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Testimony Presented to the House Science and Technology Committee

Chester R. Richmond

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DEPARTMENT OF ENERGY

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TESTIMONY PRESENTED TO THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

18 JUNE 1981

WASHINGTON, D.C.

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ABSTRACT

This report is the text of invited testimony given by the author before the House Science and Technology Committee. This Congressional hearing on Societal Risks of Energy Systems reflects the growing interest on the part of Congress, the public, the scientific community, and other groups on this extremely important topic of Risk Analysis. This presentation will contain information on the emergence of an interdisciplinary professional field of risk analysis, including the recently formed Society for Risk Analysis. I will also discuss in some detail various risk analysis programs now in progress at the Oak Ridge National Laboratory and other research institutions. Also included will be some general philosophy concerning risks from energy-producing systems and my perspective on the needs for further developments in the field of risk analysis.

TESTIMONY PRESENTED TO THE

HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

Chester R. Richmond

I. Introduction

Mr. Chairman, Panel Members, Ladies and Gentlemen:

My name is Chester R. Richmond. I am Associate Laboratory Director for Biomedical and Environmental Sciences at the Oak Ridge National Laboratory (ORNL) which, as you know, is one of the major multipurpose scientific research and development institutions operated by various private contractors for the U.S. Department of Energy. As director of a large biomedical and environmental program, I have had the opportunity to personally participate in the planning and implementation of health, safety, and environmental research related to both conventional and developing energy-producing technologies. My colleagues and I, together with individuals from other Federally supported laboratories, academic institutions, numerous Federal agencies, and private organizations, have participated in the planning and implementation of a life sciences program in support of energy-producing technologies including materials obtained from coal or shale. In this context, I had the privilege of participating in hearings held by this Committee in September 1979 on the subject of Health and Environmental Considerations for Synthetic Fuel Technologies.

My colleagues and I have also been very much involved in the rapidly evolving field of risk analysis. I think this is a natural outgrowth of concerns expressed by many individuals in the research, academic, public, and other sectors that there must be better approaches to finding answers to questions of whether a technological system under development might provide more benefit than detriment to society.

I also had the privilege of testifying before this Committee's Subcommittee on Environment and the Atmosphere in March 1976. Those hearings, conducted by the Honorable George E. Brown, Jr., were very timely because of the growing interest both in Congress and throughout the United States and the world concerning the magnitude of health effects associated with exposure to low levels of pollutants and the attendant societal costs. Those hear ngs on the Effects and Costs of Long-Term Exposure to Low Levels of Man-Made Pollutants and similar hearings argue strongly for the use of risk analysis.

I am also a member of the International Commission on Radiological Protection's (ICRP) Committee 2 on Secondary Limits. I mention this because the ICRP has recently restructured its primary radiation protection philosophy on the basis of risk to specific body organs and a comparison of radiation risks to risks that exist for workers in other occupations.

I am a charter member of the recently formed Society for Risk Analysis. I have served as a member of the Steering Committee which worked for over a year to establish the Society.

Last October I served as Chairman of a symposium on Health Risk Analysis which probed the health aspects of risk analysis in some detail. The proceedings of this symposium are being published by Franklin Institute Press. I am also serving as Scientific Adviser to the Department of Energy for an international symposium to be held next week here in the United States on the subject of Health Impacts of Different Sources of Energy. This meeting will be sponsored by the World Health Organization, The United Nations Environment Program, and the International Atomic Energy Agency in cooperation with the U.S. Department of Energy and the Oak Ridge National Laboratory.

I have also participated in various symposia and workshops related to risk assessments and risk analysis. I might mention one in particular; that is, the Symposium/Workshop on Nuclear and Non-Nuclear Energy Systems: Risk Assessment and Government Decision Making, held in 1979 by the MITRE Corporation, because both of my colleagues on this panel also participated in that workshop.

I welcome the opportunity to participate in this hearing. The timing is especially important since the Nation is struggling to understand and live with a great deal of health, energy, and environmental legislation inherited from the 1970's.

II. Emergence of an Interdisciplinary Professional Field of Risk Analysis

I believe these hearings reflect society's broad interest in the production, distribution, utilization, and disposal of materials which at some point in the life cycle may cause more detriment than benefit to man. The materials may interact directly with living systems, or indirectly via intricate and only partially understood mechanisms. There is much to be learned as to how these many materials, be they from energy producing or other technologies, ultimately affect man.

I believe risk analysis will be a challenge to many of us during this decade, and I would like to share with you some of my thoughts as to why I believe this. The 1970's are now being viewed as the decade of environmental and health legislation. Figure 1 plots significant items of environmental and health legislation from about 1935 through the late 1970's. It is clear that there was an explosion of legislation related to health and environmental issues following the passage of the National Environmental Policy Act as we entered the 1970's. The year 1970 was a bumper year with three significant pieces of legislation. The year 1972 was also busy, with four major pieces of legislation. I would particularly like to call your attention to 1976, the year in which the Resource Conservation Recovery Act (RCRA) and the Toxic Substances Control Act (TSCA) were passed.

