The original documents are located in Box 6, folder: "General Facts on Energy (3)" of the Frank Zarb Papers at the Gerald R. Ford Presidential Library.

XI. SOLAR

SOLAR ENERGY (1)

BACKGROUND

- Solar Energy has long caught man's attention as a potential source of commercial energy because we know where the resource is, and the technical means for recovering it appears to be straightforward. Unlike almost all of our other energy sources--current and prospective--we do not have to look for solar energy; we can calculate the very large size of the resource.

- Commercial development of solar energy has been impeded by two technical factors which translate into unfavorable economics.

    - Solar energy systems generally have storage problems due to the intermittent nature of sunlight and the wind. Most consumers want energy when they need it rather than when it is available.

    - The diffuse nature of most forms of solar energy, including wind and ocean thermal gradients, require very large collectors, blades or heat exchangers to capture useful quantities of energy.

    - Another factor which has inhibited development of solar energy has been the high first capital cost requirements for solar energy systems contrasted with the traditionally low first capital costs for fossil fuels. This has been further exacerbated by depletion allowances and other indirect subsidies that have been provided for nuclear and fossil fuels.

- The societal costs of solar energy systems should be lower than those of conventional energy sources due to the environmentally benign nature of solar systems which have limited public health hazards, i.e., radiation, pollution emissions, etc.

- Recent techonological advances and the significantly higher prices of alternative fuels now make solar energy technologically and economically more competitive and will enable solar energy to play an important role as a commercial energy source.

- Recognition of this change is shown by:

  - o The increased support for solar R&D within the Executive and Legislative branches of government, by industry (especially for solar heating and cooling of building), and by the general public.

  - o Laws pertaining to solar energy which have recently been enacted: The Solar Heating and Cooling Demonstration Act of 1974, 93-409; The Energy Reorganization Act of 1974, 93-438; The Solar Energy Research, Development, and Demonstration Act of 1974, 93-473; and The Federal Non-Nuclear Energy Research and Development Act of 1974. Also, State and local laws have been enacted to provide incentives for solar heating and cooling. The introduction and adoption of incentives proposals are anticipated during the 94th Congress.

  - o Over 200 U.S. firms have expressed interest in the use of solar energy for heating and cooling buildings.

  - o Mobil and Tyco have recently launched a cooperative effort to develop terrestrial applications of photovoltaic techonology. Approximately $30 million over seven years has been committed by this agreement. Other large oil companies are also investing in photovoltaic solar techonology.

- The combination of these pressures should serve to increase the rate of solar energy development and utilization.

SOLAR ENERGY CONVERSION SYSTEMS

1. Solar Heating and Cooling of buildings

2. Wind Energy Conversion

3. Bioconversion to Fuels
4. Photovoltaic Electric Power Systems
5. Ocean Thermal Conversion
6. Solar Thermal Conversion

SOLAR HEATING AND COOLING OF BUILDINGS

- The techonology of solar heating and cooling of buildings is defined as solar-driven space heating, space cooling through heat-driven refrigeration cycles, and solar water heating.

- Solar energy incident on a collector surface is converted to thermal energy in a working fluid, commonly water or air. This working fluid transfers the heat energy either directly to the conditioned space, to thermal energy storage equipment, to heat operated refrigeration equipment, or it is used directly in the form of hot water.

- The solar collector type most commonly used consists of a black flat plate which absorbs heat from the sun's rays. This plate is covered on the sun side with one or more transparent covers to reduce thermal losses due to re-radiation, convection, and conduction.

- Flate plate collector efficiencies of 35-40% are easily attainable, and under favorable conditions, efficiencies of 65% are possible.

- Economic analysis indicates that in most applications, solar heating and cooling equipment will be used in conjunction with conventional heating, ventilating, and air conditioning (HVAC) components. The extent to which it is necessary to augment the solar system with conventional equipment is dependent on cost, variations in climate conditions, and size of the required collector arrays and thermal storage capacity.

