 30 years since first exposure to plutonium is zero.

The above data is additional information that tends to support the general argument that the radiation protection guides for plutonium have not been grossly in error. In the more than three decades that plutonium has been used there has been no recorded incidence of cancer in man resulting from the internal deposition of plutonium or any of its isotopes. This excellent record has resulted from extremely effective safety and control methods. Data from occupationally exposed workers are not relevant for establishing value judgement where experimental data is not always conclusive for formulating risk evaluations.

4. Report on Plutonium Toxicity by the Medical Research Council of Great Britain

The Committee on Protection against Ionizing Radiation of Britain's Medical Research Council in January 1975 summarized and reported on present knowledge concerning potential hazards to man of plutonium. This group of 13 eminent scientists and doctors concluded that "there is at present no evidence to suggest that irradiation of the lung by particles of plutonium is likely to be markedly more carcinogenic than when the same activity is uniformly distributed" (11).

Quoting from the Committee's Report (11): "The conclusions of Tamplin and Cochran cannot be any better founded than the hypothesis on which they are based, and that is too tenuous to be worth further discussion here. Tamplin and Cochran also put themselves in the difficult situation that the risk is considered to be decreased by a factor of 115,000 if a particle containing 0.1 pCi plutonium were to break into two equal halves."

Accordingly, in all British calculations, dose is averaged throughout the lung in accordance with current ICRP concepts.

5. Conclusions

Bair, Richmond, and Wachholz (7), concludes as follows:

> "After 30 years' experience with plutonium in laboratory and production facilities, there is no evidence that the mean dose lung model on which occupational radiation protection standards for

> plutonium are based is grossly in error or leads to hazardous practices. Currently available data from occupationally exposed persons indicate that the non-homogenous dose distribution from inhaled plutonium does not result in demonstrably greater risk than that assumed for uniform dose distribution. Thus, empirical considerations lead to the conclusion that the nonuniform dose distribution of plutonium particles in the lung is not more hazardous and may be less hazardous than if the plutonium were uniformly distributed and that the mean dose lung model is a radiobiologically sound basis for establishment of plutonium standards."

Also, one can conclude that the mean dose concept represents a very conservative approach to the establishment of permissive limits for plutonium provided the radiation protection criteria for lung exposure is based on a limiting rad dose.

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2. Albert, Roy E., Fredric J. Burns, and Richard D. Heimbach, "The Effect of Penetration Depth of Electron Radiation, on Skin Tumor Formation in the Rat," Radiation Research, 30, 515-524 (March 1967).

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4. Albert, Roy E., Fredric J. Burns, and Richard Heimbach, "The Association Between Chronic Radiation Damage of the Hair Follicles and Tumor Formation in the Rat," Radiation Research, 30, 590-599 (March 1967).

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7. Bair, W. J., C. R. Richmond, and B. W. Wachholz, "A Radiobiological Assessment of the Spatial Distribution of Radiation Dose from Inhaled Plutonium," p. 47, WASH-1320 (September 1974).

8. Lushbaugh, C. C., and J. Langham, "A Dermal Lesion from Implanted Plutonium," Archives of Dermatology, 86, 121-124 (October 1962).

9. Mann, J.R., and R. A. Kirchner, "Evaluation of Lung Burden Following Acute Inhalation Exposure to Highly Insoluble PuO_2," Health Physics, 13, 877-882 (1967).

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UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Mr. Roger W. Sant
Assistant Administrator
Energy Conservation and
Environment
Federal Energy Administration
Washington, D. C. 20461

Dear Mr. Sant:

Thank you for your letter of May 1, 1975 commenting on the Proposed Final Environmental Statement (PFES) for the Liquid Metal Fast Breeder Reactor (LMFBR) Program. We are pleased that you found the PFES to contain a comprehensive review of the LMFBR's environmental impacts and we appreciate your support for continuation of the LMFBR demonstration program. We note the FEA suggestion that ERDA continue to give full consideration to developing alternative breeder concepts so that they can either supplement or replace the LMFBR, if needed. We intend to do this.

In your letter you state that FEA national conservation and demand management programs could result in electrical demand growth in the 1985 to 2000 period which is 25% less than the ERDA estimate. Please note that the cost-benefit analysis considered a range of electric power demand projections which included cases for a 50% demand reduction (see p. 11.2-58 of the PFES). In addition, cost-benefit cases assuming a 25% electric power demand reduction have been evaluated and are presented in Section III F of the Final Environmental Statement.

ERDA responses to the comments in the attachments to your letter are enclosed. Thank you again for your comments and for your interest in the LMFBR Program. Copies of the Final Environmental Statement are enclosed for your information.

Sincerely,

James L. Liverman
Assistant Administrator for
Environment and Safety

Enclosures:
1. ERDA Staff Responses to Specific FEA Comments
2. Final Environmental Statement, LMFBR Program (5 copies)

ERDA Staff Responses to FEA Comments

FEA Comment (Pages 1 and 2, attachment 1):

> "...statements are made to the effect that current releases are thought to be as low as practicable but that additional measures could be taken which could reduce these releases below what is considered to be as low as practical (Section 4.4.5.3.2).
>
> "...statements such as those in paragraph 2, Section 7.2.2.2, indicating that current releases from the fuel-fabrication plant could be reduced to one ten thousandth of present practice, should be put in perspective to indicate that presently achievable releases are acceptable and that any improvements have off-setting environmental and economical costs.
>
> "There obviously is a trade-off between reducing the environmental impact from nuclear facilities at the expense of increasing the environmental impacts by other segments of industry,...The need to balance these two opposing factors should have been pointed out in the statement."

ERDA Response:

While we agree completely with the cautionary note, we did not think it appropriate for the Environmental Statement to include assessments and judgments that basically have to be made by regulatory and standards-setting groups. We did not, however, mean to imply that cost-effectiveness or other trade-offs should not be examined as a basis for deciding whether additional control measures are worth the effort and expense. We believe this should be done (see footnote page 4.4-45).

FEA Comments (page 2, attachment 1):

> "Paragraph 1, page 7.2-15, Vol. IV indicates that, before nuclear energy centers can be constructed, present nuclear powerplant site criteria will have to be modified somewhat and new criteria developed for application to such centers...it would have been helpful if the basis for this conclusion could have been developed in more specific terms."

ERDA Response:

The referenced conclusion is more a judgment than a hard assessment. It seems to us that the co-location of many power plants, associated fuel cycle facilities, and possibly large industrial complexes using the energy, would require some evolution in various regulatory criteria and evaluation factors. The results of the on-going evaluation studies

will probably provide a basis for more specific judgments on this matter.

FEA Comment (pages 2 and 3, attachment 1):

> "Nuclear energy centers offer an advantage in the decommissioning of nuclear facilities, in that they provide increased flexibility over dispersed sites for permanent use of the site..."

ERDA Response:

We agree that this is an apparent advantage of nuclear energy centers.

FEA Comment (page 3, attachment 1):

> "The last paragraph of Section 7.4.9.4.2, page 7.4-81 states in effect that the targeting of nuclear energy centers in wartime would be masked by the overall consequence of a massive strategic attack. Accepting the validity of this statement, it nevertheless fails to take into account that nuclear energy centers, because of their large concentrations of electric power and economic resources, are more likely to become strategic targets than would a number of smaller dispersed sites."

ERDA Response:

Yes, but the scenario implies nuclear warfare and many other targets. Under those circumstances, it seems to us that whatever extra radiation might be released would be a secondary consideration in the face of direct weapons effects.

FEA Comment (page 3, attachment 1):

> "Paragraph 1, page 7.4-34 and other parts of the report indicate that portal monitors can detect the passage of 1 gram of unshielded plutonium in any of the forms in which it could be found in the LMFBR Fuel Cycle. The implication is that this is adequate protection to insure against the unauthorized and clandestine removal of plutonium from the plant...there is a need to discuss the possibility of frequent clandestine removal from the plant of small amounts of plutonium which may not be easily detected but which, when accumulated, could produce the larger amounts needed for sabotage and terrorist activities."

ERDA Response:

The substantial quantities of plutonium (kilograms or tens of kilograms) required to produce significant illicit consequences could not be accumulated, through repeated thefts of small quantities, in any reasonable period of time by an individual or a reasonably sized group of individuals working in concert. The probability that such an ongoing operation would be detected and interrupted prior to completion, by safeguards mechanisms other than portal monitors, is high. Considering these and other factors, we conclude that the risk associated with this scenario is vanishingly small, and that discussion in the PFES is not required.

FEA Comment (page 2*):

> "We believe there exists additional technical information, discussed in Attachment 2, which could more adequately portray the safety of the LMFBR demonstration plant. Such information, if it were included in the environmental impact statement, would provide a more complete picture, reduce some of the ambiguity, and therefore minimize the uncertainty regarding LMFBR safety in the present statement."

*See Attachment 2, "The Safety of LMFBR's," for detailed FEA comments.