RCRA is important due to its relationship to land burial of materials. Legislation dealing with release of materials to the air and water had been established prior to the passage of RCRA. Because there are only three places for materials to go — air, water, and land — RCRA became a forcing function in the sense that everything must go somewhere. Perhaps an example is in order. If we remove sulfur and other materials from the stacks at power plants, we must then grapple with the question of where we place the collected materials that otherwise would have been dispersed through the air to other locations. In a sense, we are trading between the dispersion of a material from its source to the concentration of the material at

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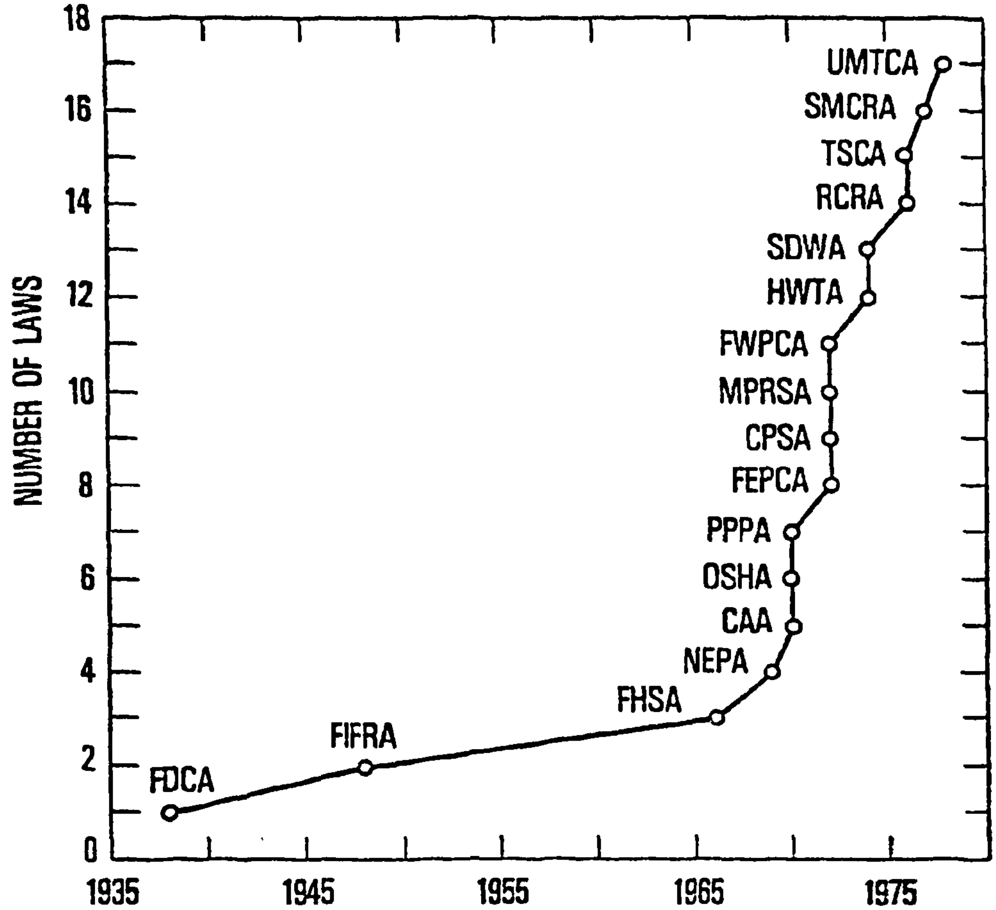

FDCA	—	Federal Drug and Cosmetics (1938)
FIFRA	—	Federal Insecticide, Fungicide, and Rodenticide (1948, 1972, 1975)
FHSA	—	Federal Hazardous Substances (1966)
NEPA	—	National Environmental Policy (1969)
PPPA	—	Poisonious Packaging Prevention (1970)
OSHA	—	Occupational Safety and Health (1970)
CAA	—	Clean Air (1970, 1977)
FWPCA	—	Federal Water Pollution Control (now Clean Water) (1972, 1977)
MPRSA	—	Marine Protection, Research, and Sanctuaries (1972)
CPSA	—	Consumer Product Safety (1972)
FEPCA	—	Federal Environmental Pollution Control (1972)
SDWA	—	Safe Drinking Water (1974, 1977)
HMTA	—	Hazardous Materials Transportation (1974)
RCRA	—	Resource Conservation and Recovery (1976, 1979)
TSCA	—	Toxic Substance Control (1976)
SMCRA	—	Surface Mine Control and Reclamation (1977)
UMTCA	—	Uranium Mill Tailings Control (1978)

Fig. 1. Health and Environmental Protection Laws

its source. Material collected by control technology systems are often "disposed of" by land burial.