- Solar space heating and water heating applications should be feasible throughout most of the United States.

- Several solar space heating houses have been operating for a number of years, and solar hot water heaters had been economically employed in several southern states prior to the availability of low cost fossil fuels, particularly natural gas.

- Solar driven space cooling technology, in general, is presently in an experimental stage of development. Commercialization is expected within a few years. Solar cooling is now being demonstrated in various applications including a school in Atlanta, Georgia, which is being equipped with solar cooling.

- Principal factors limiting broad application of solar heating and cooling equipment are the lack of low-cost collectors and the present state-of-the-art of heat-driven refrigeration systems. An important reason for the high cost of collectors is the current lack of standardization and low volume of production, as well as lack of public acceptance and tax considerations.

- It is estimated in the Project Independence Report that solar heating and cooling technology can provide $.6 \times 10^{15}$ Btu's sensible heat per year in 1985 under a business-as-usual program, and 1.5×10^{15} Btu's. sensible heat under an accelerated program which would incorporate appropriate incentives.

- Figure 2 shows a comparison of projected solar vs. conventionally heated home costs to 1985. The conventional fuel costs are typical of the Washington, D.C. area.

- SENSIBLE HEAT is the heat sensed within the living space. Often, comparisons of solar heating and cooling with conventional energy sources confuse sensible-heat Btu's with heat potential from a barrel of oil or some other comparison.

Source	Total Energy Demand (Btu)	Percent of Waste Energy	Sensible Heat
Solar	-	-	1.0
Electric	3.33	70%	1.0
Gas	1.67	40%	1.0
Oil	2.0	50%	1.0

WIND ENERGY CONVERSION

- Wind energy is a secondary form of solar energy derived from heating of the earth by the sun.

- Wind energy conversion systems (WECS) generally are comprised of a rotor device (to absorb kinetic wind energy) linked through a mechanical transmission to an electrical generator. The rotor, mounted on a tower, can turn to accommodate changes in wind direction.

- WECS electrical output may be used to drive a load directly or may be connected to an electric utility grid.

- Wind energy systems should be economically viable within a few years and in some applications are economically viable today.

    - The 1.25 MWe windmill operating in Vermont during the 1940's would today cost $500-$1,000/KWe installed.

- Applying existing technology developed over the last thirty years, such as low-speed aerodynamics, developed for STOL aircraft used in Vietnam, composite material technology, etc., should result in significant cost reductions and increasingly large market applications.

- WECS are being considered in a range of sizes from 5 to 50 Kilowatts capacity for farm and rural applications, and 1 to 3 megawatt units for interconnection with public utility grids.

- A jointly sponsored NSF/NASA committee suggested that by the year 2000, a major U.S. wind power program could result in an annual yield of 1.5 trillion kilowatt hours of electricity.

- Construction of an experimental 100-kilowatt wind generator system will be completed in 1975 at NASA's Lewis Research Center on the shores of Lake Erie. A one-megawatt unit is expected to be operating by December of 1976. (site not selected)

- Indications are that attainment of economic viability will occur in such areas as the Great Plains, Alaska, the Great Lakes, the Pacific Coast, New England, and Hawaii.

- With the support of NOAA, an initial assessment of the status of wind data and prediction requirements is underway. Because eventual investment in wind power is affected by the uncertainties of wind characteristics, this is an extremely important step.

- The key to large-scale application of WECS will be the reduction of capital costs through mass production, and development of low-cost energy storage systems.

- It is believed that mass production could be established in relatively short time with assembly line techniques.

BIOCONVERSION TO FUELS

- The Bioconversion to Fuels (BCF) solar energy technology includes the production of plant biomass and the subsequent conversion of this biomass to various clean fuels and to other useful forms of energy.

- Four major sources of biomass are potentially available:

    - urban solid wastes
    - agricultural residues
    - terrestrial energy crops
    - marine energy crops

- Major problems include:

    - increasing biomass growth rates and yields
    - devising economical means of biomass harvesting and processing
    - improving the efficiencies and reducing the costs of various conversion processes.

