CONF-790949--3

COAL

Presentation for
Energy Resources Workshop

September 26, 1979

L. E. McNeese
Director, ORNL Fossil Energy Program

DISCLAIMER

COAL

I Availability and Use
- A. World Production and Consumption
- B. Reserves and Resources
- C. Present International Coal Trade
- D. Expected Future Shifts

II Opportunities for Increased Coal Use
- A. Present Energy Use Patterns
- B. Potential Coal Use Areas
- C. Obstacles to Increased Coal Use

III New Technologies for Using Coal
- A. Direct Combustion
  1. Atmospheric Fluidized Bed Combustion
     a. Utility
     b. Industrial
  2. Pressurized Fluid Bed Combustion
- B. Liquefaction
  1. Direct Liquefaction
     a. SRC-I
     b. SRC-II
     c. H-Coal
     d. Exxon Donor Solvent
  2. Indirect Liquefaction
- C. Gasification
  1. Low Btu Gasification
  2. Intermediate Btu Gasification
  3. Pipeline Gas Production
  4. Insitu Gasification
  5. Combined Cycle Operation

IV International Cooperative Programs on Coal R&D

V ORNL Coal Research and Development
- A. Coal Preparation
- B. Fluid Bed Combustion
- C. Liquefaction
- D. Materials
- E. Health and Environmental Impacts
- F. [illegible]

COAL

World Coal Availability and Trade

Opportunities for Increased US Coal Use

New Technologies for Using Coal

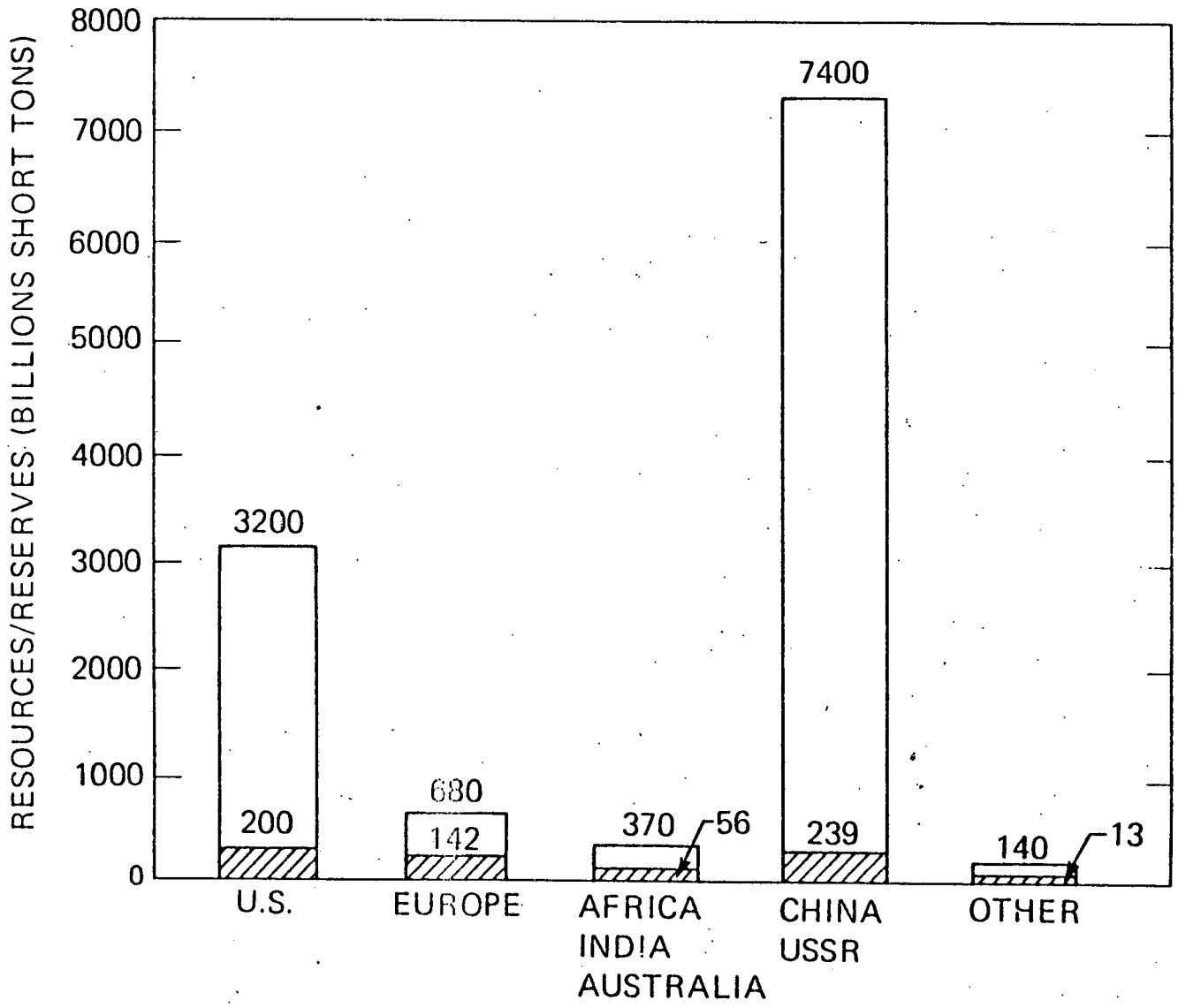
International Cooperative Programs on Coal R&D

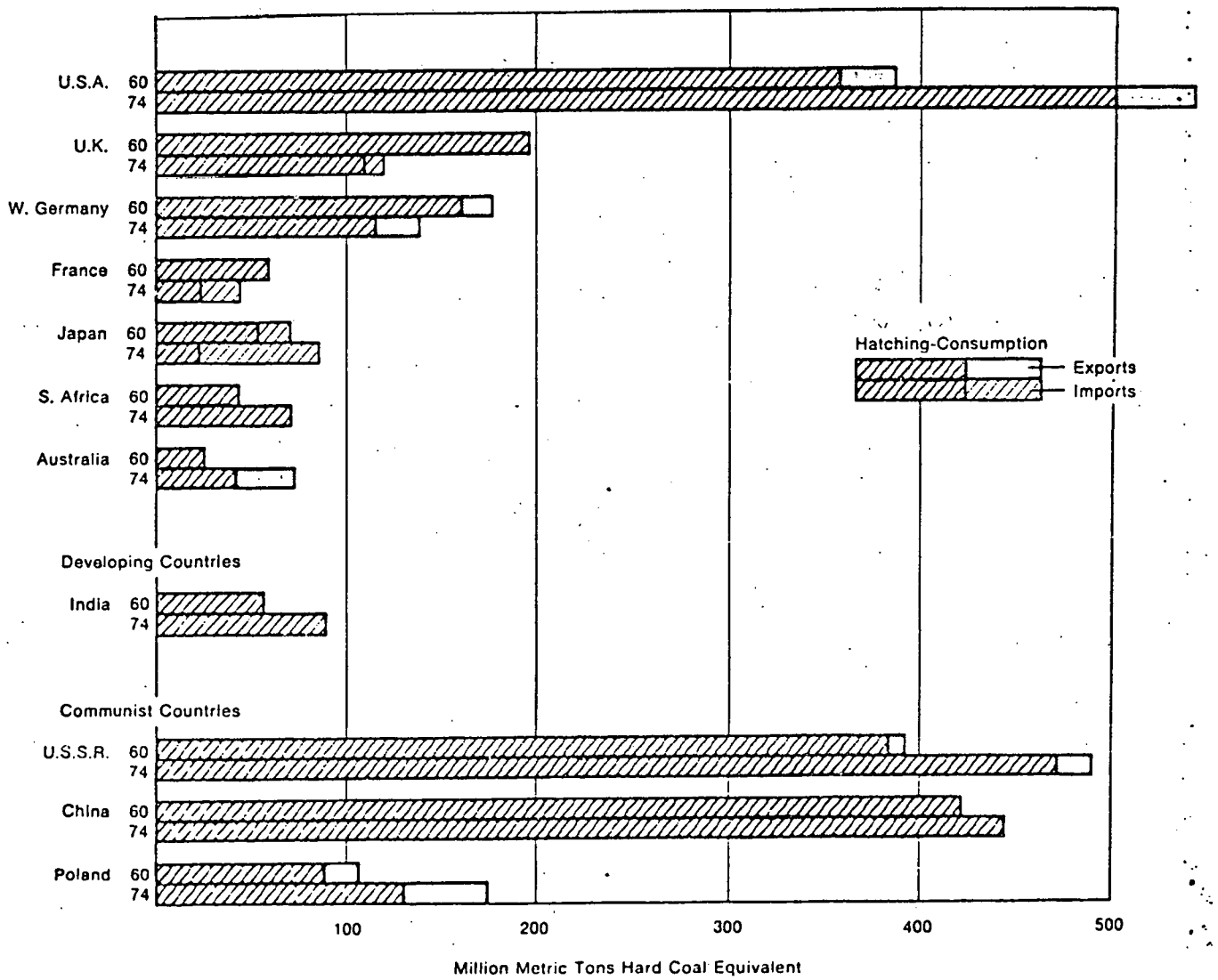
ORNL Coal Research and Development

WORLD COAL RESERVES AND RESOURCES
(billions of short tons)

	Reserves				Resources	
	Recoverable	%	Total	%	Total	%
USSR	151	23.1	301	19.5	6300	53.1
China	88.2	13.5	331	21.4	1100	9.3
Other Asian	19.3	3.0	44.6	2.9	119	1.0
US	200	30.8	401	25.8	3220	27.2
Canada	6.1	0.9	10	0.7	120	1.0
Latin America	3.1	0.5	10	0.7	36.3	0.3
Europe	140	21.4	353	22.8	670	5.6
Africa	17.2	2.6	33.4	2.2	64.9	0.6
Oceania	27	4.2	82.3	5.3	220	1.9

COAL IS A MAJOR ENERGY SOURCE FOR THE U.S. RELATIVE TO THE REST OF THE WORLD



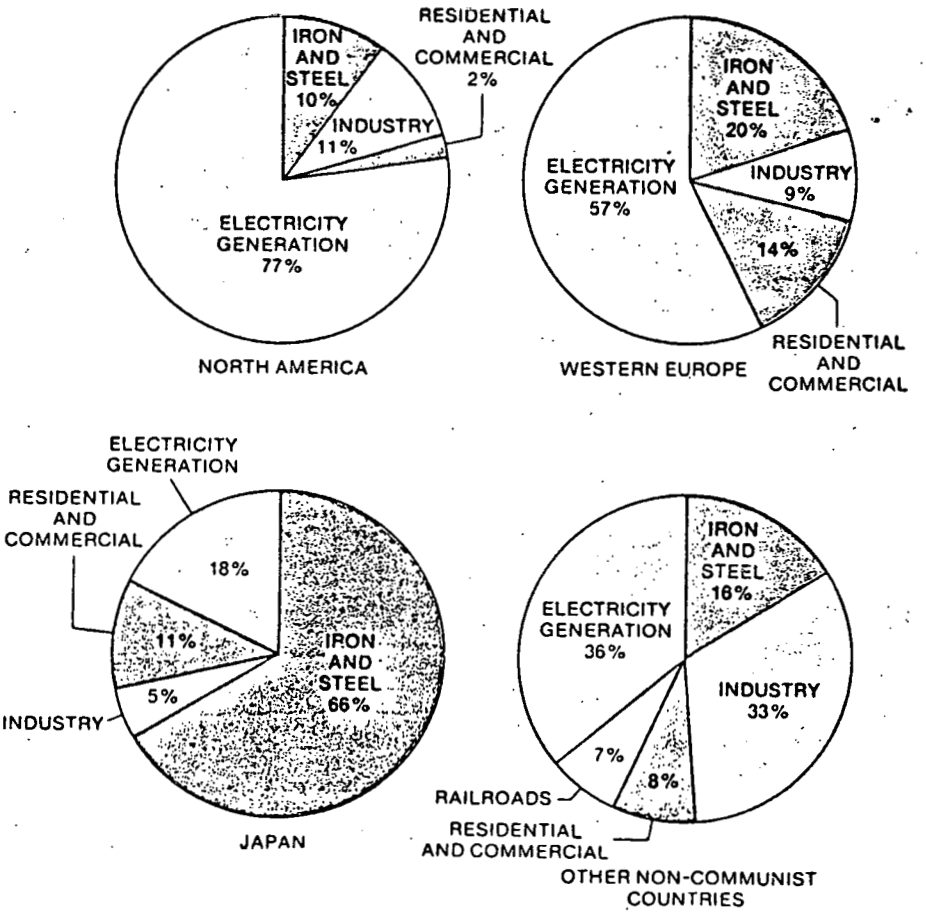


WORLD COAL PRODUCTION AND CONSUMPTION

Coal Production, Export and Import During 1977
(million metric tons)