I predict that the 1980's will be a decade in which there will be much collaboration, cooperation, and, indeed, compromise between the developing technologies and the so-called environmental movement. This may be one of the major challenges to the scientific community during the 1980's. There will be demands from many quarters of the scientific and other communities to determine whether or not individual or classes of compounds are hazardous or toxic or carcinogenic or mutagenic, and to what extent these materials may be detrimental to man. There will be many pressures and inquiries from the public, Federal and state agencies, and private interest groups. We must resist the temptation to provide quick answers to very complex problems, and, above all, we must do good science and be intolerant of those who ignore the time-honored scientific processes. We must also realize that policy judgments must often be made before all the results may be collected. In these cases we must contribute to the required analyses and assessments, especially in the health and environmental area, so that input to decision makers represents the best available interpretation of the available data. The limitations and uncertainties of the information must also be clearly communicated to the decision makers. This is an enormous challenge and one which we must accept if there is to be a sound, comprehensive basis for decision making. I believe we must all become part of that process so that we may bring new technologies on line at the least societal cost. We must recognize that technological development and the protection of individuals in the work place and society are not incompatible goals, and we must help break down the barriers between the life and environmental scientists and the technologists, who often in the past have appeared to be adversaries.

Some individuals have expressed a concern that the environmental movement may be severely crippled or destroyed during the 1980's. Although I believe that the recent momentum of the movement will be slowed and that directions may be altered, I think most of you would join me in hoping that the advances and attitudinal changes that were made in the 1970's are not totally reversed. We as a society cannot afford to destroy the gains that were made. As I indicated earlier, we must work together to foster an attitude of collaboration, cooperation, and, where necessary, compromise among all the players. As an example of this attitude, there is a growing recognition within industry and public interest groups that health, safety, and environmental issues must be integrated into the initial state of plant design. Industry is becoming more tolerant of the notion of incorporating design changes to prevent adverse environmental or health impacts. Everyone benefits if the necessary changes are identified as early as possible in the development or demonstration process.

I and others believe that risk analysis is the tool which will allow us to begin to solve many of the problems alluded to above. There is rapidly growing interest in risk analysis in the scientific and other disciplines. I would like to spend several minutes expanding on one example of the emergence of an interdisciplinary professional field of risk analysis — that is, the newly created Society for Risk Analysis which was formed as the direct result of scientists from the United States and abroad recognizing the need for such a professional organization. I believe it is also significant that some of the founders of the Society for Risk Analysis, the Steering Committee, are members of Federal regulatory agencies. The day-to-day requirements of their jobs, in my opinion, probably led to the need for a professional group of individuals interested in risk analysis and its applications. A list of the Steering Committee members is included in Appendix 1.

The official publication of the Society is "Risk Analysis — An International Journal." It will be published quarterly by Plenum Publishing Corporation. Included will be research papers, review articles, editorials, book reviews, letters, and announcements.

The Journal will provide a focal point for new developments in risk analysis for scientists from a wide range of disciplines and cover topics of considerable interest to regulators, researchers, and scientific administrators. It will deal with health risks, engineering risks, mathematical and theoretical aspects of risks, and with the social and psychological aspects such as risk perception, acceptability, ethics, and economics. The scientific articles in the Journal will be peer reviewed.

Earlier this month the Society for Risk Analysis, the World Health Organization and the Assembly for Behavioral and Social Sciences, and the Assembly for Life Sciences (Board on Toxicology and Environmental Health Hazards) of the National Academy of Sciences/National Research Council jointly sponsored an international workshop on the analysis of actual versus perceived risks. Several sessions of the program were related to energy production.

III. General Comments on Risk Analysis and Energy-Producing Systems

There are many possible reasons for studying risk, but perhaps the broadest statement is to enable decision-makers and the public to make the right choices in terms of dangers to human health or the environment. There is a further reason for evaluating risk scientifically; whether or not the subject is studied in the laboratories, somebody somewhere is doing their own crude risk analysis — not always rationally.

There are other less general purposes in studying risk. Some of the reasons, in no particular order, which have been suggested are:

- o Recent government-wide guidelines will require that risks be balanced against benefits for many future regulations.
- o Its study will provide information needed to make decisions on health and environmental standards.
- o Using risk analysis will allow scientists and engineers to identify gaps in knowledge.
- o Risk studies can measure the real health and environmental benefits of proposed controls.
- o In terms of energy systems, they would help the public to understand the non-monetary choices which have to be made.
- o It allows risks which are deemed unacceptable by some to be identified and perhaps reduced.

Although much of the work has been done in the United States, other countries have also generated studies. An analysis done at the ORNL Information Center Complex produced over 500 references on risk, from 21 countries. Most have been published in the last five years.

I would now like to briefly touch on risk from energy-producing technologies. It is important to incorporate all phases of the fuel cycle including supporting industries and storage systems in the analysis. We also need to remember that the further away a technology is from demonstration, the more benign it may appear simply because we do not have enough information. Lastly, we need to state uncertainties in the data and highlight areas where data are missing or estimated.