- Plants with good potential as biomass producers include:

    - o sugarcane
    - o sunflowers
    - o sorghums
    - o Sudangrass
    - o eucalypts
    - o water hyacinth
    - o fresh water algae

- Four possible ways to use bioconversion:

    1. Grow trees, harvest them, convert them to chips and burn them as fuel for a power plant.

    2. Convert slurries of organic materials (wastes) through fermentation to methane gas and various useful chemicals, including animal feedstocks.

    3. Convert slurries of organic materials to burnable oil through application of high temperatures in the absence of oxygen.

    4. Convert dried materials to burnable oil by charring it at high temperatures in the absence of oxygen.

- The successful operation of conversion pilot plants currently planned for several locations could introduce widespread biomass conversion, eventually increasing the nation's available fuel gas by 6 percent and diminishing our waste disposal problem.

- Bioconversion holds promise of easing municipal government problems with waste disposal.

- Two major NSF supported investigations of waste conversion:

  Dynatech Research and Development Co., Cambridge, Massachusetts, is designing "proof of concept" plant to handle several tons of municipal waste each day and convert it to methane. Their findings include:

    - o 1 pound of waste yields approximately 6 cubic feet of methane.

- o Approximately 94 million tons of solid waste suitable for bioconversion are available each year in the United States.

- o Economics of bioconversion to methane do not yet make it competitive with natural gas. Solid waste gas could run between $1 and $2 per thousand cubic feet.

University of Illinois is building a continuously operating experimental system with 50-pound per hour conversion capacity.

- The Environmental Protection Agency (EPA) is involved in two bioconversion waste projects:

  - o A pilot plant in St. Louis, Missouri.

  - o A plant near completion in Baltimore, Maryland.

  Both are pyrolysis plants, creating a burnable gas from organic wastes. Gas is sold to local power companies.

PHOTOVOLTAIC ELECTRIC POWER SYSTEMS

- Photovoltaic electric power systems use semiconductor devices to convert sunlight directly into electricity.

- Among the various semi-conductor materials used for solar cells, silicon is one of the most attractive materials because of its availability and non-toxicity; however, the use of cadmium sulfide, copper sulfide, and other materials is being studied.

- Silicon photovoltaic solar cells are currently being used to maintain the charge in storage batteries used for remote radio relays and unattended flashing signal lights.

- Photovoltaic systems (solar cells) are expected to have applications in two major market areas:

  - o The dispersed, on-site ("roof-top") market
  - o The small to moderate-size central power station

Other markets include remote and instituional.

- Economic viability for different markets will be achieved in different stages.

- Near-term cost reductions are more dependent on market volume (to bring into play automated mass production) than on technological breakthroughs.

- Economic viability for the dispersed market ($400-600 per KWe peak kilowatt) can be achieved without any technological breakthroughs by 1980. However, considerable R&D will be required to achieve economic viability of photovoltaics for central power stations by the mid-80's and early 90's.

- New government policy initiatives may be required to create a market large enough to sustain high rates of production and thereby lower costs through economies of scale.

- It should be noted that--using existing technology and modified off-the-shelf-equipment, for automated mass production--a production line could be in operation within 2 years resulting in a reduction in cost of solar cell arrays to less than $2,000 per KWe peak. Of course, a guaranteed high cost market would probably have to be assured, such as a market to provide energy self-sufficiency for remote military forces.

- Average power from photovoltaic electric power system is about 20% of peak power.

- Low cost energy storage or inter-ties with public utilities are required to provide continuous service during the night and on cloudy days.

- <u>Problems to be overcome include:</u>

  - o Reduction of capital costs of the semiconductor materials used in the manufacture of solar cells.

  - o If collector efficiencies were improved, the amount of area covered by solar-array support structure could be reduced. This would decrease the cost of photovoltaic systems.