ERDA Response:

ERDA staff fully agrees with the FEA that Section 4.2.7 of the PFES does not emphasize important items such as the existence of numerous practical answers to safety questions, and believes that these are sufficient to allow clear and adequate plant designs. There is a large body of knowledge on fast reactor safety already made available by the R&D program, along with presently available alternatives to accommodate remaining problems and uncertainties. ERDA staff agrees that in all major substantive technological areas, the basic state of understanding will allow, for example, the establishment of designs for the construction and operation of a demonstration plant. This contention and the resulting design of course are the subject of review by competent regulatory authorities (NRC, ACRS).

ERDA staff also agrees that Section 4.2.7 of the LMFBR Program PFES overemphasizes uncertainties, problems, and ambiguities related to safety questions, and that these two factors appear to permit the erroneous conclusion that there are major problems or uncertainties that are not amenable to orderly and planned resolution in the safety R&D program. This lack of balance is indicated by the fact that

several commentors appear to base their comments on the premise that an LMFBR cannot be designed to be adequate from the safety standpoint. This situation arises from an understanding that an EIS is to emphasize matters of potential public concern and resulted in an inadequate exposition of the fact that the vast majority of potential problems have been addressed and resolved.

In an attempt to remedy this inadequacy, the following supplementary material is being provided in the FES:

1. Additional information relative to the Division of Reactor Research and Development LMFBR safety development plan.

2. Additional information on energetic LMFBR core disruptions, including remarks prepared for an ACRS-HCDA Working Group.

3. Additional information on the basis for proceeding with the designing, licensing, and operation of LMFBRs while the LMFBR safety program progresses.

4. Additional information on LMFBR risk assessment methods development.

FEA Comments (pages 1-5, attachment 3):

These comments were basically observations made regarding the comments of the Natural Resources Defense Council (NRDC) regarding the AEC responses in the PFES to the NRDC comments on plutonium toxicity in the Draft Environmental Statement on the LMFBR Program. They deal with the concept of "critical particle activity" and its experimental basis (alpha-irradiation of rat skin), human skin lesions from plutonium exposure/implantation, inhalation of PuO_2 by humans and the report by the Medical Research Council of Great Britain concerning the "hot particle" hypothesis.

It was concluded that "...the mean dose concept represents a very conservative approach to the establishment of permissive limits for plutonium provided the radiation protection criteria for lung exposure is based on a limiting rad dose."

ERDA Response:

ERDA agrees with the FEA comments and would further point out that the risk per "hot particle" (1 in 2000) advocated by the NRDC is obtained from rat skin studies involving a specialized anatomical unit of the skin, the hair follicle, which has no known analogue in the lung. In

addition, the effectiveness of irradiation of the rat skin was demonstrated only when a) the most sensitive portion of the hair follicle received an optimum dose, and b) the entire hair follicle was irradiated. A single "hot particle" located in the hair follicle could not accomplish this. In these studies the entire skin was also irradiated. The fact that there is no structure in the lung equivalent to the hair follicle, that even if there were such a structure, a single "hot particle" could not irradiate the entire structure, that there is no suggestion as to how or why a "hot particle" would selectively locate in such a structure if it did exist, that if such a structure did exist its special radiosensitivity is not known, and that the 1 in 2000 factor is based on atrophied hair follicles and not irradiated hair follicles, all tend to cast doubt on the validity of assuming a 1 in 2000 risk for "hot particles." Given that the 1 in 2000 risk ratio cannot be demonstratively supported for the human lung, the minimum activity of the "hot particle" which would induce such a risk becomes academic.

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May 30, 1975

W. H. Pennington
Office of the Assistant Administrator
Energy Research and Development Administration
Washington, D. C. 20545

Dear Mr. Pennington:

I am writing to you to request that the enclosed documents, and not others in your possession, be included in the record of the hearing on the Proposed Final Environmental Statement on the Liquid Metal Fast Breeder Reactor Program and that they also be attached to the Final Environmental Statement.

1. Testimony of the Scientists Institute for Public Information presented on May 28, 1975.

2. The chapter entitled "Summary".

3. The chapter entitled "Projections of Future Electrical Demand."

I am addressing an identical letter to Mr. Robert W. Fri.

Sincerely,

Diane Yale Sauter

Diane Yale Sauter
Project Director
Task Force on the LMFBR Program

Enc.

This is recycled paper.

Testimony

in regard to the

Atomic Energy Commission's

Proposed Final Environmental Statement

on the

Liquid Metal Fast Breeder Reactor Program

Public Hearing before the

Energy Research and Development Administration

May 28, 1975

Diane Yale Sauter
Project Director
Task Force on the LMFBR Program

Scientists' Institute for Public Information
30 East 68th Street
New York, New York 10021

It is requested that this document be attached to ERDA's Final Environmental Statement.

The Proposed Final Environmental Statement (PFES) on the Liquid Metal Fast Breeder Reactor (LMFBR) Program justified the need for breeder development by an inflated projection of growth in future electrical energy demand. This amounted to a nine-fold increase in per capita installed capacity from 1972 to 2020. It was inaccurate to begin with, by assuming a continuation of the historical 7.8% annual growth till 1980, with a gradual reduction till 2020 to 3.7%. In 1974, electrical demand actually decreased .56% below the 1973 level.

The projection of electrical demand was based on assumptions of future population growth, size of work force, rates of labor productivity, total energy demand, and gross national product. In our comments on the PFES, we analyzed each parameter. We noted that in every case these were high in comparison to estimates of other experts, either because the data used were several years old, or because of an unwillingness to accept the relevance of circumstances which changed dramatically in 1974.

The PFES, dated December 1974, used a 1972 Bureau of the Census population projection, although these figures are issued several times a year. The estimate assumed a fertility rate of 2.1 children for each woman, leading to a population in 2000 of 271 million people. The 1975 Bureau of the Census estimate for a fertility rate of 2.1 has dropped to 262 million, or 3.4% less. In 1974, Electrical World's population estimate extrapolated to 2000 would be 256 million, or 6% less. In 1974, the Council on Environmental Quality assumed a fertility rate of 1.8, yielding

a population in 2000 of 250 million, or 8% less. In fact, the actual rate has dropped each year since 1972, and was 1.8 in 1974, with no factors developing that suggest a reversal in this trend. The latest Bureau of the Census projection for a fertility rate of 1.7 is 245 million people by 2000, which is 10% below the assumption of the Atomic Energy Commission (AEC).

The AEC assumed that changes in age composition of the population, which affect the size of the work force, would not be apparent until the late 1990s. The McGraw-Hill Economics Department expects the labor force to grow less rapidly beginning with the late 1970s due to changes in age composition.

The AEC assumed a 2.6% increase in labor productivity per employee per year continuing till 2020. McGraw-Hill predicts a 2.3% increase till 1988, as a result of the decline in 1974 alone.

The AEC assumed a historical total energy growth rate of 4.0% till 1980, declining to 3.5% growth till 2000, and then 3.2% till 2020. In fact, total energy demand dropped 3.3% in 1974 compared with 1973.

The AEC assumed a continuation of the historical GNP growth rate of 3.7%. While in September 1973 Electrical World agreed with that projection through 1990, by September 1974 they had revised their projection to 1995 to 3%. That was prior to the actual fourth-quarter 1974 decline of almost 9.5%. In March 1975, the Electrical World projection for 1975 was -2.3%.

The PFES failed to consider such future events as a return to "intermediate technology" which is less energy-intensive, an increase in the service-oriented portion of the economy, market saturation of certain electrical uses, the use of recycled metals in industries, such as aluminum and steel, that are highly electricity-intensive when using primary ores, etc.

The PFES also failed to consider the effects of price elasticity on demand. In 1974, seventy-eight utility companies requested price increases, tripling the amount per increase over 1970. In itself, the average 1974 price increase of 24%, using the Chapman, Tyrrell and Mount analysis, should lead to an eventual demand 36% lower than it would otherwise have been. A drop of 18% should be apparent by 1981.

Chapman et al projected a low electrical demand of 2.01 trillion kwhr in 2000, or 81% less than the AEC base case/of 10.6 kwhr for that year. The 1974 experience makes this seem far from impossible. The low projection / was based on an average annual electrical price increase of 3.3% over 1970 values for thirty years. In one year, 1974, the increase was 24%. This was coupled in the projection with a population growth of 1.4% per year; in 1974 it was 0.7%. The low projection maintained a GNP growth of 4%; in 1974 it declined 2.1%. Per capita personal income growth was projected at 2.9% per year; in 1974 unemployment reached close to 8%.

While we were encouraged to find that the Energy Research and Development Administration (ERDA) issued a pre-hearing statement in response to written comments, we found their revised

projection of demand still excessive. Of course ERDA will have to clarify its rationale and the values of the parameters used to reach this revised projection.

The revision would lower the base case for the year 2020 by about 25%, to about 21 trillion kwhrs, or over twelve times the 1.7 trillion kwhrs sold in 1974. It is stated that the -25% case would lower the 10% discounted benefits to about $14 billion. At the currently estimated R & D cost of over $10 billion, this yields a benefit/cost ratio of under 1.4.

Somewhat confusing was ERDA's statement that at -50% of the base case, which would be a demand of almost 14 trillion kwhrs in 2020, 10% discounted benefits would be reduced to about $10 billion. We found the gross benefit to be this high in the AEC's cost/benefit analysis in only one case, with a breeder introduction date of 1987, which is beyond possibility, and low uranium supply. Even here, with the given R & D cost less than half that now expected, the benefit/cost ratio was only 1.0.