The 1964 United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) study was among the first reasonably comprehensive risk studies. Since then many have appeared in journals and books. A partial listing of some additional risk studies is given in Table I.

Table I. Selective Listing of Risk Studies on Energy Systems

- The 1969 Starr paper
- The 1969 Doll study in Britain
- The 1974—5 WASH—1400 report by the U.S. Atomic Energy Commission
- The 1975 Pochin study comparing five energy sources
- The 1977 International Commission on Radiological Protection
- A 1978 Canadian Atomic Energy Control Guard study
- The 1979 British Canvey Island Study
- A 1979 U.S. document (the "Lewis report") evaluating WASH-1400
- A 1980 U.S. Committee on Nuclear and Alternate Energy Systems report
- The 1980 German Risk Study, paralleling WASH-1400
- The 1981 NRC document on index of risk exposure

A current example of comparative energy risk study by E. E. Pochin (Physics in Technology 11: 93—8, 1980) is entitled "Biological Risk Involved in Power Production." Pochin points out that estimates of harm, even for death, are uncertain and incomplete and much more work is needed. Still, it appears that approximate estimates can be obtained, and these are likely to differ by factors of up to sixty for different major fuel sources. The largest risk was 10—15 deaths per year in a population of one or two million people deriving electricity from coal. Pochin normalizes his effects to one GW(e) year output (power for one to two million people). In decreasing order, he found about ten deaths from oil, seven from hydroelectric, two from nuclear, and 0.25 from natural gas. The ranges of the estimates increased with the number of deaths (e.g., about nine to forty for coal).

For the population in question (one to two million people) there would be 450-900 deaths from all accidental causes and 12,000 to 24,000 deaths from all causes. He points out the difficulties in assessing proper significance to radionuclides such as ^{14}C and ^{129}I which can deliver low doses of radiation to the world population for very long times. Similarly, he mentions that additional harm to future generations from a progressive build-up of carbon dioxide in the atmosphere is difficult to assess.

Another recent comparative study is worth mentioning. This one was produced by A. V. Cohen and D. K. Pritchard of the British Health and Safety Executive (Comparative Risks of Electricity Production Systems: A Critical Survey of the Literature, Research Paper II, HM Stationery Office, London L2, England). They studied the international experience of safety for the complete fuel cycle of each system. They found that the nuclear system involved no more and probably less risk to the public than oil- or coal-burning systems for producing electricity. Cohen and Pritchard based their findings on 87 studies produced prior to May 1980. Because risk estimates for unconventional alternative systems which are not developed beyond the prototype stage were too speculative for comparison, they concentrated on oil, coal, and nuclear (mostly light water reactors) fuel cycles.

IV. Risk Analysis Programs at the Oak Ridge National Laboratory and Other Research Institutions

Risk Studies at the Oak Ridge National Laboratory

A wide variety of risk-related activities now take place at ORNL. It is not the object of this section to list all of them in detail.

Risk analysis studies at ORNL include energy system analysis under normal and accident conditions. Research has estimated the probabilities of undesired events and attempted to ensure that target probabilities are not exceeded. Methods are being developed to evaluate reactor designs; mathematical fault trees are being formulated to determine the risk of these designs due to common cause events. Techniques are being developed to identify and reduce risks associated with human factors — in particular, nuclear power plant operators.

ORNL staff have much experience in prepar.ng environmental impact statements for a wide range of energy-related projects. Some of the information in these statements can be used in risk assessments. The amounts of potentially harmful materials, their transport and what happens to them, ecological effects, biological pathways to man, and probable health effects are being analyzed by ORNL staff. Environmental assessments also deal with resource availability, aesthetics, and ecological integrity.

ORNL is an internationally recognized center of expertise in mathematical modelling of environmental and health effects of energy-related pollutants. Comparative "dose conversion" factors for a given quantity of radiation or chemicals are being developed. For over 30 years, ORNL has served as the principal developer and reference source for models and techniques to estimate radiation doses received by humans. Most nations have uniformly adopted the ORNL models and techniques through the recommendations of the International Commission on Radiological Protection.

The Laboratory has experience in comparative risk assessments of different energy technologies. Several comparisons have been made of the risks of generating electricity from coal and nuclear fuels. A new staff member, Dr. H. Inhaber, has analyzed the human health risks of the entire fuel cycles of conventional and non-conventional energy systems.

As mentioned above, there are less immediately obvious aspects of risk. The social, economic, and psychological considerations necessary to set numerical risk criteria are being studied under ORNL sponsorship.

The six major categories for risk analysis or assessment work at ORNL are as follows:

- o energy system analysis, primarily nuclear, including reliability, as well as human factors, environmental impact statements, and safety and security analysis;
- o basic data generation and collection and evaluation of data, including much biological research, as well as information and data centers;
- o risk-benefit assessments, primarily non-nuclear, including financial and strategic risk, socio-economic impacts, and related topics;
- o comparative risk assessments;
- o perception of risk; and
- o decision analysis and mathematical methods and models.