  - o Methods must be developed to reduce the cost of manufacturing solar cells. One promising new technique involves the growth of continuous ribbons for single-crystal silicon from which solar cells can be made that will eventually reduce the cost of manufactured cells.

- o Early markets must be developed for solar cell arrays until the economies of scale can be brought into play.

OCEAN THERMAL CONVERSION

- Ocean thermal energy conversion power plants will extract heat from ocean surface waters, utilize this heat to drive a turbine, and reject heat to the heat sink provided by the cold ocean water at lower depths.
- Energy is obtained by exchanging heat between the salt water and a working fluid such as ammonia or propane, operating in a "closed cycle" similar to a refrigeration cycle.
- A total system includes a semi-submersible hull incorporating power-pack modules. Each module contains an evaporator, turbine, condenser, and pumps to circulate the working fluid and the warm and cold water.
- Near-shore ocean thermal power plants will probably provide electrical power directly to land areas.
- It is likely that use of the ocean as an energy source will not exhibit rapid growth until 1985 to 1990.
- Commercialization of ocean thermal technology will be dependent upon the solution of a number of engineering and institutional problems which will permit the development of cost-effective power plants.

SOLAR THERMAL CONVERSION

- This system consists of solar collectors and thermal storage devices delivering high-temperature thermal energy to a turbine power plant or delivered as process heat. Five major elements:

  1. Solar concentrator to concentrate sun's energy.
  2. Receiver to absorb concentrated energy.
  3. Means to transfer heat to the thermal storage facility or to the turbo-generator.

4. Thermal storage element to store thermal energy for use at night and on cloudy days.

5. Turbo-generator to produce electrical energy.

- Two possible avenues of development:

    - Solar thermal plants solely for power generation.
    - Total energy approach to obtain both electricity and heat.

- There are no basic technical limitations to prevent building of solar thermal power stations. Technology is old: sixty years ago, 1913-1914, solar heat powered a 50 horsepower steam engine at Meadi, Egypt.

- Estimates of conversion efficiencies (direct solar insolation to electrical power) in range of 20-30 percent have been made.

- Applications of solar thermal conversion are most promising in regions of high insolation, such as the southwestern United States.

- Land usage for solar thermal energy systems would be about 100 MWe per square mile.

- Cooperative efforts are underway between Southern California Edison Co., Bonneville Power Admin., Northern States Power Co., and the Electric Power Research Institute to select solar conversion power plant sites and share costs.

- The Department of Defense is identifying candidate facilities for the installation of a total energy system project.