Whereas the PFES cited demand projections made by the Federal Power Commission (FPC) from 1969 to 1973, we compared cases projected in 1974 by the FPC's Technical Advisory Committee on Finance. We found that the projection considered by the AEC to be 50% <u>below</u> their base case of 7.8% historical growth till 1980, was <u>above</u> the FPC projection for an all-electric case accelerated beyond historical growth in that period. Similarly, in 1990, the AEC -50% case was still above the FPC projection for historical growth.

Finally, the dynamics of profitability to nuclear manufacturers and utilities should not be confused with the public's true need for electrical power. ERDA's statement says that the AEC selected the LMFBR as its highest priority partly because of existing industry support. The AEC and the nuclear industry cooperated in the earliest days of defining the breeder project in 1969, and continued to do so to arrange for the development, design, construction and operation of the Clinch River demonstration plant.

For manufacturers and utilities, growth in kilowatt hour sales is crucial to maintaining acceptable earnings per share. Faced with shortages and rising costs of fossil fuels, they claim that growth in demand requires increased reliance on nuclear fuels, and continued reliance on nuclear capability requires an evolution to a breeder economy. This will protect the $80 billion already invested in the nuclear industry.

The Atomic Industrial Forum (AIF) has stated that "the long-term future of the nuclear industry is closely tied to the development of the breeder reactor". They have doubled their annual budget to $1.2 million this year to get their message across. Their education campaign includes an initial emphasis on informing ERDA, as well as the Nuclear Regulatory Commission, Federal Energy Administration, and key Congressional committees and their staffs.

We will therefore no doubt hear this afternoon an argument to support the conclusion that the electrical needs of this nation are so large and are likely to grow to such an extent that the breeder is an essential component of our energy future, particularly if we are to attain energy independence.

SUMMARY

One year ago the Atomic Energy Commission (AEC) released a Draft Environmental Statement on the Liquid Metal Fast Breeder Reactor Program. The Scientists' Institute for Public Information (SIPI) found this document grossly inadequate, and called for a new draft that seriously confronted "the complex issue of how best to produce and use the energy that is essential to the nation's future".

As one of its last acts, the AEC released a Proposed Final Environmental Statement on the breeder program, giving its successor, the Energy Research and Development Administration (ERDA), the option to adopt the Statement after review. While this revision made a cosmetic attempt to improve some of the blemishes exposed by commentors, it remains outdated, incomplete, inaccurate and misleading. This Statement continues to be an inadequate document upon which to base a decision that will influence the structure of society for decades to come.

Particularly, it fails to confront the impacts of changes of great magnitude that have occurred in the past six months, both within the agency responsible for issuing the Statement, and in the American nation itself. As a result, SIPI concludes that the Statement must be withdrawn by ERDA, and the breeder program must be completely reassessed, incorporating new comments made by the public, before presentation of a relevant environmental impact statement.

The Lead Agency

This Statement was prepared by the AEC, which was created by the Atomic Energy Act of 1946, amended in 1954, with the paramount objective of assuring and maximizing military defense and security

through the development and control of atomic energy. The AEC was abolished by act of Congress in 1974, and its nuclear research and development activities were inherited by ERDA.

ERDA has been assigned additional responsibilities under the Energy Reorganization Act of 1974, the Federal Nonnuclear Energy Research and Development Act of 1974, the Solar Heating and Cooling Act of 1974, the Solar Research, Development and Demonstration Act of 1974, and the Geothermal Energy, Development and Demonstration Act of 1974. While the Proposed Final Environmental Statement was mailed to commentors by the AEC, over the signature of James L. Liverman, on December 31, 1974, ERDA did not officially begin operation until January 19, 1975, although Dr. Robert C. Seamans, Jr. took office as Administrator on December 30, 1974.

ERDA's mandate is quite different from the AEC's: to increase the efficiency and reliability of the use of all energy sources to meet the needs of present and future generations, while advancing the goals of restoring, protecting and enhancing environmental quality, and assuring public health and safety. The various methods of utilitizing solar energy, whose contributions are minimized and difficulties exaggerated in the Statement, are specifically named as warranting priority by ERDA. Maximum conservation measures, simimarly minimized in the Statement, are also specified as an ERDA goal.

In addition to ERDA's Assistant Administrators in charge of nuclear energy and national security, there are also Assistant Administrators in charge of fossil energy; environment and safety; solar, geothermal and advanced energy systems; and conservation. While ERDA received a large transfer of personnel from the AEC,

there are also 1165 employees transferred from the Department of the Interior, the National Science Foundation, and the Environmental Protection Agency. It is apparent that their areas of competence are not reflected in the Statement.

A comparison is appended at the end of this introductory chapter, which details the many areas in which the responsibilities of ERDA differ from those of the AEC, including the dissemination of information to the public.

ERDA is required by June 30, 1975 to present to Congress the nation's first comprehensive plan for energy research, development and demonstration, to achieve short-term (to the early 1980's), middle-term (early 1980's to 2000), and long-term (beyond 2000) solutions. This plan is to be accompanied by a comprehensive program to implement ERDA's nonnuclear functions, and will include an evaluation of costs as well as economic, environmental, technological and social merits. This plan is currently in preparation, with the assistance of the Mitre Corporation, and TRW, Incorporated. It will have the benefit of review within sixty days by the congressional Office of Technology Assessment.

The National Environmental Policy Act (NEPA) specifies that the lead agency in a proposed action must prepare an original environmental impact statement and may not accept one "carte blanche" from another agency (Greene County vs. Federal Power Commission and Kalur vs. Resor). Through no fault of its own, ERDA has been placed in the position of having to answer to the public for a statement which it did not prepare, and which fails to satisfy its own mandate as well as several requirements of NEPA, including full disclosure to the affected community.

Fortunately, before the end of this fiscal year, ERDA should have a better idea of what place it considers the breeder program should have in a comprehensive national energy plan, and be able to begin preparation of a new statement with a more current data base.

An Example of the Statement's Definition of "Current"

In basic ways, the Proposed Final Environmental Statement (PFES) remains unchanged from the Draft Environmental Statement (DES). An example follows, taken from one small section of the Summary volume.

Volume I, Section 2.1 of the PFES, "Relationship of the LMFBR Program to the U.S. Energy Economy", is twenty-five pages long, and contains a total of seventeen figures and tables. Sixteen of these are identical with those that appear in the same section of the DES, and were generally produced in 1972 or earlier. The one addition to the PFES is a figure comparing 1968 per capita income and energy consumption.

The PFES Section 2.1.3.3., dealing with the "Current Situation" in the generation of electricity, presents Table 2.1-11, identical to the DES Table 2.1-11, giving U.S. electrical utility industry statistics for 1972. Similar statistics are published for 1973 and beyond in monthly issues of the Federal Energy Administration's Monthly Energy Review published in 1974, and so were certainly available to the AEC at the time the PFES was being prepared.

Several identical Tables (2.1-12, 2.1-13, 2.1-14) which were produced in 1972 contain projections of population, energy consumption, and/or generating capacity. (The PFES bases its projections for electrical demand on 1972 Bureau of the Census projections,

though these are revised several times a year.)*

Compared word for word, the PFES Section 2.1.3.4 dealing with "Projections of Future Electrical Demand" is substantively identical with the same section of the DES, with the substitution of "there is wide agreement" in one instance where "there is universal agreement" had appeared, and the addition of "but now we must add the expectation that electrical energy will be substituted for applications that had been served directly by dwindling oil and gas supplies".

To support its own projections of electrical demand, the Statement cites projections that were made by the Federal Power Commission (FPC) from 1969 through 1973 (pp 2.1-14,15). Yet projections released by the FPC in 1974 are substantially lower than these. A projection considered by the AEC to be 50% below their base case of historical growth of 7.8% per year till 1980 (p. 11.2-9) was above the FPC projection for an all-electric case accelerated beyond historical growth in that period. Similarly, the AEC -50% case was still above the FPC projection for historical growth till 1990.**

The Cost-Benefit Analysis

The Statement claims that "the range of variables explored in the cost-benefit analysis...(e.g. cases which assume a 50% reduction in the base case projection of electrical demand in the

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* Publications Order Form: Current Population Reports, U.S. Dept. of Commerce, Bureau of the Census, Form BC-2340, October, 1973.

** A Report to the Federal Power Commission by the Technical Advisory Committee - Finance, The Financial Outlook for the U.S. Electric Power Industry, December 1974 (Preliminary Release), pp. 72, 76, 139, 140.

year 2020) appears to provide adequate insight into the possible effects of major uncertainties in the assumptions used". It further claims that benefits are reduced below costs only when a number of assumptions are simultaneously weighted in a manner which is considered unlikely to occur (p. 11S-1).

We observe that these "unlikely" circumstances only begin to touch upon current and realistic interactions of the chosen parameters. It is from this point that ERDA may have to begin to prepare new input to the econometric model, providing current information on the delayed breeder introduction date, increased capital costs, lower energy demand compounded by all the parameters cited, more optimistic uranium supply, and increased research and development costs. A discussion of each of these parameters follows.