Some examples of specific risk analyses now being performed at ORNL are as follows:

- o health risks of high voltage transmission lines;
- o health and safety impacts of eastern oil shale development;
- o environmental and health impacts associated with solid fuels as residential heat sources;
- o health and safety issues associated with combustion of toxic substances in high temperature incinerators;
- o National Environmental Policy Act related documents for uranium mill tailings;

- o health and safety analyses of biomass energy;
- o public and occupational health effects of direct and indirect coal liquefaction and oil shale; and
- o occupational risk and injury assessment of conventional and emerging energy technologies.

Organizations Performing Risk Analysis and Assessment Work

It is perhaps more difficult to identify the present major centers of activity in risk analysis. Some which come to mind, to give some idea of the kinds of organizations, are:

- o the DOE national laboratories, primarily ORNL and Brookhaven;
- o MITRE Corporation;
- o NUS Corporation;
- o ISPRA Research Center in Italy;
- o the British Health and Safety Executive;
- o the U.S. Nuclear Regulatory Commission;
- o the U.S. Environmental Protection Agency;
- o Kraftwerke Union in the Federal Republic of Germany;
- o George Washington University;
- o Atomic Energy of Canada Limited in Canada;
- o the U.S. Office of Technology Assessment;
- o Massachusetts Institute of Technology;
- o Harvard University;
- o University of California at Los Angeles
- o University of California, Berkeley;
- o Decision Research, Inc. (Oregon);
- o Science Applications, Inc.;
- o General Atomics, Inc.;
- o Resources for the Future;
- o J. H. Wiggins Co.;
- o Brookings Institute
- o Clark University;
- o New York University; and
- o Franklin Pierce Law Center.

While it is difficult to estimate which of these has the largest number of personnel studying risk, it likely would be the national laboratories, the NRC, and the British Health and Safety Executive. Some are small groups of six or fewer people.

Department of Energy's Health and Environmental Risk Analysis Program (HERAP)

The Department of Energy's Health and Environmental Risk Analysis Program (HERAP) is a part of the Office of Health and Environmental Research (OHER), which is a component of the Office of Energy Research. As an integral part of OHER, HERAP draws directly on DOE health and environmental research efforts. DOE/HERAP program managers have close contact with contractor health and environmental research program personnel, because assessment activities are closely coupled and coordinated with research efforts. The assessments themselves draw on all available knowledge and are not limited to DOE-supported research results. HERAP activities are also closely meshed with other assessment efforts at both the national and international levels. There have been, to list a few, participations with the Department of State, the Environmental Protection Agency, the Office of Technology Assessment within the U.S., and on a broader scale, the United Nations Environment Program and the Organization for Economic Cooperation and Development.

In addition to providing a continuing and iterative process of integrating research results in a coherent method, the HERAP provides the essential opportunity to assist research managers within OHER identify research gaps, and thereby establish research priorities. Risk analysis, therefore, allows one to produce more than the typical litany of research needs. It permits one to estimate the specific contributions that research efforts will make toward understanding the risk of a specific technology.

The objective of the HERAP is to improve the basis for decisions throughout the Department of Energy by providing quantitative, analytical descriptions based on current information of knowledge and uncertainty regarding the nature and magnitude of the potential health and ecological impacts of installing, operating, and decommissioning energy technologies. The approach used is to initiate continuing analytical efforts at a level of three to five person years per year to identify and evaluate the technical information relevant to describing the nature and magnitude of potential health and ecological impacts of energy technologies and to provide periodically a health and environmental effects document which presents the understanding of such impacts at that point in time. It is planned that this will be an iterative process. Efforts underway are planned or grouped into three categories:

(1) methodology development;
(2) generic analyses; and
(3) specific energy technologies.

The HERAP activities and contractors are shown in the following Table II.

The underlying challenge proposed by this activity is to converge current scientific data with analyses of developing technologies. Much of the data is missing and many paramaters used in the analyses contain much variability. Currently the health portions of the analyses are thought to contain the greatest uncertainties and, therefore, require the most attention. We need to remind ourselves periodically that despite the uncertainties a well-conducted risk analysis represents our best attempt to summarize what is known and what is not known of the risks of a given developing or established technology.