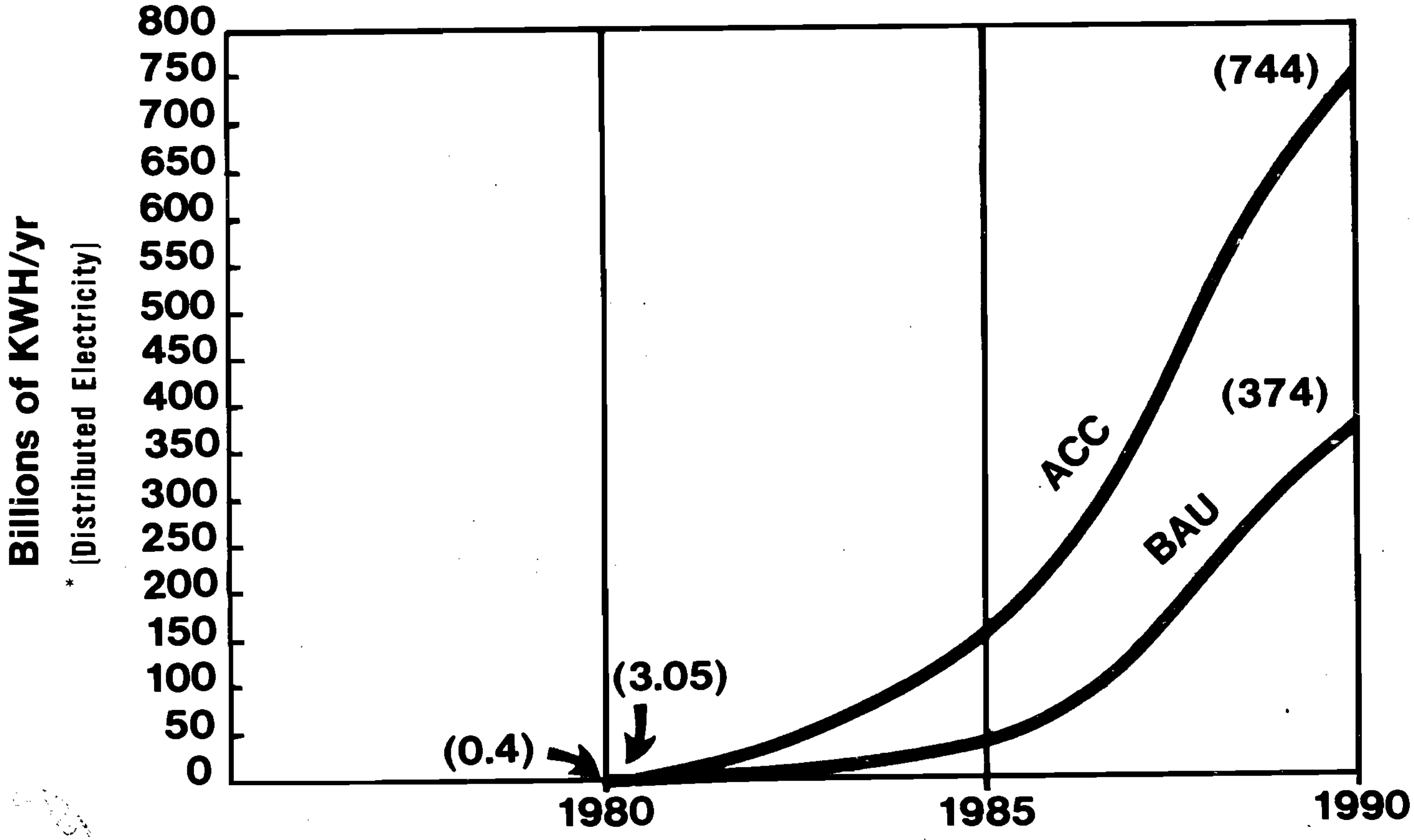
- Recent technical achievements include:

    - Fabrication of a parabolic trough concentrator-collector, heat pipe and hardware for thermal conversion experiments.

    - A computer simulation model for evaluating solar thermal conversion systems integrated into a power grid.

    - A stabilized silver-silicon selective absorber coating operable at 1000° F.