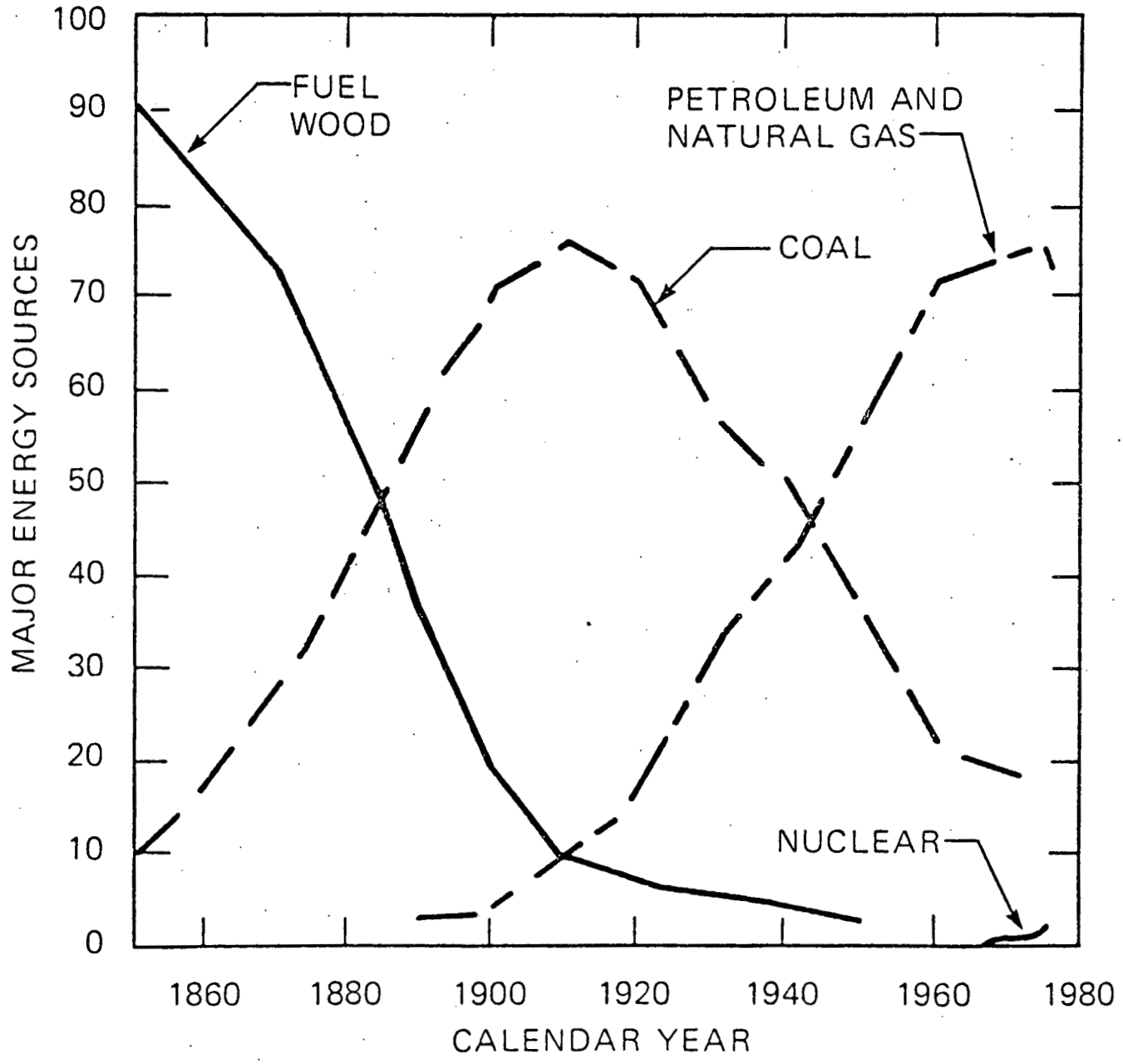
Country	Exports	Imports	Production
United States	49.3	1.5	615.3
Poland	39.2	1.1	593.0
Australia	35.5	2.4	101.4
USSR	25.8	9.4	722.1
Federal Republic of Germany	14.6	6.35	207.5
United Kingdom	1.9	2.4	120.8
Peoples Republic of China	*	*	490.0
Japan	--	60.8	18.2

*No figures available

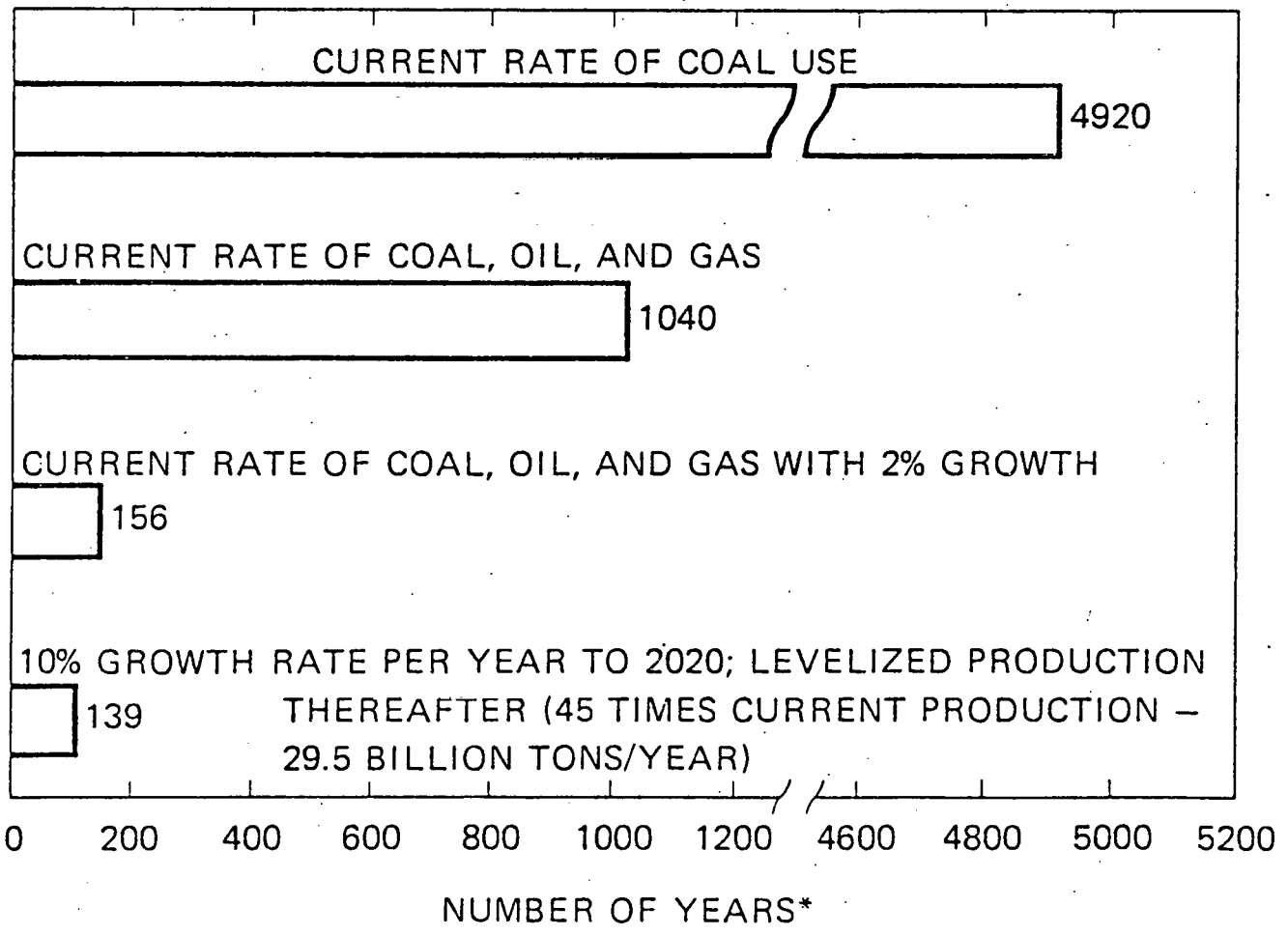


MAJOR MARKETS FOR COAL around the world in 1976 were electric-generating plants and the iron and steel industry. More than three-fourths of the coal consumed in North America was used to generate electricity. In Japan the dominant user of coal was the iron and steel industry. Industrial uses of coal were also significant in developing countries, notably India.

U. S. ENERGY CONSUMPTION PATTERNS

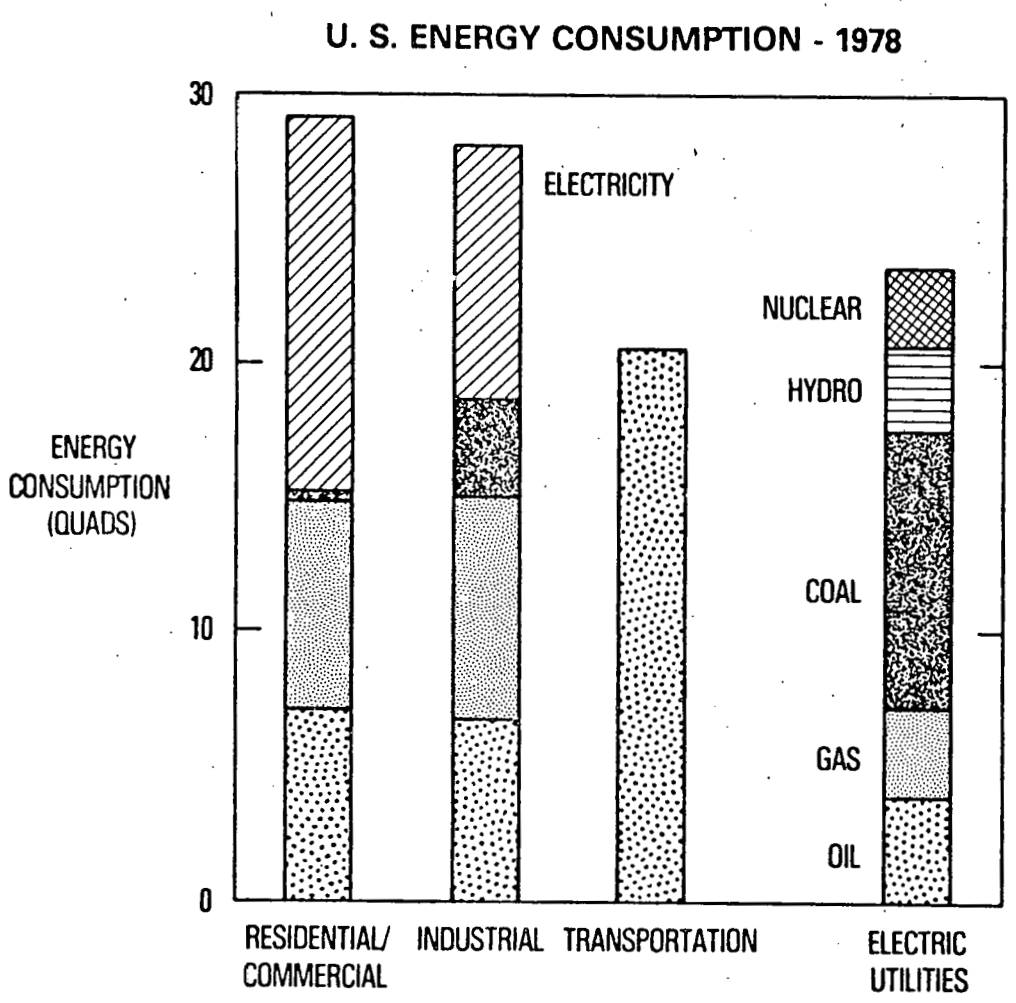


HOW LONG WILL U. S. COAL LAST?