Environmental Protection Agency Risk Programs

At least seven major Federal acts (Toxic Substances Control Act, Clean Air Act, Federal Water Pollution Control Act, Safe Drinking Water Act, Federal Insecticide, Fungicide and Rodenticide Act, and Resource Recovery and Conservation Act) mandate the Environmental Protection Agency to control substances that are harmful to human

Table II. Major Components of Department of Energy's Health and Environmental Risk Analysis Program (HERAP)

Title	Contractor
Methodology Development	
Analyses of Dose Response	University of California – Davis
Hydrocarbon Carcinogenicity	Harvard University
Health Indicators	Brookhaven National Laboratory
Risk Analysis Methodologies	University of Maryland
Generic Analyses	
Waterborne Hydrocarbons	MITRE Corporation
Airborne Particles	Harvard University
Nitrogen Oxides	Brookhaven National Laboratory
Specific Energy Technologies	
Comparative Impacts	Brookhaven National Laboratory
Battery Systems	Argonne National Laboratory
Diesels	Inhalation Toxicology Research Institute
Photovoltaics	Brookhaven National Laboratory
Oil Shale	IWG Corporation
Coal Liquefaction H-Coal	Oak Ridge National Laboratory
Coal Liquefaction SRC-II	to be assigned
Coal Gasification	Argonne National Laboratory
Space Nuclear Systems	University of California – Davis
Municipal Waste Combustion	Ames Laboratory
Fluidized Bed Combustion	Inhalation Toxicology Research Institute
Geothermal	Lawrence Livermore National Laboratory
Fusion	to be assigned
Indoor Air Quality	to be assigned

health and the environment. The control of substances is based upon health and environmental risk assessments varying from single chemicals to chemical ranking systems to technology-wide applications.

The Office of Health and Environmental Assessment provides overall assessment support to other EPA offices implementing the mandates of the laws. The objective is to enhance the risk assessment capabilities within the Agency and develop scientific criteria concerning the effects of pollutants on ecosystems and human health. Initial risk assessment activities stress the development of guidelines and methodologies for agency-wide use that determine the potential risk from exposure to specific pollutants. Targeted areas for assessment include exposure and carcinogenic, reproductive and other chronic effects.

The Office of Pesticides and Toxic Substances in cooperation with the Organization for Economic Cooperation and Development is developing ranking systems to prioritize chemicals so that those with the greatest need for control or testing are identified first.

Energy-related activities are carried out primarily through the Federal Interagency Energy/Environmental Research and Development Program which is planned and coordinated by the Environmental Protection Agency through the Office of Research and Development. Research projects supported by the program range from the analysis of health and environmental effects of energy systems to the development of environmental control systems. Major program areas are Health Effects, Ecological Effects, Atmospheric Transport and Effects, Control Technology, and Synthetic Fuels. In the most general sense, the total program relates to risk assessments for energy technologies by providing needed inputs. However, the activities that are designated energy-related risk assessments per se are limited. The integrated assessments component constitutes about 3-4% of the total Interagency Energy/Environment Budget.

About two thirds of the integrated assessment research occurs within EPA facilities and through private subcontractors. Other research is coordinated by EPA but conducted by other agencies including the Department of Energy, the Department of Agriculture, the Department of Interior, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Bureau of Standards, National Institute of Occupational Safety and Health, National Institute of Environmental Health Sciences, and the Tennessee Valley Authority. Most of the activities within the program relate to development of coal resources with lesser emphasis on alternative technologies.

Assessments of fossil fuel, wood burning, geothermal, waste-as-fuel, and solar technologies are carried out by the Industrial Environmental Research Laboratories at Research Triangle Park and Cincinnati. In addition, the Cincinnati lab is investigating the impact and control of indoor air pollutants such as radon, asbestos, formaldehyde and carbon monoxide.

A new EPA-funded project to conduct risk assessments of entire synthetic fuel systems was started at ORNL in April 1981. The project will address the health and environmental impacts of direct and indirect coal liquefaction and oil from shale and will help to identify and prioritize data/research needs in synfuels-related health and environmental research.

Risk Studies at the Brookhaven National Laboratory

Brookhaven National Laboratory has been involved in health and environmental risk assessment for energy technologies since 1973. It is currently conducting an integrative analysis of various energy sources for the DOE/HERAP including conventional coal, oil and nuclear, and is also developing methods for comparative analysis of new energy technologies. Other areas of activity include health effects of photovoltaics; health aspects of conservation in urban transport; occupational health in industries supporting solar energy development; health effects of synfuels, including epidemiological support of a joint DOE-EPA-NIOSH-sponsored study of the Kosova coal gasification plant in Yugoslavia; effects of air pollution on agricultural crops; methods for designation of wilderness lands; and locational analysis of endangered species.

V. International Activities in Risk Analysis

The following is a list of organizations concerned with risk analysis. The list is not comprehensive, and the emphasis is on health aspects of risk analysis. This information was obtained primarily from materials reported on at the Department of Energy's Health and Environmental Risk Analysis Program (HERAP) Contractors' Meeting in February 1981.

International Commission on Radiological Protection (ICRP)

The ICRP publishes radiation protection recommentations for the general public and for those occupationally exposed to radiation.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

UNSCEAR provides in-depth critical reviews of the sources, pathways, and biological effects of ionizing radiations, and provides an up-to-date survey of the risks to health of radiation. In its latest report (1977), radiation sources in the nuclear fuel cycle are reviewed in detail; the 1977 UNSCEAR Report serves as a useful resource for the assessment of radiation hazard to health, occupational and public, from the nuclear fuel cycle.