LMFBR Introduction Date

Of fifty-six cases run in this "updated" cost-benefit analysis which considered introduction of the LMFBR, only four possible dates were evaluated (Appendix IV.D):

Year of introduction	No. of cases considered/year
1985	6
1987	40
1988	4
1991	6

Yet the most recent pronouncement of the date of introduction* hoped for the generation of electricity by the breeder "in the early 1990s", if there was "extensive industrial and governmental

* Summary Sheet accompanying letter of transmittal, dated February 11, 1975, U.S. Atomic Energy Commission, along with Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program.

cooperation". This referred in part to the deferrment and cancellation by utilities of 170,000 out of 360,000 mw (47%) of generating capacity, in 1974, due to major financing difficulties.*

Therefore, at most, only 10.7% of cases run were possibly relevant. A meaningful Statement would have to consider several introduction dates beginning with 1991, reflecting a penalty for each year of delay. In the Statement, this penalty is described as follows: "Delaying the introduction date for the LMFBR reduces the benefits by $½ to 1½ billion per year of delay, with the exact value depending upon the uranium supply and the energy demand" (p. 11.2-15).

Capital Costs

The assumption is made in the Statement that a decrease will occur in the capital cost of the LMFBR, due to the learning process associated with the introduction of a new plant type, from $520/kwe in 1985 declining to $360/kwe in 2000, in 1974 dollars (p. 11.2-12).

Comparing this to the experience with light water nuclear reactors, we find an original estimate of $135/kwe raised to $240/kwe, then $350/kwe, and later to $400-$510/kwe. in an eight year period. In real costs, during the two years 1971 to 1973, this amounted to a $90 million capital cost increase for a 1000 mwe LWR.**

Research and Development Costs

While the maximum undiscounted research and development cost used in the Statement is $8.7 billion, or generally $4.7 billion at

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* "Utilities: Weak Point in the Energy Future", Business Week, January 20, 1975, p. 46.

**Power Plant Capital Costs, WASH-1345, U.S. Atomic Energy Commission, October 1974, pp. 6, 7, 8.

the accepted 10% discount rate (Appendix IV-D) the AEC estimated in January 1975 that it would require $10 billion of government funds plus substantial private funds to develop the breeder into a commercially viable energy option.*

Dr. Seamans himself has said, "The unstable financial situation has certainly contributed to problems in the development of the fast breeder...cost over-runs have far exceeded the rate of inflation."**

Electrical Demand

Although 1974 and 1975 have been designated "shrink years" that have caused the Edison Electric Institute, Electrical World, and the Federal Power Commission, as well as various electrical utility and manufacturing corporations to revise their former predictions of future electrical growth rates, the Statement explicitly rejects this course, considering it "most prudent" to center its own demand projections on historical experience (p. 11.2-55). This is in contradiction of its own admission that "Any projection model used to estimate electrical energy growth depends directly on the continued relevance of the parameters selected" (p. 11.2-57).

Parameters used in the Statement to predict future electrical demand are population growth, size of work force, rates of labor productivity, gross national product, and total energy demand (p. 11.2-53). These are inflated in the Statement in every case, either because the data used were several years old, or because of

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* Federal Register, Vo. 40, No. 17, January 24, 1975, p. 3806.

** "Speeches", Information from ERDA, February 26, 1975, p. 4.

an unwillingness to accept the relevance of changed circumstances. No serious evaluation was made of the future impact of the drastic declines which have occurred since September 1974, or of the possible impacts of proposed Federal programs such as Project Independence.

The cost-benefit analysis does not incorporate new information. It continues to assume the historic increase in electrical demand of 7.8% per year till 1980 (p. 11.2-9) whereas in 1974 demand actually decreased .56% below the 1973 level,*and the first two months of 1975 showed only a 4% increase. Instances are cited below where values of parameters used in the Statement deviate from those of other experts or from recent experience. These comments are offered not only for the percentage differences they suggest, but also as an evaluation of the Statement's methodology.

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*"1975 Annual Statistical Report", Electrical World, March 15, 1975, p. 66.

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Population

Source of projection	Estimated fertility rate	Population by the year 2000 (millions)	Difference from Statement's projection
* Statement, based on 1972 Bureau of Census	2.1	271	
** 1972 Dept. of Interior	2.4	279.9	+3%
*** 1975 Bureau of Census	2.1	262	-3.4%
**** 1972 Planned Parenthood	2.1	271	
***** 1974 Planned Parenthood		"to be revised"	
****** 1974 Electrical World (extrapolated)		256	-6%
******* 1974 Council on Environmental Quality	1.8	250	-8%
*** 1975 Bureau of Census	1.7	245	-10%

Moreover, the National Center for Health Statistics reported an actual United States fertility rate of 1.9 in 1973, with the rate continuing to decline in 1974.********

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* p. 11.2-53.

**p. 2.1-16.

***News Release CB75-29, U.S. Dept. of Commerce, February 10, 1975.

****Population Boom or Bust?, Planned Parenthood World Population, N.Y., October 1972.

*****Lawrence A. Mayer, "It's a Bear Market for Babies, Too", Fortune Magazine, December 1974, p. 137.

******Leonard M. Olmsted, "25th Annual Electrical Industry Forecast", Electrical World, September 15, 1974, p. 44.

*******A National Energy Conservation Program: The Half and Half Plan, Council on Environmental Quality, March 1974, p. 6.

********Dana Little, "Marriages on the Decline", New York Times, March 1, 1975, p. 18.

Size of Work Force

Statement: The effects of changes in age composition of the population, which affect the size of the work force, will not be apparent until the late 1990s (p. 11.2-53).

McGraw Hill: The U.S. labor force, because of the changing age composition of our population, will grow less rapidly beginning with the late 1970s.*

Labor Productivity

Statement: 2.6% increase/employee/year till 2020 (p. 11.2-53).

McGraw-Hill: 2.3% increase/employee/year till 1988.**

Gross National Product

Source	Annual growth rate
*** Statement projection	Historical (3.7%)
**** 1973 Electrical World projection	3.7% to 1990
**** 1974 Electrical World projection	3.0% to 1995
***** Actual GNP, 1974	-2.1%
****** 1975 Electrical World projection for 1975	-2.3%

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*Economics Department, The American Economy: Prospects for Growth to 1988, McGraw-Hill, Inc., N.Y., 1975, p. 4.

**Ibid., pp. 5, 6.

***p. 11.2-53.

****Olmsted, op. cit.

*****"1975 Annual Statistical Report", p. 44.

******Ibid.

Price Elasticity

Seventy-eight utility companies requested price increases in 1974, tripling the amount per increase over 1970.* Although the cost-benefit analysis does not consider price elasticity, the average 24% increase in the price of electricity in 1974 should, using the Chapman, Tyrrell and Mount analysis,** eventually lead to a demand 36% less than it would otherwise have been. A drop of 18% would be apparent in 1981, with a drop of 3.6% by the end of 1975.

Conclusion

WASH-1535, the Proposed Final Environmental Statement for the Liquid Metal Fast Breeder Reactor Program, is the obsolete vision of a now defunct agency. It would be tragic indeed if uncountable future generations of humans were committed to the irreversible effects and irretrievable losses imposed by breeder development, simply because proper evaluation of the program was impeded during an administrative transition.

With capital formation among the most serious problems facing the nation, continued investment in this program would inevitably foreclose the development of other energy options which ERDA, in its comprehensive plan, and with its expanded authority, may choose to emphasize.

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*"1975 Annual Statistical Report", p. 68.

**Duane Chapman, Timothy Tyrrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crises", Science, Vol. 178, November 17, 1972, pp. 703-8.

Comparison of the Mandates of the AEC Under the Atomic Energy Act of 1946 (and 1954, Amended) and ERDA Under the Energy Reorganization Act of 1974 and the Federal Nonnuclear Energy Research and Development Act of 1974

Paramount Objective

AEC

1946: To assure common defense, with development and utilization of atomic energy. So far as practicable, to improve the common welfare (Sec. 1(a)).

1954: To make maximum contribution to the common defense and security (Sec. 1(a)).

ERDA

ERA: To increase the efficiency and reliability of the use of all energy sources to meet the needs of present and future generations, while restoring, protecting and enhancing environmental quality and assuring public health and safety (Sec. 2(a)).

FNERDA:
To support the broadest range of energy policy options through conservation and use of domestic resources by socially and environmentally acceptable means (Sec. 3(a)).

Officers (in order of mention)

AEC

1954: General Manager,
Director of the Division of Military Application,
Director of the Division of Civilian Uses of Atomic Energy,
General Counsel,
Director of the Inspection Division (Sec. 25).

ERDA

ERA: Administrator,
Deputy Administrator,
6 Assistant Administrators of:
1) fossil energy
2) nuclear energy
3) environment and safety
4) conservation
5) solar, geothermal and advanced energy systems
6) national security

General Counsel,
Up to 8 additional officers,
Director of Military Application
(Sec. 102 (a) through (g)).