*BASED ON TOTAL RESOURCE

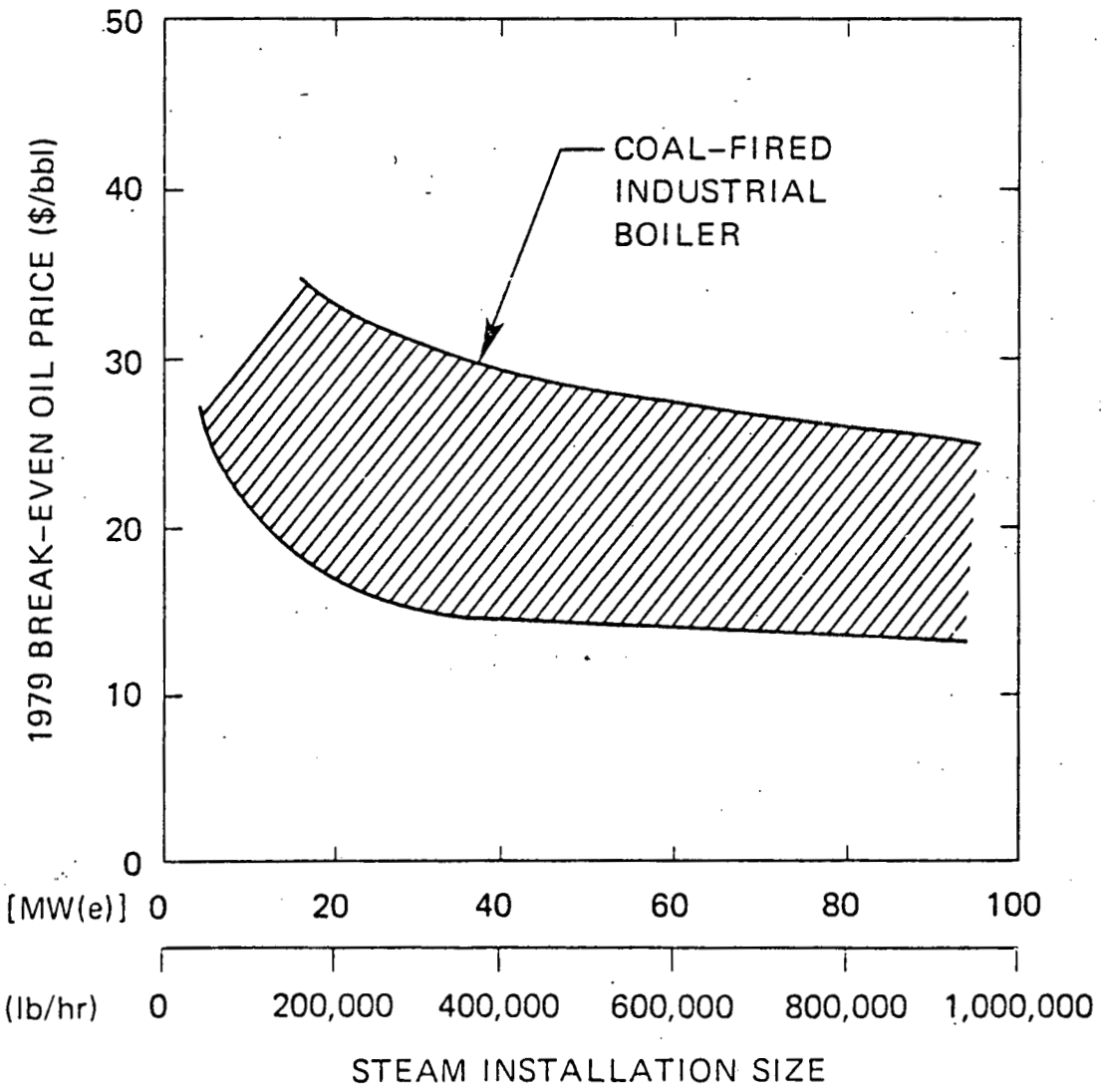
ORNL-DWG 79-13389



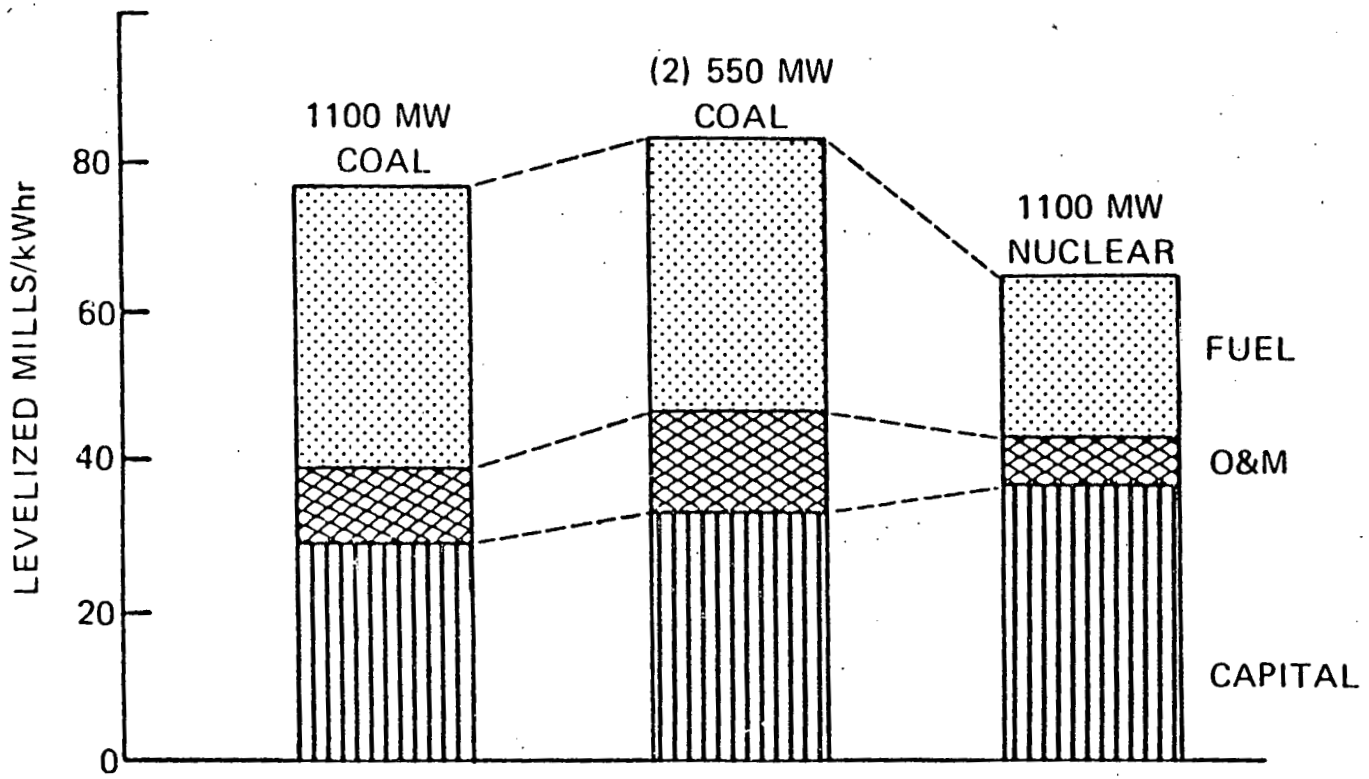
OBSTACLES TO U.S. INDUSTRIAL CONVERSION TO COAL

- Technical Risks for Advanced Combustion Technologies Are High
- Economics Are Unattractive
  - Small Users Cannot Obtain Competitive Transportation Rates or Long Term Contracts
  - Unavailability of Capital
- Air Quality Considerations Present Difficulties
  - Uncertain Regulatory Policy
  - Conversion to Coal Will Increase Air Emissions
  - Areas with Pollution Problems will be Unable to Absorb New Increases