International Atomic Energy Agency (IAEA)

The IAEA has a strong interest in the technical base from which to assess health and environmental consequences of all aspects of the nuclear fuel cycle. IAEA cooperates with other agencies on nuclear assessments — for example, with the World Health Organization (WHO) Regional Office for Europe and the United Nations Environment Program (UNEP) Nuclear Fuel Cycle Panel.

World Health Organization (WHO)

The WHO's Division of Environmental Health is studying pollutants in general, some of which obviously come from energy sources. A new small-scale study is underway on comparative effects of low levels of environmental pollutants from energy sources.

North Atlantic Treaty Organization (NATO)

The NATO Committee on the Challenges of Modern Society (CCMS) has produced air quality criteria documents and had several energy-environment-related projects, e.g., use of a systems approach for establishing air pollution control programs in NATO states.

United Nations Environment Program (UNEP)

UNEP has begun a reiterative program of reviewing the health and environmental impacts of individual fuel cycles with the assistance and advice of international panels of experts invited by UNEP for this purpose.

In addition, UNEP co-sponsored with Reijer Institute, Stockholm, and USSR Commission for UNEP, an International Workshop on Environmental Implications and Strategies for Expanded Coal Utilization. An excellent Workshop Report is now in preparation.

Organization for Economic Cooperation and Development (OECD)

The Environmental Committee of OECD has strong general environmental expertise plus significant potential for economic analysis of various impacts that takes advantage of OECD's strong background in economics. It has expertise in sulfur issues, long-range transport, and transfrontier pollution problems.

International Institute for Applied Systems Analysis (IIASA)

Energy with emphasis on energy modelling has been a major component of the IIASA program. With support from UNEP, IIASA undertook a limited assessment of environmental consideration in energy use. This was confined to an assessment of the possible beneficial effects of energy on human health — attempts to correlate reduced infant mortality in various countries throughout the world with energy use.

European Economic Community (EEC)

The community has dealt with many energy-related environmental problems, especially air pollution from the coal and steel industries, water pollution, and contamination by radioactive wastes. The community has strong occupational health and safety programs that include energy and some assessment of health and environmental aspects of the fuel cycles.

Numerous relevant reports and specialized seminar proceedings have been published by these organizations.

Cooperation Among International Organizations

Earlier I mentioned the International Symposium on Health Impacts of Different Sources of Energy sponsored by the World Health Organization, the United Nations Environment Program, and the International Atomic Energy Agency. This meeting will be held for a week beginning the 22nd of June. On the program will be individuals interested in risk analysis and assessment from the United States, including a science advisor to Senator Howard Baker, Jr. In addition, presentations will be given by representatives of the following countries: Canada; United Kingdom; Federal Republic of Germany; India; Poland; France; The Netherlands; Yugoslavia; Italy; Denmark; Finland; Austria; and U.S.S.R. One paper is a joint IAEA/IIASA risk assessment project for Japan. Forty one countries, including the Peoples Republic of China, will send representatives. Five international organizations, not including the three sponsors, will be represented.

It is obvious that international boundaries have little meaning for materials produced and released by man. Two cases in point are the atmospheric CO_2 and acid deposition. I think it is quite obvious that more cooperative risk studies among nations will need to be done in the 1980's.

For example, the World Meteorological Organization (WMO) recently issued an appeal for an urgent worldwide study to seek ways of controlling the impact of increasing carbon dioxide upon climate and total environment. The appeal followed a meeting of experts from WMO, the United Nations Environment Program, and the International Council of Scientific Unions. The group concluded:

"A major international interdisciplinary research effort is necessary to develop a set of impact scenarios based upon extended sets of data not now available so as to deal successfully with uncertainty and to prepare a management plan of action adequate to cope with the likely impacts. It is essential that the research proposed here be undertaken as a matter of urgency."

We are witnessing more collaborative efforts on the international scientific level in the field of risk assessment. I have been working with a group of experts from six other nations (France, Denmark, Italy, The Netherlands, Spain, United Kingdom, and the United States) on a report entitled "The Environmental and Biological Behavior of Plutonium and Some Other Transuranium Elements," for the Organization for Economic Cooperation and Development (OECD). This particular report develops health risk coefficients for man. It is important to have input to such efforts by individuals from different countries. In this way one can attempt to integrate the various philosophies and experiences. Believe me, such studies are extensively reviewed since many countries are involved.

VI. Need for Further Developments in Risk Analysis

As the integrating component of comprehensive health and environmental studies, risk analysis also integrates all the uncertainties associated with determining exposures and hazards. Thus risk analysis will advance in general as basic knowledge accumulates. However, progress may be served if basic research were conducted within the framework of comprehensive risk analysis methods. The major role of risk analysis at present is to identify and prioritize data/research needs within a consistent and comprehensive framework. This role is of major importance but has not been utilized enough or consistently. In order to fulfill this role in a credible manner, risk analysis methods development and applications should be conducted by teams of scientists from different disciplines.