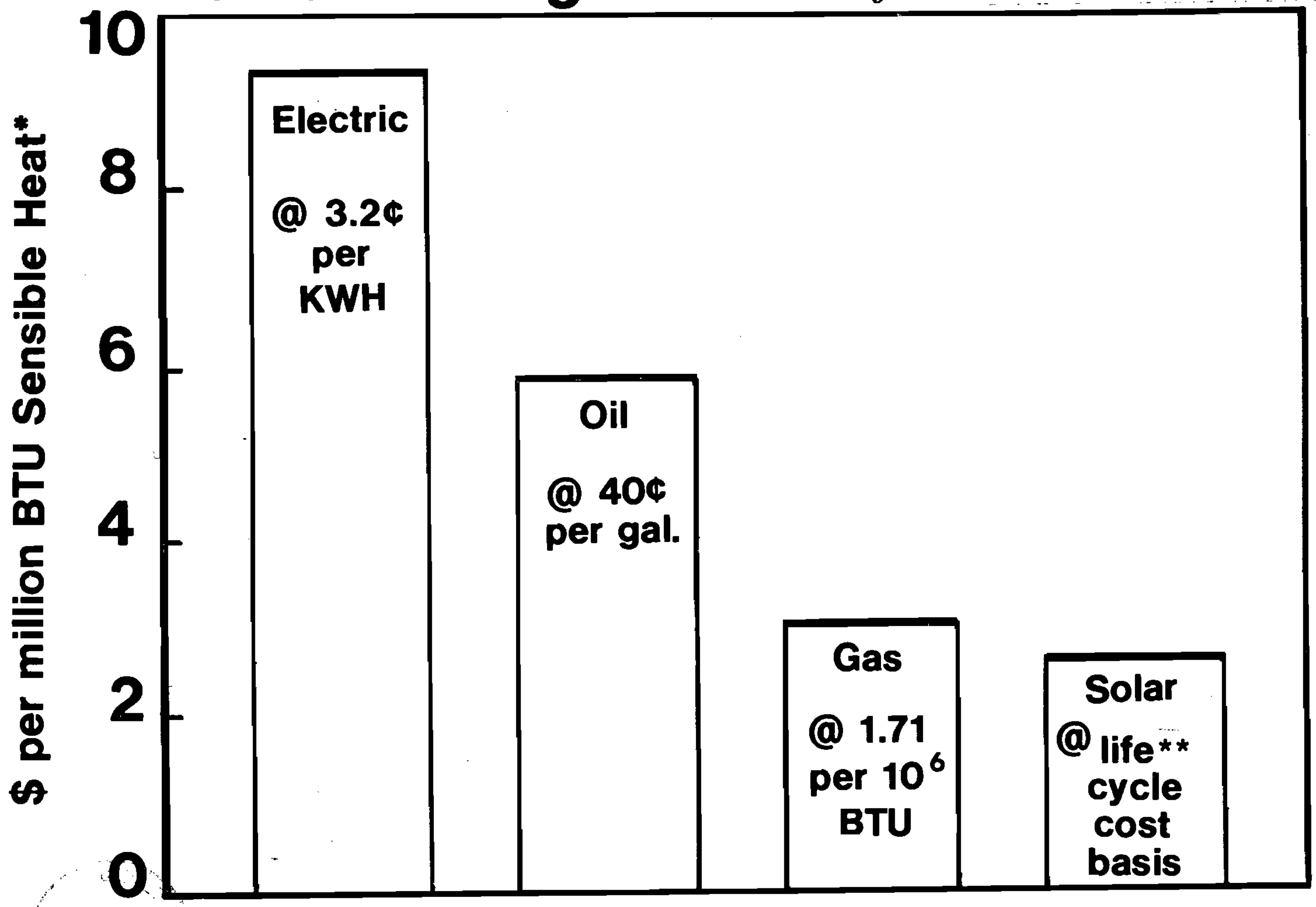
Solar Electric Potential



*At least 10,000 BTU's are required to generate 1 KWH of distributed electricity

Figure 1

Home Heating Costs (Solar Heating and Cooling Costs Projected to 1980-1985 Time Frame)



* includes furnace efficency

** approx. 25 years.

(Conventional fuel costs are typical of Washington, D.C. area in 1974)