COAL IS LESS ECONOMICALLY ATTRACTIVE THAN OIL AND GAS FOR SMALL INDUSTRIAL BOILERS



AND LESS ECONOMICALLY ATTRACTIVE THAN NUCLEAR FOR LARGE UTILITY BOILERS

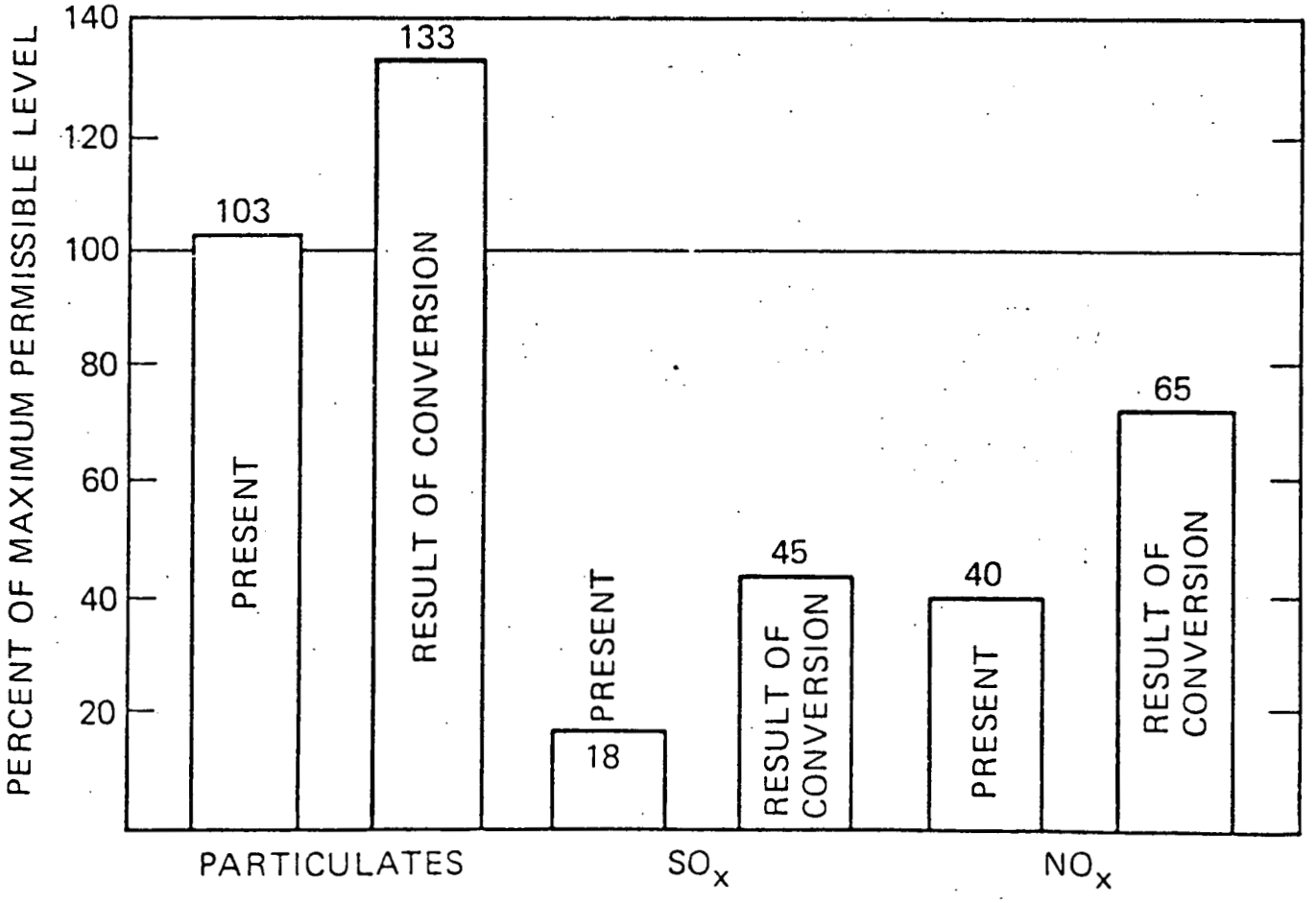


– MID–1985 STARTUP, 30–YEAR LIFE

– 65% PLANT CAPACITY FACTOR

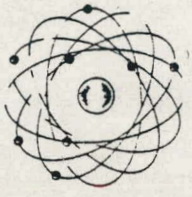
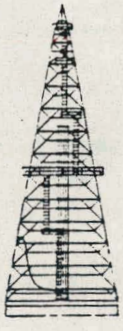
ENVIRONMENTAL ISSUES ARE ANOTHER MAJOR OBSTACLE

- NEW SOURCE PERFORMANCE STANDARDS
- EMMISSION TRADEOFFS IN "NONCOMPLIANCE" REGIONS BASED ON AMBIENT AIR QUALITY STANDARDS
- PREVENTION OF SIGNIFICANT DETERIORATION

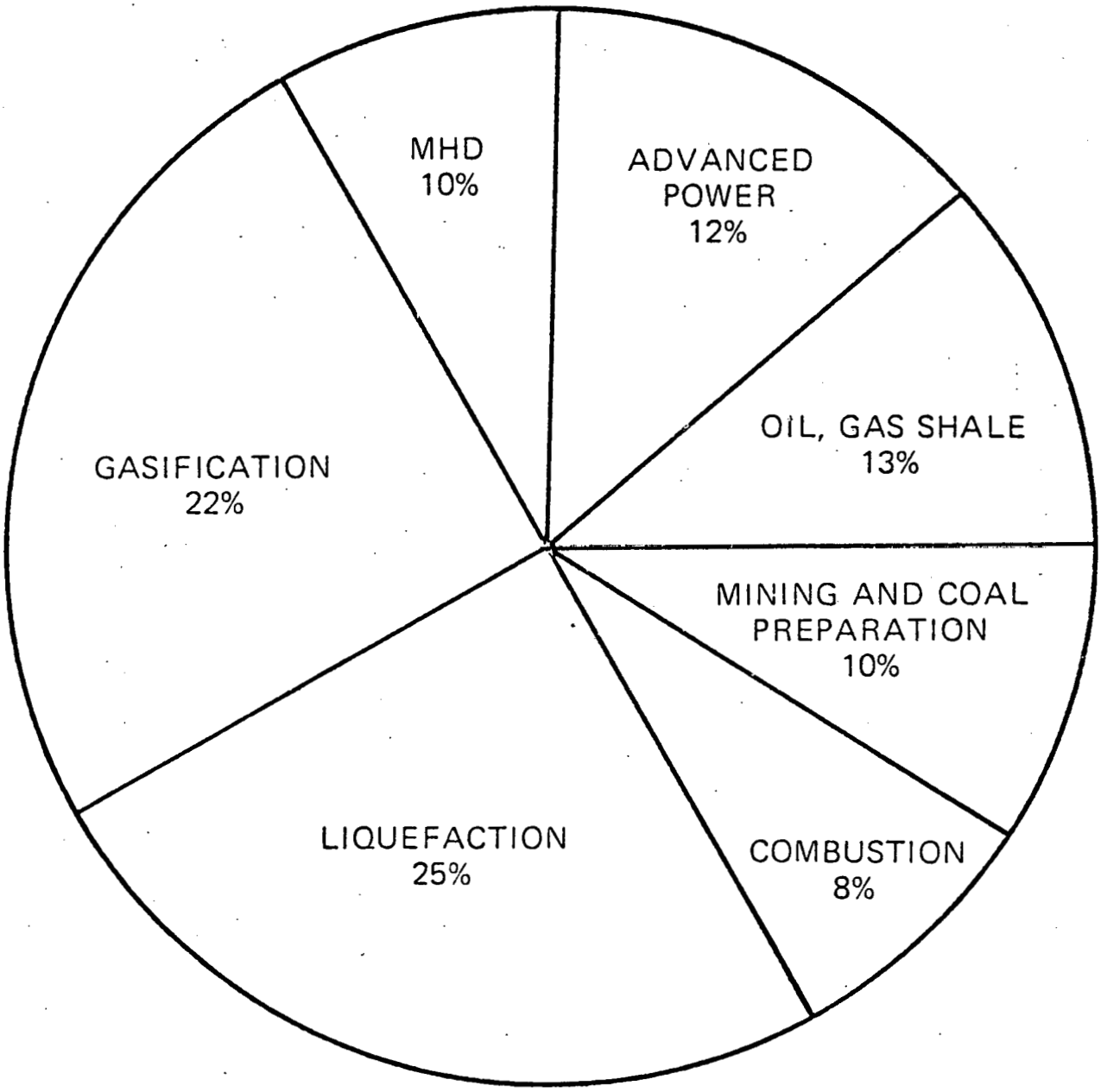


IMPACT OF CONVERSION TO COAL IN THE HOUSTON AREA

OCCUPATIONAL HEALTH AND SAFETY MAY BECOME AN INCREASINGLY IMPORTANT ISSUE

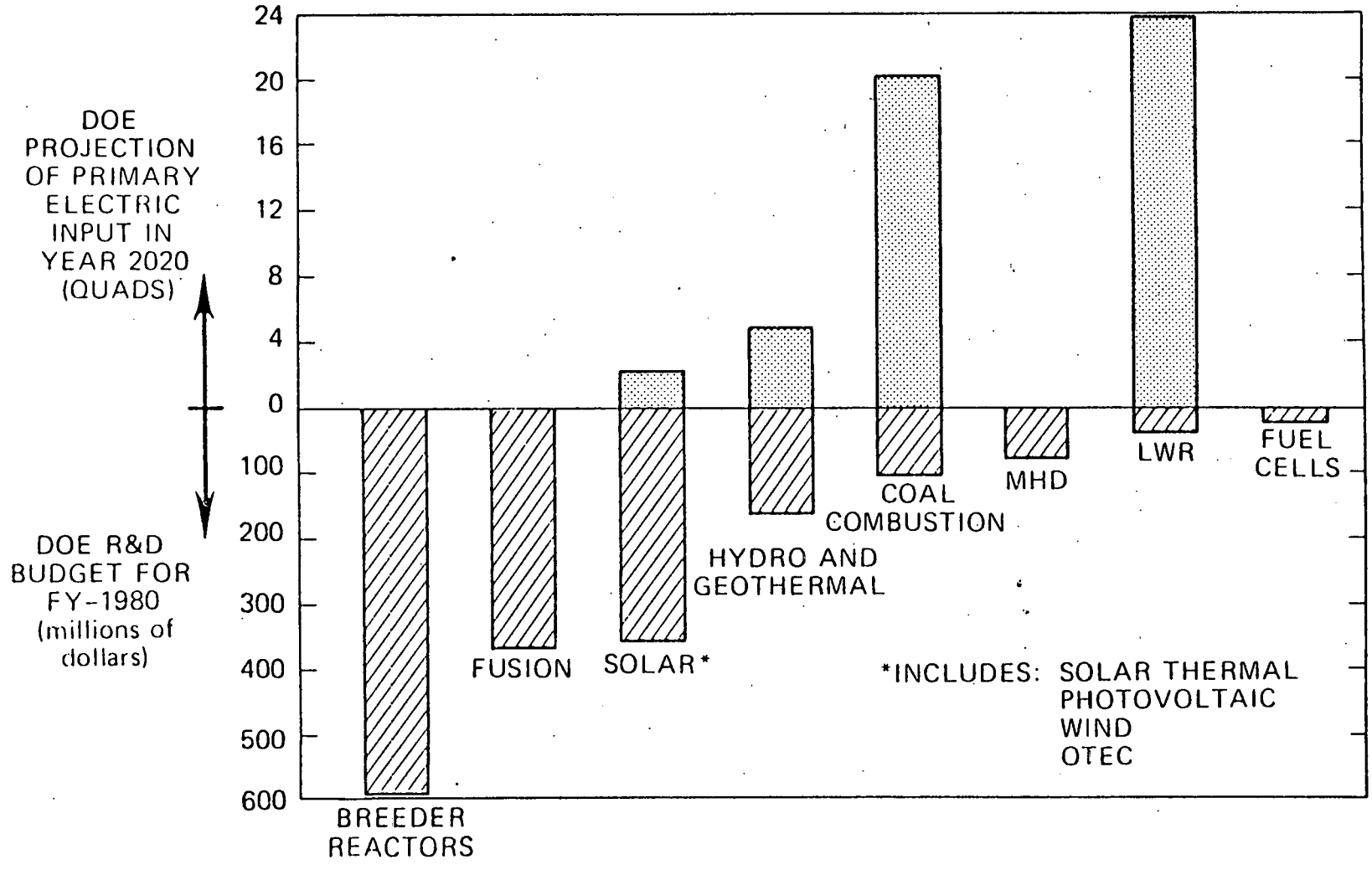
	LOST DAYS/10^{12} Btu
COAL 	310
NUCLEAR 	32
OIL 	57
NATURAL GAS 	30
HYDROELECTRICITY 	160