Primary Research and Development Responsibility

AEC

1954: R&D related to nuclear processes, atomic energy, utilization of nuclear and radioactive materials (Sec. 31 (a)).

ERDA

ERA: R&D, including demonstration of commercial feasibility and practical applications of the extraction, conversion, storage, transmission and utilization phases related to the development and use of energy from fossil, nuclear, solar, geothermal, and other energy sources (Sec. 103 (2)).
Priority might include but not be limited to various solar technologies (Sec. 2(e)).

Comprehensive Energy Policy Planning

AEC

Not included.

ERDA

ERA: Central responsibility for near-term and long-range policy planning, respecting all energy sources (Sec. 103(1)).

FNERDA:
To prepare an annual comprehensive plan for energy research, development and demonstration, in regard to short, middle, and long-term solutions, evaluating economic, environmental, technological and social merits, and including a program to implement nonnuclear aspects of the plan (Sec. 5(a)(2); 6(a) and (b), (1) through (3), (A) through (Q)).

Reports to Congress

AEC

1946: A report to Congress each January and July, concerning their activities, including recommendations for new legislation (Sec. 17).

1954: Same (Sec. 251).

ERDA

ERA: A report to the President and Congress at the end of each fiscal year concerning their activities, with a statement of short and long-range goals, priorities and plans, and assessment of progress (Sec. 307 (a)).
Note: The Nuclear Regulatory Commission has to submit a report with the same content as it relates to benefits, costs, and risks of commercial nuclear power, including design, abnormal occurrences and defects, safeguards, thefts, waste disposal, and protection against low-level radioactive emissions (Sec. 307 (c)).

FNERDA:
A report to Congress on or before each June 30 as in "Comprehensive Energy Policy Planning" above (Sec. 6).

Information to the Public

AEC

1954: Permits and encourages dissemination of scientific and technical information relating to atomic energy (Sec. 141(b)).

ERDA

ERA: Responsible for developing, collecting, distributing, and making available for distribution, scientific and technical information concerning the manufacture or development of energy and its efficient extraction, conversion, transmission, and utilization (Sec. 103(6)); for creating and encouraging general information to the public on all energy conservation technologies and energy sources, using mass communications where practicable (Sec. 103(7)); and for disseminating information from its policy planning efforts (Sec. 103(1)).

International Cooperation

AEC

1946: Maximum effect was to be given to policies contained in international treaties (Sec. 8).

1954: Same as above, but no cooperation was to be

undertaken in other instances until the President and Joint Committee approved the agreement (Sec. 121, 122, 123, 144).

ERDA

ERA: Encourages participation in international cooperation in energy and related environmental research and development (Sec. 103(9)).

Military Applications

AEC

1946: To conduct R&D into military applications of atomic energy, produce atomic weapons and deliver them to the armed forces (Sec. 6(a)).

1954: Same, to Department of Defense (Sec. 91).

ERDA

ERA: During first year of operation, to review desirability and feasibility of transferring all military applications to the Department of Defense or other Federal agency (Sec. 307(b)).

Health and Safety Research

AEC

1946: Relating to utilization of fissionable and radioactive materials for medical, biological, and health or military purposes (Sec. 3(a)(3)) and the protection of health during research and production activities (Sec. 3(a)(5)).

1954: Relating to utilization of special nuclear and radioactive material for medical, biological, agricultural, health or military purposes (Sec. 31 (a)(3)) and the protection of health and promotion of safety during research and production activities (Sec. 31(a)(5)).

ERDA

ERA: Engaging in and supporting environmental, biomedical, physical and safety research related to the development of energy sources and utilization technologies (Sec. 103(3)).

Conservation of Energy

AEC

Not included.

IA-5

ERDA

ERA: Encouraging and conducting R&D in energy conservation, toward goal of maximum reduction of total energy consumption and maximum improvement in efficiency of energy use (Sec. 103(8)).

CHAPTER III III-1

PROJECTIONS OF FUTURE ELECTRICAL DEMAND

SIPI's comments called for a detailed and careful discussion of the assumptions made in forecasting the growth of electric power demand over the next fifty years (SIPI, pp.IV-4,5).

The Statement's projection of electrical demand is as follows (pp.11.2-8, 58):

By the year:	Base case:	Possible range, -50% to +20% of base case: (in trillion kwhr)
2000	10.6	7.1 to 11.7
2020	27.6	13.8 to 33.0

This corresponds with a projected nine-fold increase in the per capita installed electric capacity between 1972 and 2020, from 1.92 kw per capita (population 208.2 million) to 17.5 kw per capita (assumed population 306.8 million)(pp.1.1-5, 6).

While the Statement acknowledges that "any projection model used to estimate electrical energy growth depends directly on the continued relevance of the parameters selected" (p.11.2-57), it has centered its base case on historical projection, which is defined as the "most prudent" course in the analysis of cost vs. benefit of the LMFBR program (p.11.2-55). The parameters selected were population growth, size of work force, rates of labor productivity, gross national product, and total energy demand (p.11.2-53).

Assumptions about each parameter formed the basis for assumptions about the next, until an estimate of electrical demand was finally derived from the last.

To support its position, the Statement uses projections of demand that were made by the Federal Power Commission from 1969 through 1973 (pp.2.1-14, 15). However, projections released by the FPC in December 1974 (the date of the Statement) are "substantially lower" than these, "partly explainable in terms of the passage of time and the occurrance of significant events".*

Table I follows, comparing the FPC 1974 seven-scenario projections of electrical output till 1990 with similar projections from Electrical World's 1974 forecast, input to the FPC's 1970 National Power Survey, and an FPC 1973 projection. All FPC projections quoted in the Statement are higher than the FPC 1974 scenarios, with the exception of the "all electric" Case IV, which represents an acceleration of historic growth.**

Figure I follows, showing the FPC seven-scenarios for output till 1990. We have interpolated the Statement's output projections for this period by adding 10% to the projected demand shown in Figure 11.2-5 on page 11.2-9. This was judged "honest" by Paul Wagner, manager of press relations, of the Edison Electric Institute, based on the historical relationship between sales, which have been equivalent to demand, and output.*** The

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* A Report to the Federal Power Commission by the Technical Advisory Committee-Finance, The Financial Outlook for the U.S. Electric Power Industry, December 1974 (Preliminary Release), p.72.

** Ibid., p.140.

*** Telephone interview, March 26, 1975.

Table I

U.S. Electric Power Industry [21]
Electrical Output, 1970-1990

	Cases I & IA Moderate Growth	Case II Historic Growth	Case III Low Growth	Case IV All-Electric	Case V Zero Growth	Case VI Topping Out	Case VII Modified Topping Out	For Comparison: Electrical World's 25th [22] Forecast	For Comparison: TAC-Power Supply Projections "Most Probable Case" [23]	For Comparison: FPC 1973 Projections in Statement [24] Table 2.1-12
Electrical Output (Trillions of kwh)										
1970 (actual)	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54		
1975	1.83	1.92	1.76	2.00	1.72	1.86	1.84	2.06		2.30
1980	2.63	2.81	2.41	2.99	1.86	2.58	2.32	2.77	3.30	3.29
1985	3.55	3.91	2.95	4.83	1.96	3.01	2.71	3.59	4.40	4.60
1990	4.64	5.38	3.42	7.40	2.09	3.16	2.99	4.64	5.80	6.54

Source:
Report to the Federal Power Commission by the Technical Advisory Committee-Finance, The Financial Outlook for the U.S. Electric Power Industry, December, 1974, p.73.

21 Source of 1970 actual data is "Statistical Year Book of the Electric Utility Industry", Edison Electric Institute, New York, New York. Excludes non-utility private power plant generation.

22 Electrical World, September 15, 1974.

23 Report to the Federal Power Commission by the Technical Advisory Committee on Power Supply, advisory to the FPC in connection with the National Power Survey.

24 1973 Federal Power Commission projection, reproduced in Table 2.1-12 of Proposed Final Environmental Statement, LMFBR Program, December 1974, Vol. I, p.2.1-15.