Figure 2

Potential For Solar Heating And Cooling Of Buildings

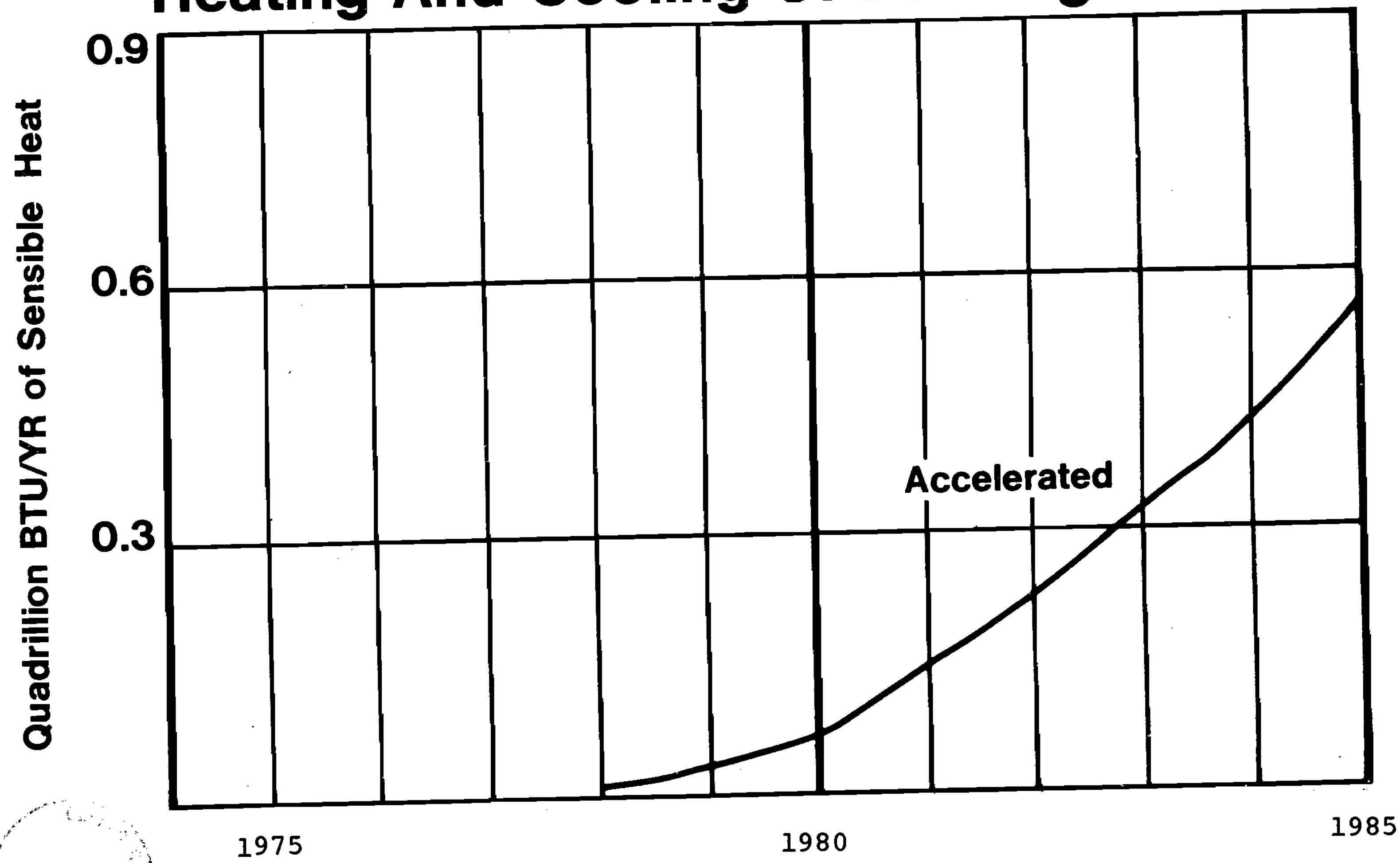


Figure 3

SOURCES

(1) OFFICE OF ENERGY CONVERSION, December 1974, Office of Energy Resource Development, FEA

XII. GEOTHERMAL ENERGY

GEOTHERMAL ENERGY

GEOTHERMAL RESOURCES (1)

- Geothermal energy, in the broadest sense, is the natural heat of the earth. Temperatures in the earth rise with increasing depth, but most of the earth's heat is far too deeply buried ever to be tapped by man. The depths from which heat might be extracted profitably are unlikely to be greater than 10 km, yet even in this outer few km, most of the geothermal heat is far too diffuse to be recovered economically. At present, economically significant concentrations of geothermal energy occur where elevated temperatures are found at depths less than 10,000 feet (about 3 km).
- Geothermal resources can be broadly classified as dry-steam, hot-water, hot dry rock, and geopressured reservoirs.