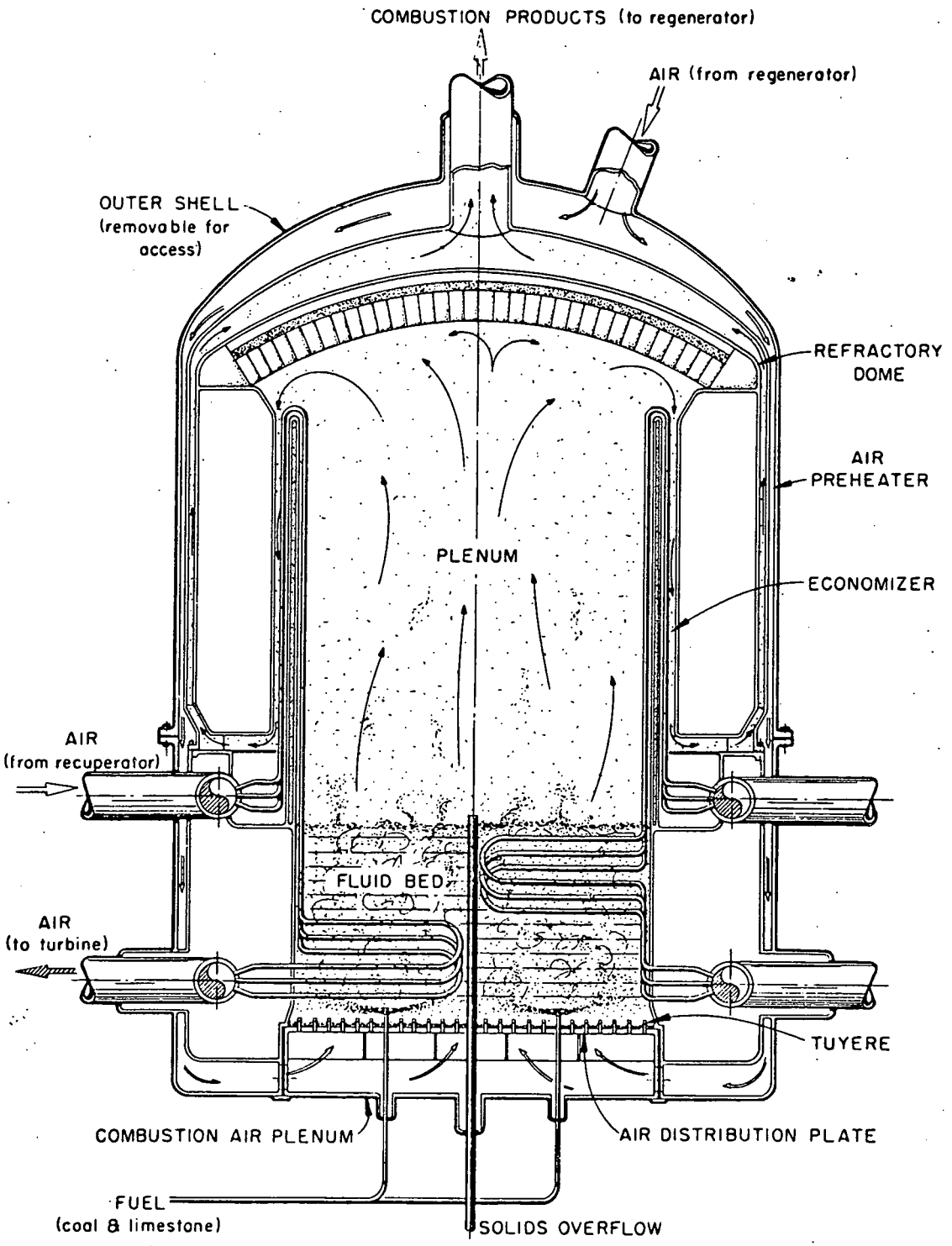
NATIONAL FOSSIL ENERGY PROGRAM BUDGET IS DIVIDED AMONG SEVEN AREAS



TOTAL FY 1979 BUDGET IS $760 MILLION

DOE'S MAJOR R&D PROGRAMS ON ELECTRIC POWER GENERATION EMPHASIZE LONG-TERM TECHNOLOGIES




COMBUSTION PRODUCTS (to regenerator)
AIR (from regenerator)
OUTER SHELL (removable for access)
REFRACTORY DOME
AIR PREHEATER
PLENUM
ECONOMIZER
AIR (from recuperator)
FLUID BED
AIR (to turbine)
TUYERE
COMBUSTION AIR PLENUM
AIR DISTRIBUTION PLATE
FUEL (coal & limestone)
SOLIDS OVERFLOW