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U.S. ELECTRIC POWER INDUSTRY
ELECTRICAL OUTPUT
1965-1990

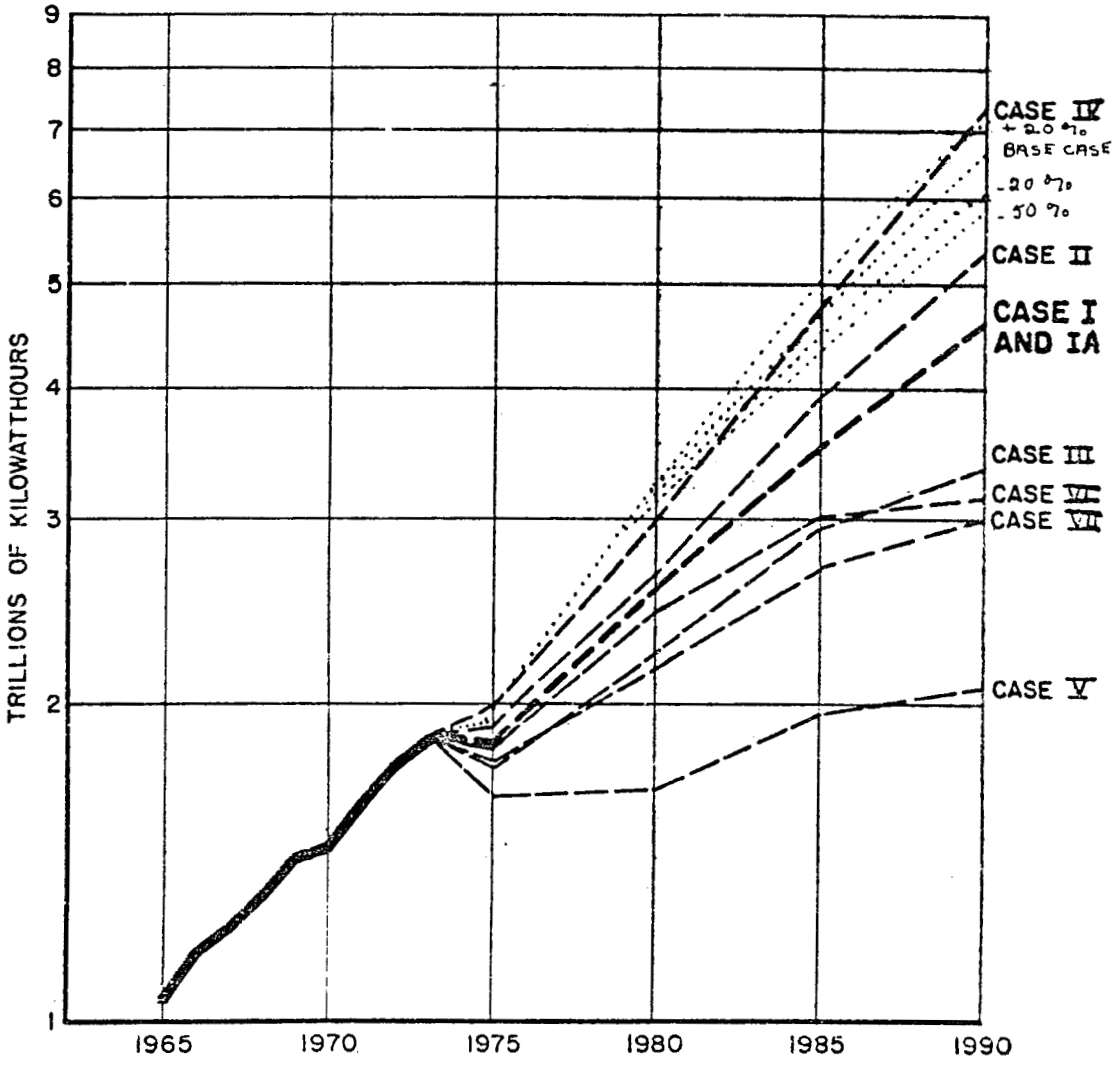


FIGURE I

Sources:

A) Cases I through VII:
Report to the Federal Power Commission by the Technical Advisory Committee-Finance, The Financial Outlook for the U.S. Electric Power Industry, December 1974, p.76.

B) +20%, Base Case, -20%, -50%
Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program, WASH-1535, Vol. II, December 1974, p.11.2-9.

10% is lost in transmission and in use by the utilities. Chapman et al add 9% for transmission losses to demand in order to derive generating requirements (output).*

The Statement claims that its model assumes historic growth of 7.8% per year till 1980, with a gradual reduction by the year 2020 to 4.2% in the +20% case, 3.7% in the base case, 3.0% in the -20% case, and 2.8% in the -50% case (p.11.2-9). Yet a comparison of the December 1974 projections by both the FPC and Statement shows that for the year 1980, all of the Statement's projections, including that for -50% of the base case, exceed the FPC projections for all cases including their highest growth, all electric Case IV.

By 1990, all of the Statement's projections, including that for -50% of the base case, are still above the FPC Case II, which represents historic growth, defined as a resumption of past trends after a moderate 1974 slow-down, with some moderation in the 1980's.** By 1990, the Statement's base case is 30% above the FPC's moderate growth Cases I and IA, which represent a moderation of past growth trends, after a sharp 1974 slow-down.*** The Statement's -50% case is 20% above Cases I and IA.

Other experts on electrical demand have recognized the need to revise their projections downward in the recent past. For

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* Duane Chapman, Timothy Tyrrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crisis", Science, Vol.178, November 17, 1972, p.707.

** Report to the Federal Power Commission, p.139.

*** Ibid., p.139.

example, the "24th Annual Electrical Industry Forecast" in the September 15, 1973 issue of Electrical World projected a total electrical sales in the year 1990 of 5.07 trillion kwhr, under the subheading "Utilities plan expansion to meet record demands".* By the time the "25th Annual Electrical Industry Forecast" was published in the September 15, 1974 issue, the sales projection for 1990 had declined over 17%, to 4.19 trillion kwhr, and the subheading read "Slower growth in sales and peaks sparks sharp cut in expansion plans..."**

Additionally, since September 1974, changes of great magnitude have occurred that have completely invalidated projections made before that time, and the situation remains uneven to this date.

Electrical World's consulting editor, Leonard M. Olmsted, author of the 1974 forecast, said in February 1975 that as late as September 1974 the projected growth of electrical sales in 1975 was for a historical 7% increase, but the rate is currently 4%. The projected growth rate for 1974 was 2%, but instead the rate declined by .5%, so that projection was off by 2.5%. Among factors that had not been anticipated were major industry shutdowns, as in auto manufacturing.***

In February 1975, Irving Levine, assistant director for public information for Con Edison in New York, said that projections

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* "24th Annual Electrical Industry Forecast", Electrical World, September 15, 1973, p.50.

** Leonard M. Olmsted, "25th Annual Electrical Industry Forecast", Electrical World, September 15, 1974, p.54.

*** Telephone interview, February 26, 1975.

six months old were obsolete - "There's a new energy ethic... it's a whole new ball game."* In March 1975, John R. Dyer, director of public relations of the Edison Electric Institute, said there are no projections of electric power demand that are meaningful at this time, and none can be generated until a condition of stability is reached again. He said the electrical industry now had to make short-term decisions (five to ten years) based on regional differences.**

In a chapter entitled "Current Situation" (p.2.1-12), a sentence is inserted which indicates there was some attempt to make the Statement seem current: "Over the past year, however, growth in the use of electric energy in the U.S. decreased to about 0.6% as compared with the 7+% growth rate of prior years" (p.2.1-13). However, the Statement denigrates the efforts of other experts to incorporate this new information in their future planning: "(R)elatively abrupt revisions in growth projections seem likely to be more a reaction to current uncertainties than to hard assessments of future demands" (p.1.1-7).

Accordingly, the cost-benefit analysis does not take into account these new circumstances. As stated, it assumes a historical increase in demand of 7.8% per year until 1980 (p.11.2-138), with growth in demand then falling in the base case to an average of 3.7% by 2020 (pp.11.2-8, 9).

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* Telephone interview, February 19, 1975.

** Telephone interview, March 17, 1975.

III-8

Beginning from 1980 only, and through 2020, cases were run in the Statement's model down to -50% of the base case projection, at which point the benefit-cost ratio was generally shown to approach or fall below 1.0, whatever the other variables, at the 10% discount rate (p.IV.D-3, 4). The Statement claims, however, that benefits are reduced below costs only when a number of assumptions are simultaneously weighted in a manner which is considered unlikely to occur (p.11S-1).

The table on page 11.2-140 indicates that -50% of base case demand would occur at an annual rate of increase of 3.6% in 2000, 2.8% in 2020, or an average of 4.6% between 1974 and 2020. It shows an annual rate of increase of 7.8% projected for 1974. The fact that the rate of increase has already fallen below the rate of 7.8% which was presumed till 1980 makes the attainment of a benefit reduced below cost far more likely than the Statement assumes. When Electrical World published the fact that total sales in 1974 dropped .56% below the 1973 level, it forecast, "1975 will turn out to be the second shrink year in a row, and significantly worse than we had expected only a few months ago."*

Discussion follows which describes the fallacy of particular assumptions upon which the Statement's demand parameters were based.

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* "1975 Annual Statistical Report", Electrical World, March 15, 1975, pp.66, 44.

Population

The Statement's forecast of future electrical requirements utilizes the 1972 E-series population projections of the Bureau of the Census, which, the Statement claims, "takes into account the recent sharp decline in fertility". It predicts the following population, in millions (p.11.2-53):

1980	1985	2000	2020
228	240	271	307

Population Estimates and Projections, from which these figures were derived (p.11.2-59), are issued by the Bureau of the Census approximately twenty times per year,* and we find it is curious that a Statement dated December 1974 would rely for its most basic parameter on estimates issued early in 1972. We are advised that even by December 1972, the E-series projection for the year 2000 had fallen 2.6%, to 264 million.**

More recent projections, released by the Bureau of the Census in February 1975,***indicate a population in the year 2000 of 262 million, assuming the E-series fertility rate of 2.1 births. (The fertility rate is the average number of births per woman upon completion of child-bearing). They also offer a lower population estimate for an assumed fertility rate of 1.7, which would yield a population in 2000 of 245 million. These two new 1975 estimates would alone yield between 3.4 and 10% less electrical demand than

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*Publications Order Form: Current Population Reports, U.S. Dept. of Commerce, Bureau of the Census, Form BC-2340, October 1973.