Full time support for such teams is a major present need. Multidisciplinary approaches are given much lip service and are employed in a few cases to conduct research in certain areas. But stable base support in the risk analysis context is yet to be realized. There is no commonly accepted methodology for comparison of energy technologies or other activities on a common scale. Acceptable risk has not been defined. Relative risk approaches are fraught with large uncertainties and attendant biases. We do believe, however, that progress can be made toward a clear understanding and application of risk analysis methods. Risk analysis must be established as the integrating component of research and development activities and the major activity that will interpret and translate results into comprehensible guidance for policy makers.

It is not easy to determine what national needs are in terms of risk analysis, because no one single body directs and funds this research. However, we can gain some idea from a series of questions (slightly altered here) that were posed by the Technology and Assessment Group of the National Science Foundation:

(1) How do we determine how safe is safe enough?

(2) How good are the data on which we depend for estimates of risk?

(3) How are estimates of risk translated into decision-making?

(4) How should we deal with uncertainty?

(5) What should institutions do when confronted with risk uncertainty?

(6) How do we perceive risk?

(7) Do individual perceptions of risk add up to a total view of society, i.e., does the whole equal the sum of the parts?

(8) Are some risks unacceptable, regardless of the accompanying benefits?

Another indication of possible national needs was given in the bill introduced by Congressman Ritter of Pennsylvania in the 97th Congress (H.R. 3441). This bill, designed to be cited as the "Risk Analysis Research and Development Act of 1981," is, in my opinion, an important and necessary piece of legislation.

The broad statements made in both the National Science Foundation document and Congressman Ritter's bill suggest the need for a strong scientific basis for risk analysis. Some of that foundation has already been laid, but there is considerable work to be done. In particular, there is need to (a) develop the basic theory and methods; (b) support the experimental determination of risk-related data; (c) study risk perception and decision analysis; and, most important of all, (d) do the actual risk assessments.

Without the methodology, no overall risk assessment can be constructed. It is clear that improving the methodology will require advances in mathematical techniques.

The data are also a key component of the final risk assessment. In some cases much of the data are either only vaguely known or in dispute, so there is considerable room for improvement.

While the many ways in which risk can be analyzed do not lead themselves to a single unified approach as yet, it should be remembered that the study of radiation has greatly improved our understanding of risk.

VII. Summary

The following material is taken from a paper I presented at the Symposium on Health Risk Analysis in October 1980. I think it is appropriate to these hearings.

> "The citizens of this country are bombarded every day with news about hazardous and toxic materials in their homes, their work places, the food they eat, the air they breathe, the water they drink, the chemicals they may encounter from various sources, the dyes that color their hair and foods, and even the materials their children sleep in. How will the general taxpaying public respond to this explosion of information concerning transformation, promoting agents, metabolic degradation products, carcinogens, teratogens, mutagens, and cocarcinogens? Many individuals will be convinced that the situation is severe but others may become saturated and selectively tune out news on the toxic materials of the day or month. A few might appreciate that knowledge is being accumulated about how materials, either alone or in various combinations, might ultimately affect them. (I say ultimately because years, perhaps even decades, may pass between exposure to a given material and the subsequent effect on man.) Many precious resources, including time and money, must be allocated to the task of deciding what materials are hazardous or toxic and analyzing their impact on human health.
>
> "We should not underestimate the size of this task. It is a huge undertaking to test product after product even if only one test or several relatively simple tests are used, once we can all agree upon the test or tests that should be used. Then we must consider associated problems. How do we develop dosimetric schemes to allow us to relate

exposure to effect as has been done in the field of ionizing radiation? Should we develop dosimetric schemes and models, or should we be content with learning relationships between exposure and effect? Should more effort be placed on the understanding of underlying principles and mechanisms? How can data obtained from one or more species be extrapolated to man? How do we commit our resources on a national basis, considering the large number of chemical compounds of real or potential concern? And, of course, to what level of risk should society be protected from a given material for a given level of benefit?

"It is obvious that there is a high level of interest, both nationally and internationally, in the subject of health risk analysis. I believe it is most important to discuss comparative risks and to place risks in proper perspective, especially when one is dealing with the translation of information from the scientific and technical domain to that of the general public."

Of course, health risk analysis is only an integral, but very important, part of risk analysis. We must get on with the job of understanding as best we can the risks associated with energy development and other activities. I believe Risk Analysis is the tool that will allow us to make the best decision as to what paths to follow.

I would like to include for the hearing record a copy of a paper entitled, "Risks in Perspective: Natural, Occupational, and de Minimis," that I presented to the 68th National Safety Congress and Exposition last October in Chicago.

I thank you.

Appendix 1

SOCIETY FOR RISK ANALYSIS
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