FLUIDIZED BED COMBUSTION

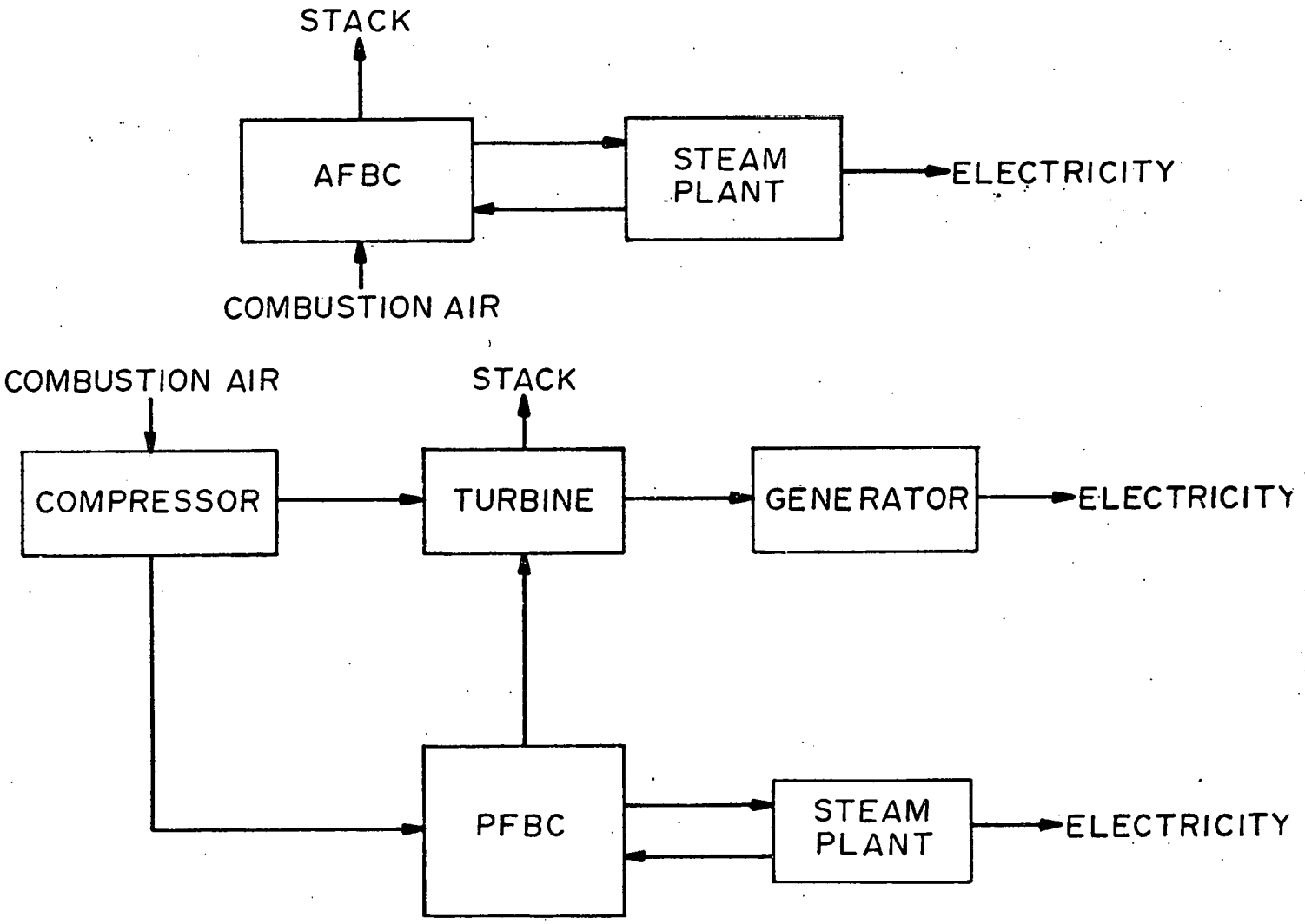
Atmospheric Fluid Bed

Utility

Industrial

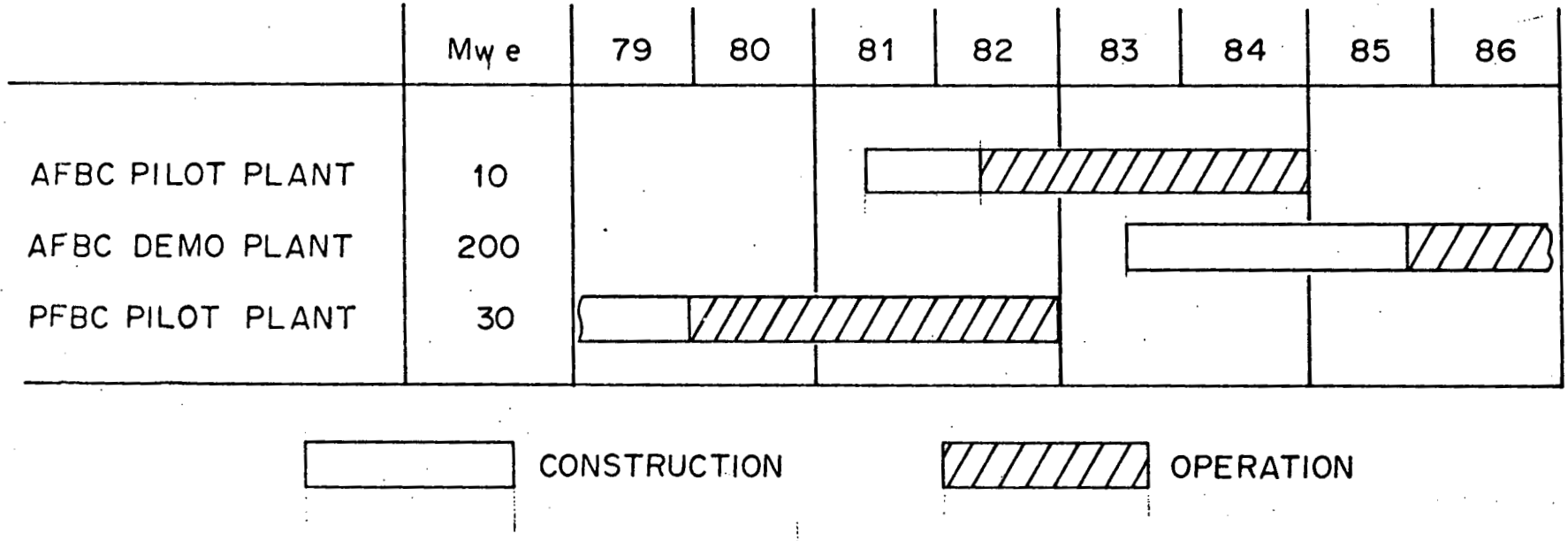
Pressurized Fluid Bed

ORNL DWG 79-1495

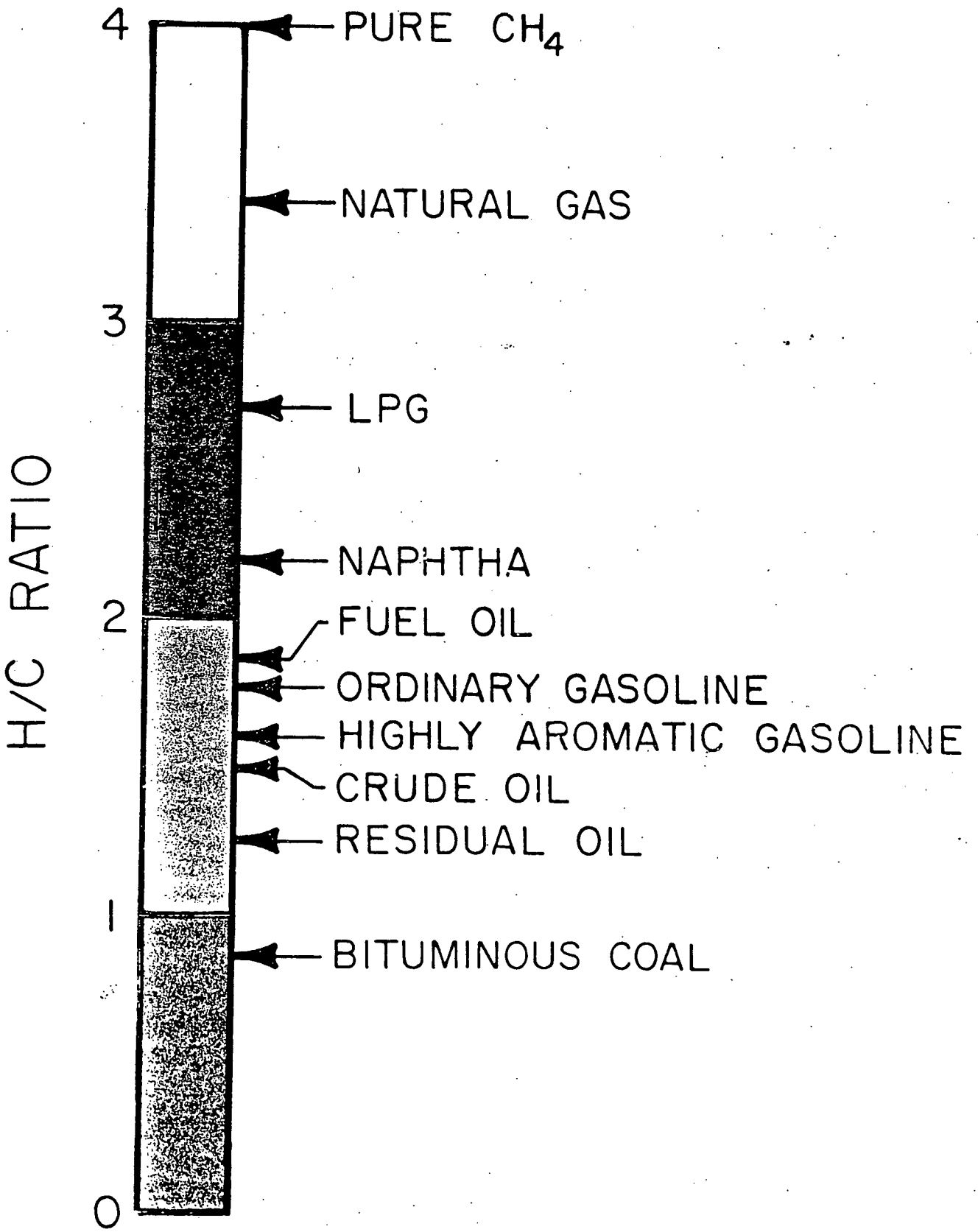


FLUIDIZED BED COMBUSTION APPROACHES

ORNL DWG 79-1494



FBC PILOT PLANT – DEMO PLANT SCHEDULES



SOURCE: WISER (1973)

$$\text{Coal} + \text{air} + H_2O \longrightarrow CO + H_2 + N_2 \qquad (\sim 150\ \text{Btu/ft}^3)$$

$$\text{Coal} + O_2 + H_2O \longrightarrow CO + H_2 \qquad (\sim 350\ \text{Btu/ft}^3)$$