**Telephone advice from U.S. Dept. of Commerce Library, N.Y. District Office, February 11, 1975.

***News Release CB75-29, U.S. Dept. of Commerce, February 10, 1975.

the one used in the Statement.

While the Statement refers for support to the Department of the Interior's 1972 population projection of 279.9 million by 2000 (p.2.1-16), which assumed a fertility rate of about 2.4, it does not refer to the Council on Environmental Quality's projection of 250 million by 2000. This assumed a fertility rate of 1.8, which CEQ called "equivalent to a continuation of the present annual growth rate of 0.7%."*

There is reason to believe that the lower estimates may be sustained. The National Center for Health Statistics has released data showing that the 1973 fertility rate dropped below the replacement level of 2.1, reaching 1.9 children per family. In 1974, rates continued to decline, though not so steeply as between 1970 and 1973. Though the number of women in the child-bearing years increased 2% in 1974 over 1973, the number of births rose only 1%. At the same time, there was a decrease in marriage rates and an increase in divorce rates.**

A nationwide survey undertaken by the Roper Organization in the spring of 1974 concluded:

> Nearly half of American women and men think having two children is ideal - compared to only one in four who thought so in 1952 (p.64)...Attitudes of women today suggest a continuing down-trend in birth rates. Women in the prime child-bearing years - between 18 and 29 - are markedly less interested in having more than two children than women ten years older (p.68)...

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* A National Energy Conservation Program: The Half and Half Plan, Council on Environmental Quality, March 1974, p.6.

** Dana Little,"Marriages on the Decline", New York Times, March 1, 1975, p.18.

> Furthermore, only one in four women feels that having children is an impelling reason for marrying. And children are considered by only half of all women to be 'very important' to a good marriage (p.1). *

Planned Parenthood-World Population, which in 1972 used the same estimate of 271 million population by 2000** that was used in the Statement, said in December 1974 that "a new set of projections is due soon".***

In contrast to the Statement's projection of 271 million by 2000, the population projection found in the September 15, 1974 Electrical World, extrapolated to 2000****, would be 256 million, or 6% less. McGraw-Hill characterizes their forecast of 239 million by 1988 as "one-third slower than the gain in the 1958-73 years".***** In commenting on the slowing of the population growth rate, McGraw-Hill concludes, "there are no economic, social or environmental factors developing that suggest a reversal of this trend".******

Size of Work Force and Productivity Per Employee

In its projections of future electricity demand, the Statement estimates the size of the work force from the historical

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*The Virginia Slims American Women's Opinion Poll, Volume III, The Roper Organization, Inc., N.Y., 1974

**Population Boom or Bust?, Planned Parenthood-World Population, N.Y., October 1972.

***Lawrence A. Mayer, "It's a Bear Market for Babies, Too", Fortune Magazine, December 1974, p.137.

****Olmsted, p.44.

*****Economics Department, The American Economy: Prospects for Growth to 1988, McGraw-Hill, Inc., N.Y., 1975, p.4.

******Ibid., p.2.

population in the 18 to 64 age group (p.11.2-53). It states that the effects of changes in age composition of the population would not be apparent until the late 1990s (p.11.2-138). In contrast, the McGraw-Hill study predicts "...the U.S. labor force, because of the changing age composition of our population, will grow less rapidly beginning with the late 1970s than in earlier years".* The Statement does not consider changes in the unemployment rate,which is currently over 8%.

Similarly, the Statement assumes a continuation of the historical 2.6% increase in productivity per employee per annum (p.11.2-53). It does not consider changes in working hours, which the McGraw-Hill study predicts will be down 6% per employee by 1988,* or efforts at conservation of energy, which would reverse the increase in labor productivity. Although the McGraw-Hill study predicts a resumption of the 2.6% rate of increase after 1974, it estimates an over-all decline to 2.3% from 1973 to 1988 as a result of the decline in 1974 alone.**

While the McGraw-Hill forecast represents just one example of a difference in evaluation from that expressed in the Statement and does not extend to the full time period under consideration, this shows that variability of these parameters and the effect on electrical demand have not been adequately explored. The Bureau of Labor Statistics of the U.S. Department of Labor, for instance, discusses trends in the Occupational Outlook Handbook which is revised annually. No information from the Bureau of Labor Statis-

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* Ibid., p.4.

** Ibid., pp.5, 6.

tics was found in the Statement.

Gross National Product

Late in 1973, following a period of business expansion that began in 1970, the Federal Reserve Board's index of industrial production was at a peak of 127.5* This is the culmination of historical experience upon which the Statement based its projection of gross national product. Figures II through IV illustrate the abrupt decline of 12.2% that occurred, however, between September 1974 and February 1975. In January 1975, the month when ERDA began operation, the index fell to 113.7. It was the sharpest monthly reduction in output since December 1937. Albert Rees, director of the Administration's Council on Wage and Price Stability, has predicted that the present economic slackness "will persist for some time in the great majority of industries".**

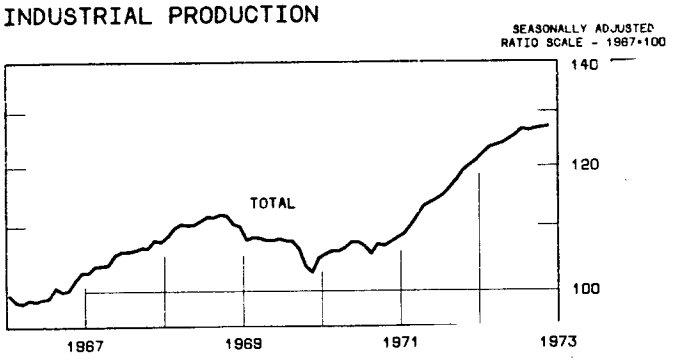
Real GNP had been growing at an annual rate of 3.7% since World War II, and as late as 1973, Electrical World continued to project this rate to 1990. On September 15, 1974, their projection was revised to 3% growth till 1995.*** In fact, real GNP declined 2.1% in 1974, with the fourth-quarter decline estimated at nearly 9.5%. A decline of 2.3% has now been forecast for 1975. This is the first time there have been two consecutive

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* Industrial Production News Releases, Federal Reserve Board, December 14, 1973 and March 14, 1975; and Vartanig G. Vartan, "Industrial Output is Down for Fifth Month in a Row", New York Times, March 15, 1975, pp.1, 37.

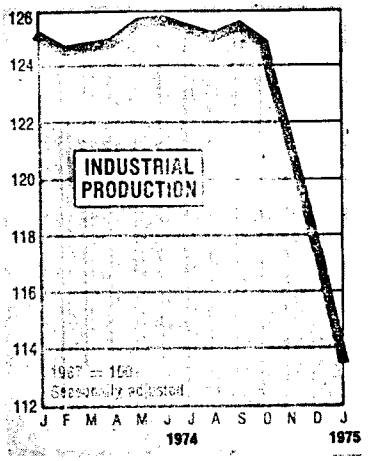
** "Economic Lag Seen Persisting", New York Times, February 28, 1975, p.46.

*** Olmsted, p.44.



Source: Federal Reserve Board, Statistical Release

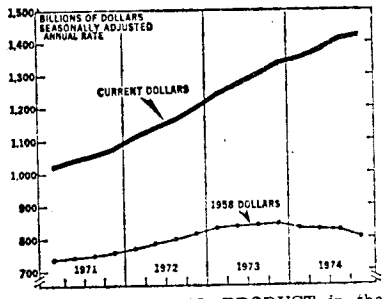
Figure II



Source: Newsweek 2/24/75 p.58

Figure III

Gross National Product



GROSS NATIONAL PRODUCT in the fourth quarter rose to a seasonally adjusted annual rate of $1,430.2 billion from $1,416.3 billion in the third quarter. Computed in 1958 dollars, the fourth quarter figure fell to $803.8 billion, from $823.1 billion in the third quarter.

Source: Wall Street Journal 3/13/75 p.1

Figure IV

shrink years since 1946-1947.*

Yet, comparing projections made in the September 15, 1974 issue of Electrical World** with projections of GNP made in the Statement (p.11.2-53), we find:

Year	Percentage by which Statement's projection of December 1974 is higher than Electrical World's projection of September 1974, in constant dollars	
1980	12.9%	
1985	16.0%	
2000	23.2%	(Electric World's projection extrapolated)

Similarly, the Statement's GNP projection for 1985 is 17.5% higher than McGraw-Hill's projection for GNP in 1988.***

It cannot be predicted with certainty what our future growth in GNP will be, or its relation to energy demand. But projections could more reasonably be made considering several scenarios and their energy-GNP rations. The U.S. Chamber of Commerce has said, "We may be entering an era in which the growth of productive capacity itself is subject to new and severe constraints."****

1. Accelerating energy prices and high unemployment may herald a return to an "intermediate technology" which is more

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* "1975 Annual Statistical Report", Electrical World , March 15, 1975, p.44.