$$CO + H_2O \longrightarrow CO_2 + H_2 \qquad (\text{shift})$$

$$CO + 3H_2 \longrightarrow CH_4 + H_2O \qquad (\sim 1000\ \text{Btu/ft}^3)$$

Production of Low, Intermediate, High Btu Gas and Hydrogen

GASIFICATION

Low Btu Gasification

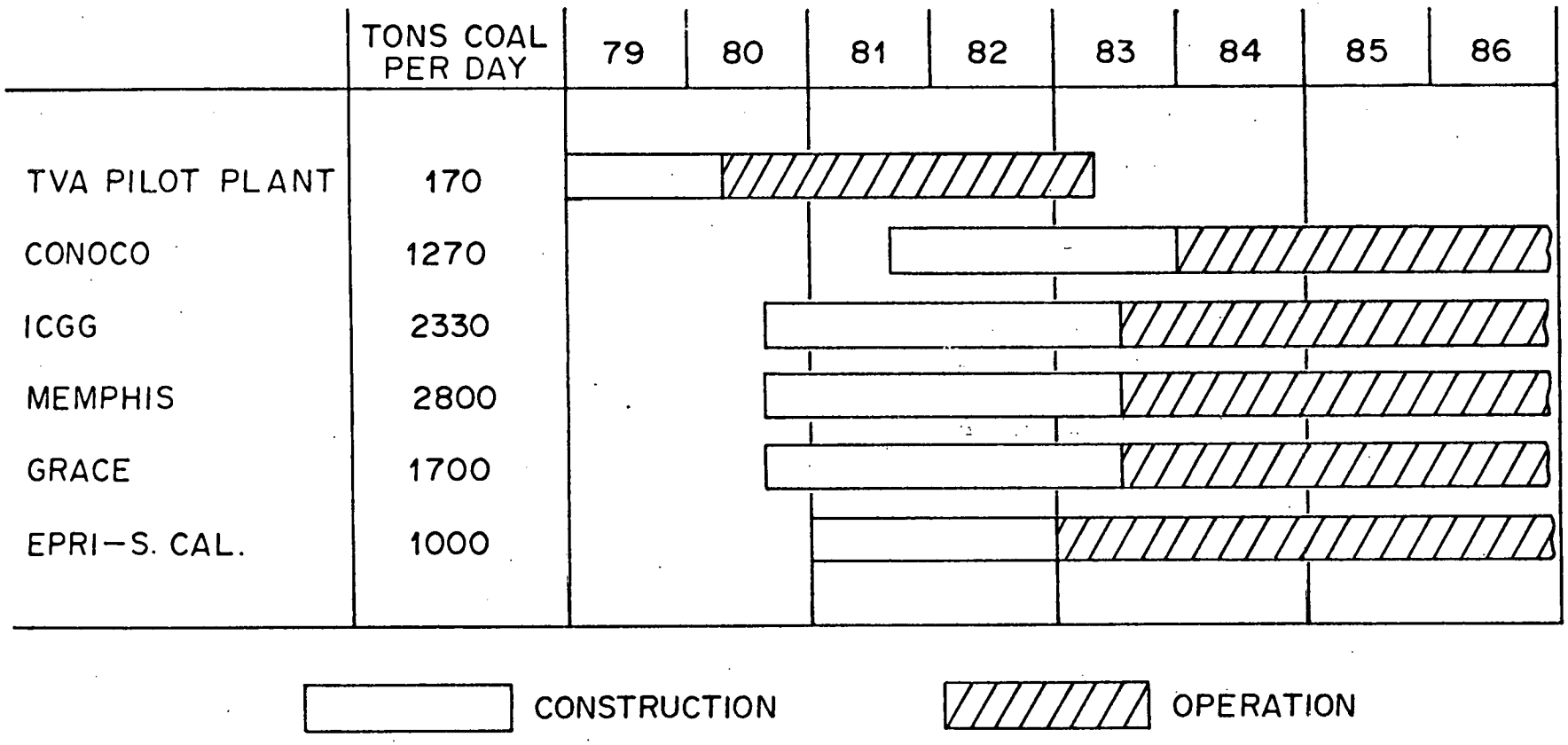
Intermediate Btu Gasification

Pipeline Gas Production

Insitu Gasification

Combined Cycle

ORNL DWG 79-1496



GASIFICATION PILOT PLANT – DEMO PLANT SCHEDULES

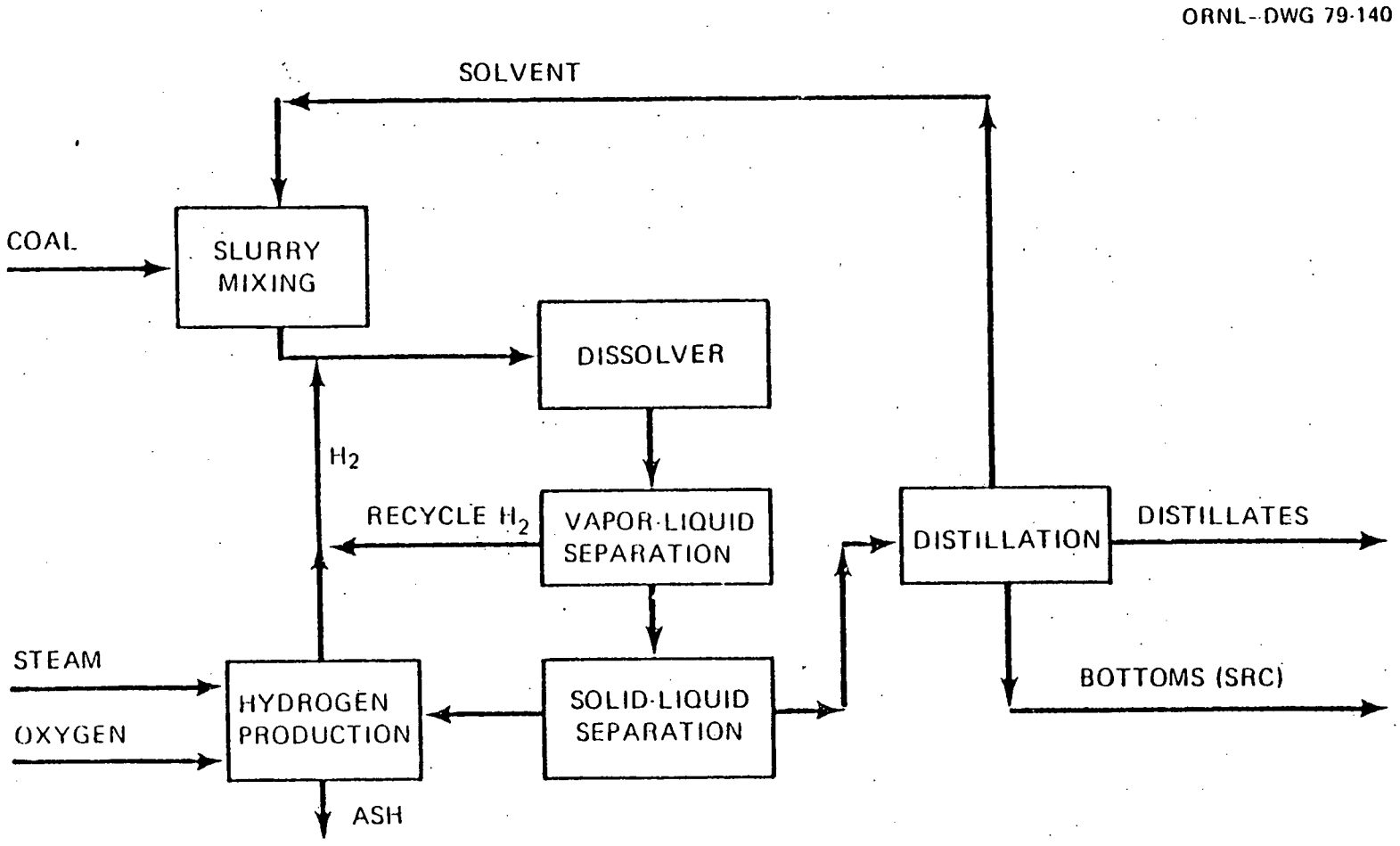
COAL LIQUEFACTION

Direct Liquefaction

- SRC-I
- SRC-II
- H-Coal
- Exxon Donor Solvent

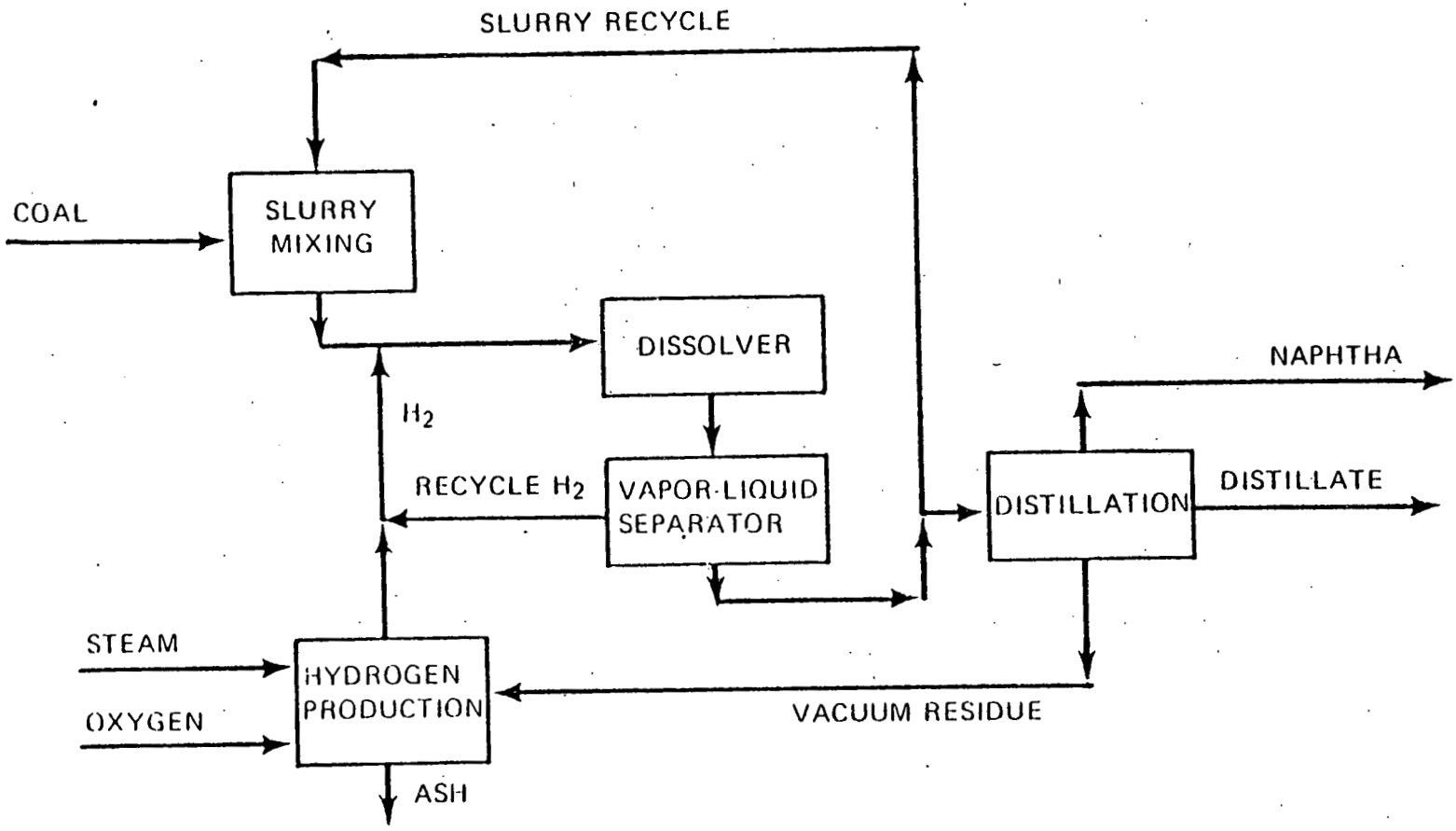
Indirect Liquefaction

- Fischer Tropsch
- Methanol
- Methanol to Gasoline



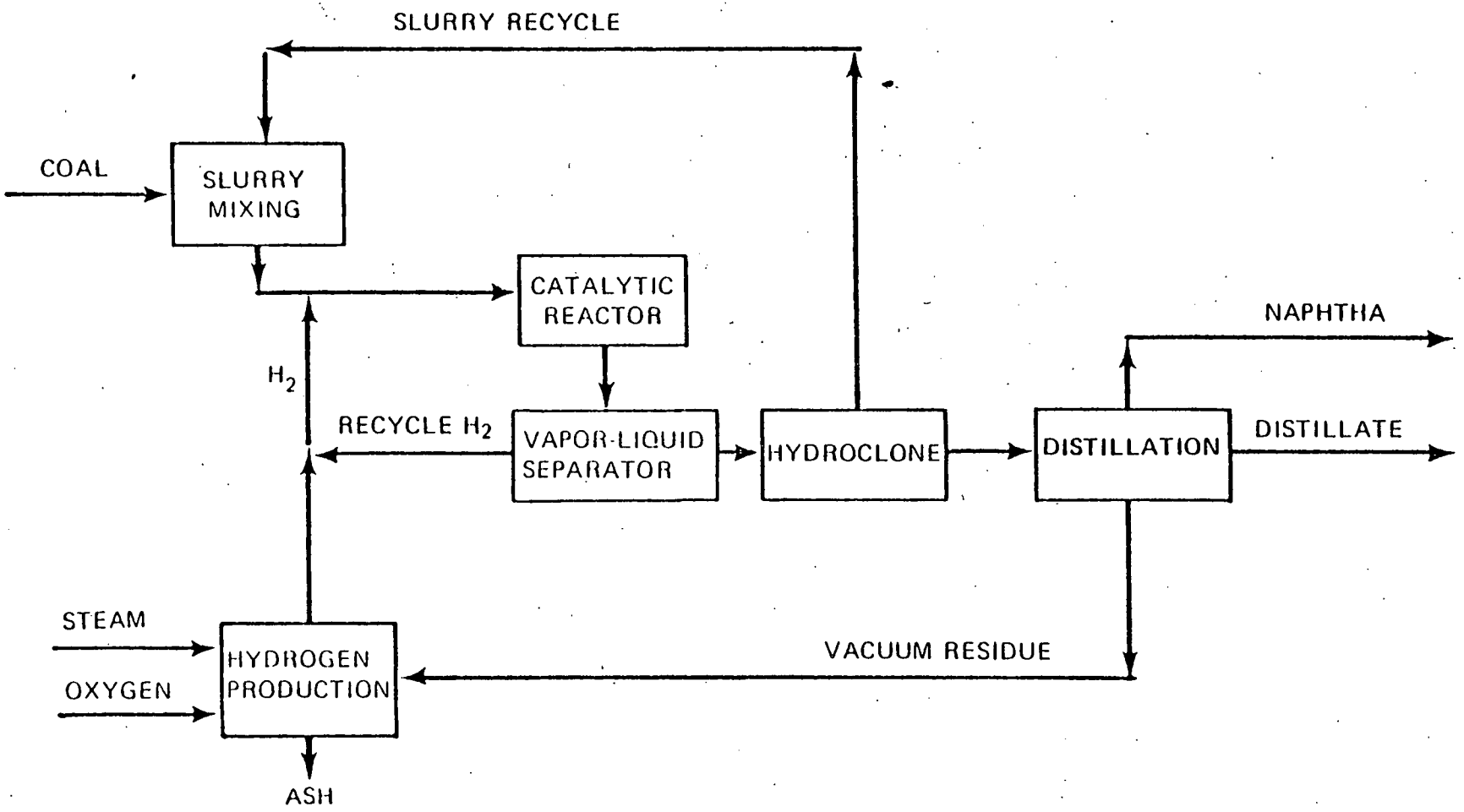
SRC-I PROCESS

ORNL–DWG 79-141



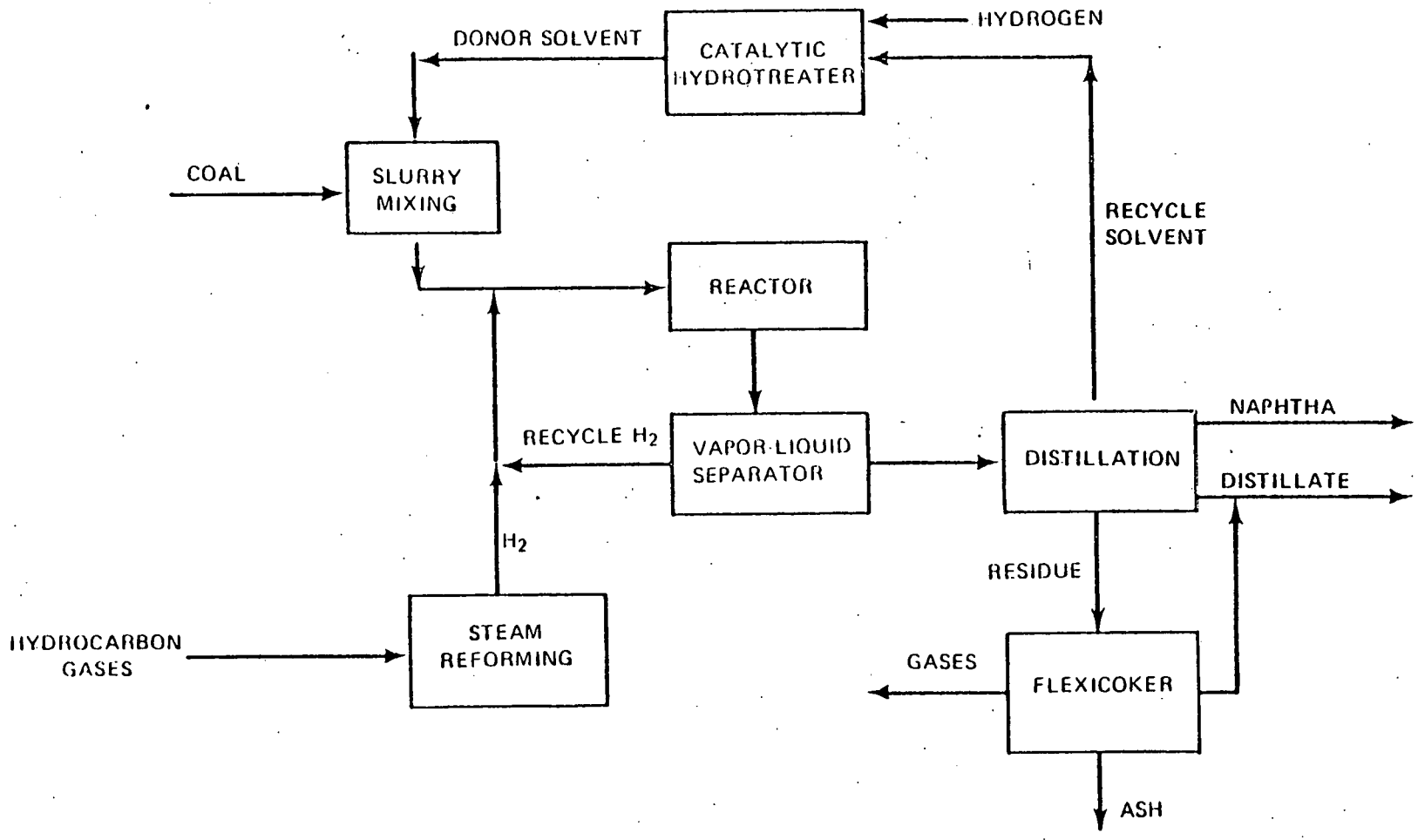
SRC-II PROCESS

ORNL–DWG 79-142



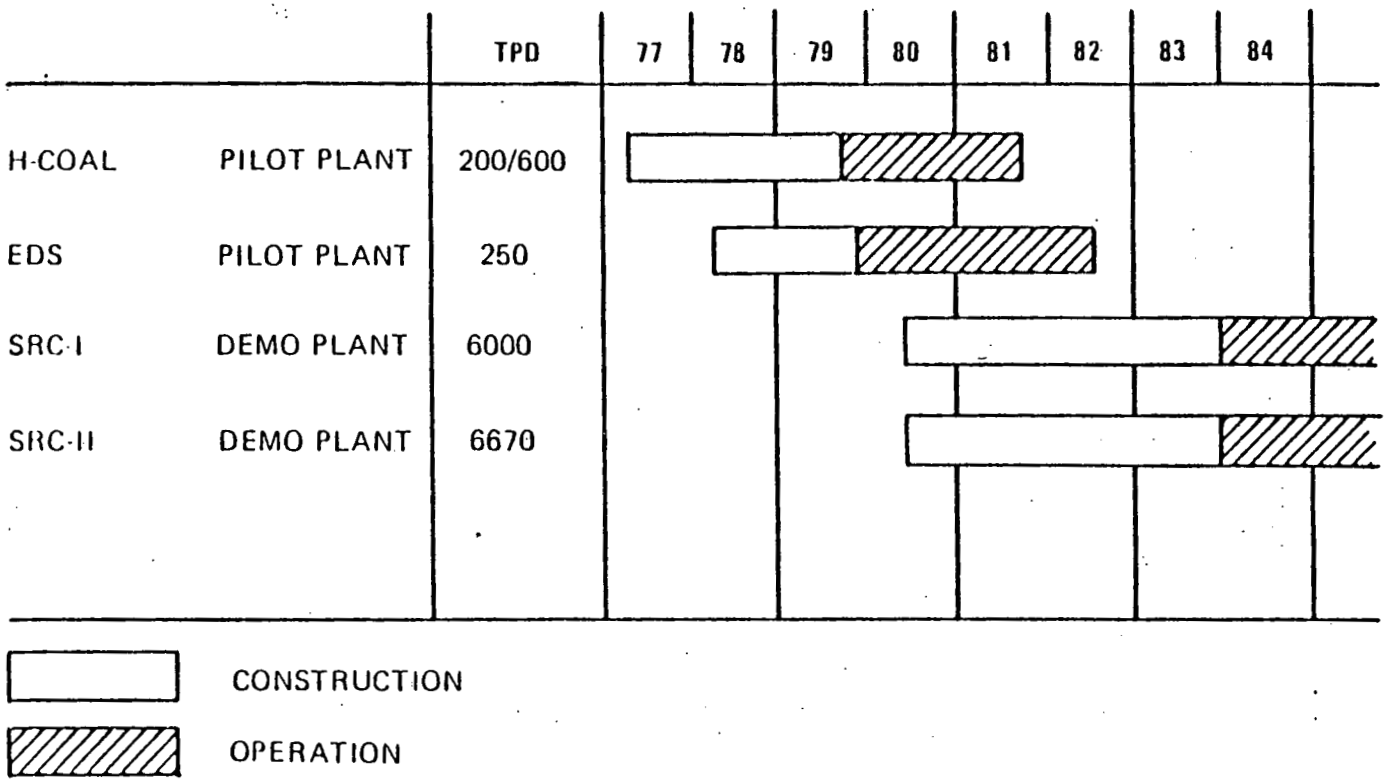
H-COAL PROCESS

ORNL-DWG 79-143



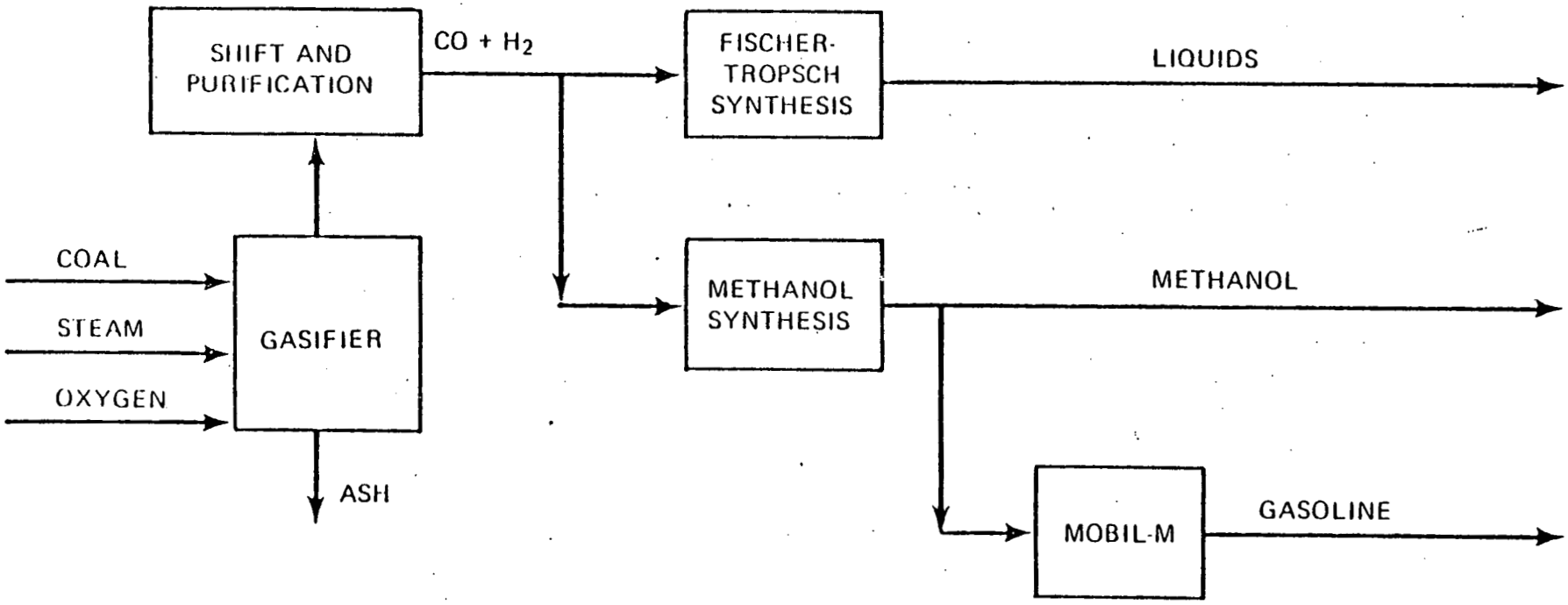
EDS PROCESS

ORNL–DWG 79-144



DIRECT LIQUEFACTION PILOT PLANT –
DEMO PLANT SCHEDULE

ORNL–DWG 79-147



INDIRECT LIQUEFACTION

OBSTACLES TO SYNFUELS PRODUCTION

Uncertainty

- Cost Relative to World Oil
- Regulatory
- Technological Risk
- Lack of Public Consensus

Mining Capacity

Coal Transportation Capability

Environmental and Health Considerations

COAL DEVELOPMENT

PROGRAMS UNDERWAY IN THE WORLD

LIQUEFACTION

Organization	Country	Description
National Coal Board	U.K.	Supercritical gas extraction; extraction of coal constituents with light aromatics at elevated temperature and pressure
National Coal Board	U.K.	Hydroliquefaction
Bergbau-Forschung	FRG	Hydroliquefaction with disposable catalyst at 300 atmospheres pressure
Saarbergwerke	FRG	Hydroliquefaction with disposable catalyst at 200-300 atmospheres
Broken Hill Proprietary, Ltd. (BHP)	Australia	Hydroliquefaction
Commonwealth Scientific and Research Organization (CSIRO)	Australia	Pyrolysis
Australian Coal Industry Research Laboratories	Australia	Hydroliquefaction
Mitsui	Japan	SRC I; modified to use some petroleum liquids as feedstocks
Sumitomo	Japan	Donor solvent
Gaz de France	France	Hydroliquefaction/gasification

FLUIDIZED BED COMBUSTION

Organization	Country	Description
IEA (Grimethorpe)	U.K.	Pressurized fluidized bed combustion (PFBC), 10 ATM., 11 TPH coal feed
NCB/British Steel Corp. (BSC)	U.K.	80,000 pound per hour boiler, at BSC's River Don Steel Mill
NCB	U.K.	Fifteen government subsidized units ranging from 10,000-80,000 PPH steam equivalent
Babcock & Wilson, Ltd./ Stal Laval (U.K. subsidiary)	U.K.	170 MWe PFBC unit with turbines/ generators for American Electric Power
Ruhrkohle/Gruppe Deutsche Babcock AG	FRG	35 MWe AFBC near Dusseldorf
Ruhrkohle/Standardkessel/ Thyssen Energie	FRG	6 MWe AFBC, near Recklin Hausen
Mustad and Søn AS	Sweden	District heating unit at En Koepings (Sweden)

GASIFICATION

Organization	Country	Description
British Gas	U.K.	Slagging fixed bed gasification
CRE (Stoke Orchard)	U.K.	Fluidized bed gasifier
Ruhrchemie/Ruhrkohle	FRG	Texaco process, 40 atmosphere, 6 TPH feed
Saarberg-Otto	FRG	Entrained slagging, 25-30 ATM., 10 TPH
Shell-Koppers	FRG	Entrained slagging, 30 ATM., 6 TPH
Rheinische Braun-Kohlen Werke (Rheinbraun)	FRG	High temperature Winkler, 10 ATM., 1 TPH
Rheinbraun/Bergbau/Forschung, et al	FRG	Hydrogasification, 880 lb/hr
Ruhr/Ruhrkohle/Steag	FRG	High pressure Lurgi, 100 ATM., 7 TPA
Vereinigte Elektrizitats-werke West Falen AG (VEW)	FRG	Pyrolysis and partial gasification of coal plus burning residual char to produce electricity

INTERNATIONAL COOPERATIVE PROGRAMS ON COAL R&D

IEA Coal Research

- Economic Assessment Service
- Grimethorpe PFBC ($90M)

SRC-II

- Federal Republic of Germany ($175M)
- Japan

Methanol to Gasoline

- Federal Republic of Germany ($30M)

Fluid Bed Combustion

- India

MHD

- USSR
- Final Negotiations with Holland
- Poland
- Japan - letter of interest

Coal-Oil Mixtures

- Canadians (task sharing)
- Australian-Japanese

Low NO_x Burner

- US Development
- Foreign Interest

INTERNATIONAL COOPERATIVE PROGRAMS ON COAL R&D (continued)

Mining

- United Kingdom
- Poland

Insitu Gasification

Long Range R&D

ORNL COAL RESEARCH AND DEVELOPMENT

Coal Preparation

- Dry Magnetic Beneficiation of Coal
- Preparation Plant Automation

Fluidized Bed Combustion

- TVA Demonstration Plant Support
- Industrial Cogeneration
- Supercharged FBC

Liquefaction

- Chemistry, Physical Properties, Technology Support
- Pilot and Demonstration Plant Support
- Indirect Liquefaction Evaluation

Materials

- National Fossil Energy Materials Program
- Program and Project Support

Health and Environmental Impacts

- Biological and Ecological Research
- Environmental Assessments

Environmental Control Technology