** Olmsted, p.44.

*** The American Economy, McGraw-Hill, Inc., p.5.

**** A Report of the Council on Trends and Perspective, Economic Growth: New Views and Issues, Chamber of Commerce of the U.S., Washington, D.C., 1975, p.24.

labor-intensive, yielding a lower GNP.*

2. An increasing portion of the GNP will be claimed by activities which are less energy-intensive than the production of commodities: education, leisure, health care, government activities and other services. This has been evidenced by a decline in recent years of incremental kwhr/incremental constant dollars.**

3. Market saturation may be approaching in radios, television, refrigerators and other home appliances, illumination, automation of many industrial processes, air conditioning in the commercial sector.***

4. There may be less capital available from loans. In September 1974, Bank of America, the world's largest bank, reported a year to year loan growth of 31%. By December 1974, it had fallen to 26%, and the intention was reported in February 1975 to purposely lower it to 10%, a rate that was considered one they could "sustain on a long-term basis".****

5. The future of electricity-intensive industries such as aluminum, petro-chemicals and uranium enrichment is uncertain:

a. The production of primary aluminum absorbed nearly 12% of industrial electrical sales in 1973, or almost 5% of total

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* E.F. Schumacher, Small is Beautiful, Harper & Row, New York, 1973.

** (FPC) The Financial Outlook, pp.146-7.

*** Ibid., pp.135, 144-5.

**** "Why They're Slowing Growth at the World's Biggest Bank", Business Week, February 24, 1975, p.54.

electric sales.* However, recycling takes only 5% of the energy needed to create aluminum from virgin ore.**

b. Nations that produce oil and other key materials, such as copper, aluminum and tin, will be seeking a larger share of the economic pie, raising prices and shrinking American industrial production, which is currently 40.4% of electrical demand.*** Saudi Arabia, for example, has a new five-year economic plan which includes huge industrial projects that will make it a major supplier of petrochemical products.****

A conference of 104 developing countries has produced a program to raise their share of the world's economy from 7 to 25% by the end of the century, calling it a new international economic order. The plan includes the formation of more raw materials cartels, the right to nationalize foreign industries, and the transfer of basic industries from rich to poor countries.***** Even before release of this plan, U.S. energy consumption was projected by Shell to shrink from 32% of world consumption in 1970 to 22% by 2000.******

c. Uranium enrichment, accounted for 5% of industrial electrical sales in 1973, or 2% of total electrical sales, is dependant

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* Olmsted, p.49.

** Reynolds Aluminum ad: "We Don't Believe in Waste".

*** Olmsted, p.48.

**** Juan De Onis, "Saudi Arabia Plans More Huge Plants", New York Times, February 22, 1975, pp.33, 35.

***** "Developing Nations Finish Plan to Raise Share of Economy", New York Times, February 19, 1975, p.46.

****** "Energy Self-Sufficiency:1", Shell Reports, Shell Oil Company, Houston, July, 1974, p.1.

upon the future of the nuclear industry.*

Total Energy Demand

The Statement projects an historical energy growth rate of 4.0% till 1980, declining to 3.5% from 1980 to 2000 and 3.2% from 2000 to 2020 (p.11.2-54). Electrical energy generation is assumed to grow from 25% of current total energy consumption to 65% in 2020 (p.1.1-5).

Of five references given in the chapter on "Projections of Energy Growth" (p.2.1-6), four are from 1972 and one from 1973. It is stated, "Past forecasts of energy consumption frequently have proved to underestimate the demand that subsequently occurred". Aside from the Ford Foundation's Energy Project, all of the other reports with which the Statement superficially compares its forecast, were made from 1960 to 1971 (p.11.2-54).

The 3.4% per year growth rate assumed in the Ford Foundation's "historical" scenario is cited for its proximity to the Statement's model, but growth rates of the other two Ford Foundation scenarios are not cited, namely 1.7% for the "technical fix" and 1.4% for "zero energy growth" till 1985.**

Though SIPI's comments specifically asked for an evaluation

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* Olmsted, p.50.

** John C. Myers, "Energy Conservation and Economic Growth - Are They Incompatible?", The Conference Board Record, February 1975, p.27.

of the Council on Environmental Quality's "half and half" plan, which results in an annual energy growth rate of 1.8% by 2000,* this was not mentioned. Nor is the impact discussed of the effect on demand of the Federal Energy Office's plan (SIPI,p.IV-8). The FEO is now the Federal Energy Administration, which produced the Project Independence Report. This projects a range of growth rates from 3.2% down to 2.1% by 1985.**

In the chapter on the "Current Situation" (p.2.1-5), which is three brief paragraphs long, one paragraph and a table describe sources of energy during 1972. Another paragraph begins, "Over the past few years, the energy situation has changed dramatically", but the oil embargo of 1974 and sequela are not mentioned, or the dramatic energy programs currently under consideration by the executive and legislative branches of government to reduce total demand. The embargo is referred to in another context, however, to underline the need to develop and use energy sources besides oil or gas (p.1.1-5).

The Conference Board has expressed a concern which was not reflected in the Statement:

> Energy prices rose nearly 11% faster than the general price level (26.5% compared with 14.1%) from 1970 to 1973, and by the third quarter of 1974 had widened the margin by an additional 50% (over the 1973 average). Increases in relative energy prices of this magnitude should bring about substantial changes in energy use. ***

However, the Board concludes that energy use could grow at

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* Council on Environmental Quality, A National Energy Conservation: The Half and Half Plan, March 1974, p.10.

** Myers, p.27.

*** Ibid., p.30.

an annual rate of only 1.5% till 1985 without damage to the economy, assuming "adjustments in production and consumption that will permit less energy to be consumed per unit of product."*

Price Elasticity

SIPI's comments requested an evaluation of how recent price increases would affect future electrical demand (SIPI, p. IV-5 to 7). This was not found, though there was mention of the Chapman, Tyrrell and Mount study on price elasticity, which was said to project consumption of 1.9 to 4.6 trillion kwhr by 2000 (p.11.2-56). This study estimates that a 1% increase in price causes electrical demand eventually to be an average of 1.5% less than it would otherwise have been.** Price elasticity studies by Fisher and Kaysen, Anderson, and Wilson were not referred to *** nor was the study in the Project Independence Report.

While total kwhr sales dropped .56% in 1974 over the 1973 figures, U.S. utility revenues climbed 23.3%, due to rate increases and fuel-cost adjustments. The average price per kwhr was up to

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* Ibid., p.32.

** Chapman, Tyrrell, Mount, pp.703-8.

*** M.R. Seidel, S.E. Plotkin, & R.O. Reck, Energy Conservation Strategies, Implementation Research Division, Office of Research and Monitoring, U.S. Environmental Protection Agency, Washington, D.C., July 1973, pp.16-19.

$2.30, an increase of nearly 24% over the 1973 average. Table II follows, which shows not only the trend toward zero decreases and large numbers of increases in price, but over a tripling of amount per increase since 1970.*

Electric rate increases

	Granted		Pending at year end	
	No. companies	Dollars	Applications	Dollars
1964	4	27,500,000	1	270,000
1965	0	0	1	270,000
1966	4	33,432,000	0	0
1967	2	701,000	0	0
1968	8	20,657,000	19	194,827,000
1969	19	145,123,000	33	490,317,000
1970	45	430,578,000	40	629,798,000
1971	51	802,678,000	66	970,515,000
1972	94	827,090,000	69	906,676,000
1973	64	1,150,763,300	71	1,566,545,600
1974	**78**	**2,337,746,000**	**65**	**2,043,146,000**

Source: Ebasco Services, Inc.

Electric rate decreases

	No. companies	Dollars
1964	77	119,200,000
1965	83	113,400,000
1966	46	56,866,000
1967	26	37,703,000
1968	14	13,887,000
1969	7	5,833,000
1970	2	4,500,000
1971	1	1,000,000
1972	0	0
1973	0	0
1974	**0**	**0**

Table II

Using the Chapman, Tyrrell and Mount analysis, the 24% price increase in 1974 should eventually lead to a demand 36% less than it would otherwise have been, with a drop of 18% apparent in 1981. A drop of 3.6% should be apparent by the end of 1975. A drop of 3.6% from the historic growth of 7.8% projected in the Statement would be a growth of 4.2% over the 1.70 trillion kwhr sold in 1974, or 1.77 trillion. The growth rate reported in January and February 1975 was indeed 4%.** The price effect may be occurring sooner than Chapman et al predicted,

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* "1975 Statistical Report", pp.66-69.

** Telephone interview with Leonard M. Olmsted, consulting editor, Electrical World, February 26, 1975.

which was for the 1980's and thereafter.

In general, their conclusions may turn out to be conservative. Their lowest projections were based on the assumption of an average annual electricity price increase of 3.33% of 1970 values for thirty years, or a doubling of price by the year 2000. Their demand projection of 2.01 trillion kwhr in 2000 used that rate of price increase, coupled with a population growth of 1.4% per year, GNP of 4% and per capita personal income growth of 2.9% per year. The experience in 1974 makes this low demand seem more possible: a price increase of 24% over the 1973 level, population growth of 0.7%, GNP decline of 2.1%, and unemployment reaching 8% by early 1975.