MAJOR TYPES OF GEOTHERMAL RESOURCES

- Dry-Steam Systems (vapor-dominated) - Geothermal reservoirs which produce superheated steam with minor amounts of other gases, but little or no water. Within the vapor-dominated geothermal reservoir, saturated steam and water coexist, with steam being the phase that controls the pressure. Hot brine probably exists below the vapor-dominated reservoirs, but the reservoirs have not yet been drilled deep enough to confirm the presence of such brine.

  So far, only five vapor-dominated systems have been discovered (i.e. surface manifestations), of which only three are really commercial:

  1. Larderello, Italy - the first geothermal field to be exploited (1904). Currently provides 400 megawatts of power.

2. The Geysers, California - the first geothermal power plant in the United States (1960). Current production provides about 440 megawatts of power.

3. Matsukawa, Japan

- Hot-Water Systems - Hot liquid geothermal systems contain water at temperatures that may exceed surface boiling temperatures substantially because of the effect of the higher pressure in elevating the boiling temperature. In major zones of upflow, coexisting steam and water may extend to the surface and result in geysers and hot boiling springs. Water in most hot liquid geothermal systems is a dilute aqueous solution containing sodium, potassium, lithium, chloride, bicarbonate, sulfate, borate, and silica predominantly.

  Such regions are commonly found in zones of young volcanism and mountain-building. Known hot-water resources are about twenty times more abundant than dry-steam resources. Systems occur worldwide; major known fields are located:

  1. Yellowstone geyser basin in Wyoming
  2. Cerro Prieto in Baja California, Mexico
  3. Salton Sea field in California
  4. Wairakai and Broadlands in New Zealand
  5. Philippines

- Hot Dry Rock Systems - Hot impermeable rock systems are those geothermal regions where the heat is contained almost entirely in rock of very low porosity. It has been estimated that the thermal energy released by cooling one cubic mile of rock from an equivalent initial temperature of 350°C to 177°C would be equivalent to that available from 300 million barrels of oil.

  Interactions of the large plates of the earth's surface along the West Coast of North America have generated high heat flows, responsible in part for the presence of once-molten granite masses which have formed the core of the Sierras and other batholiths.

The existence near the surface of the earth of hot dry rock is far more common than that of hot water or steam which can be brought to the surface. For example, the hot dry rock deposits in the Western U.S. alone have been estimated to be equivalent to the U.S. coal reserves (about 300 quadrillion Btu). Although much of the extractive technology needed may exist, it has not yet been successfully demonstrated. The development of hot dry rock resources requires drilling a well and cracking the deep rock, either hydraulically, or by explosives. Water then would be injected to function as a heat transfer agent. The hot water would be withdrawn through another well.

The National Science Foundation and the Atomic Energy Commission are conducting experimental programs in this area.

- Geopressurized Zones - Deep sedimentary basins filled with sand and clay or shale are generally undercompacted below depths of 2-3 km, and, therefore, the interstitial fluid pressure carries a part of the overburden load. Such regions are said to be geopressured. Geopressured zones have three sources of energy - heat, the mechanical energy from the high pressures, and natural gas.

  In the United States, geopressured zones have been found in the Gulf Coast, California, and Wyoming

  While geopressured zones seem to have high potential as energy sources, so little is known about them that there are major questions about how to utilize them. However, these resources have been commanding increasing attention, and an experimental (10 megawatt) power plant is being planned (Gulf of Mexico).

GEOTHERMAL RESOURCE AREAS

- Potential Resources - (U.S.) 100 million acres, approximately 55 percent Federally owned. (2)

- Known Geothermal Resource Areas (KGRA) - 1.8 million acres, located in 11 western states and Alaska. (2)

- See Figure 1 for map of U.S. areas with geothermal potential.

GEOTHERMAL RESOURCES—AREAS OF PROMISE

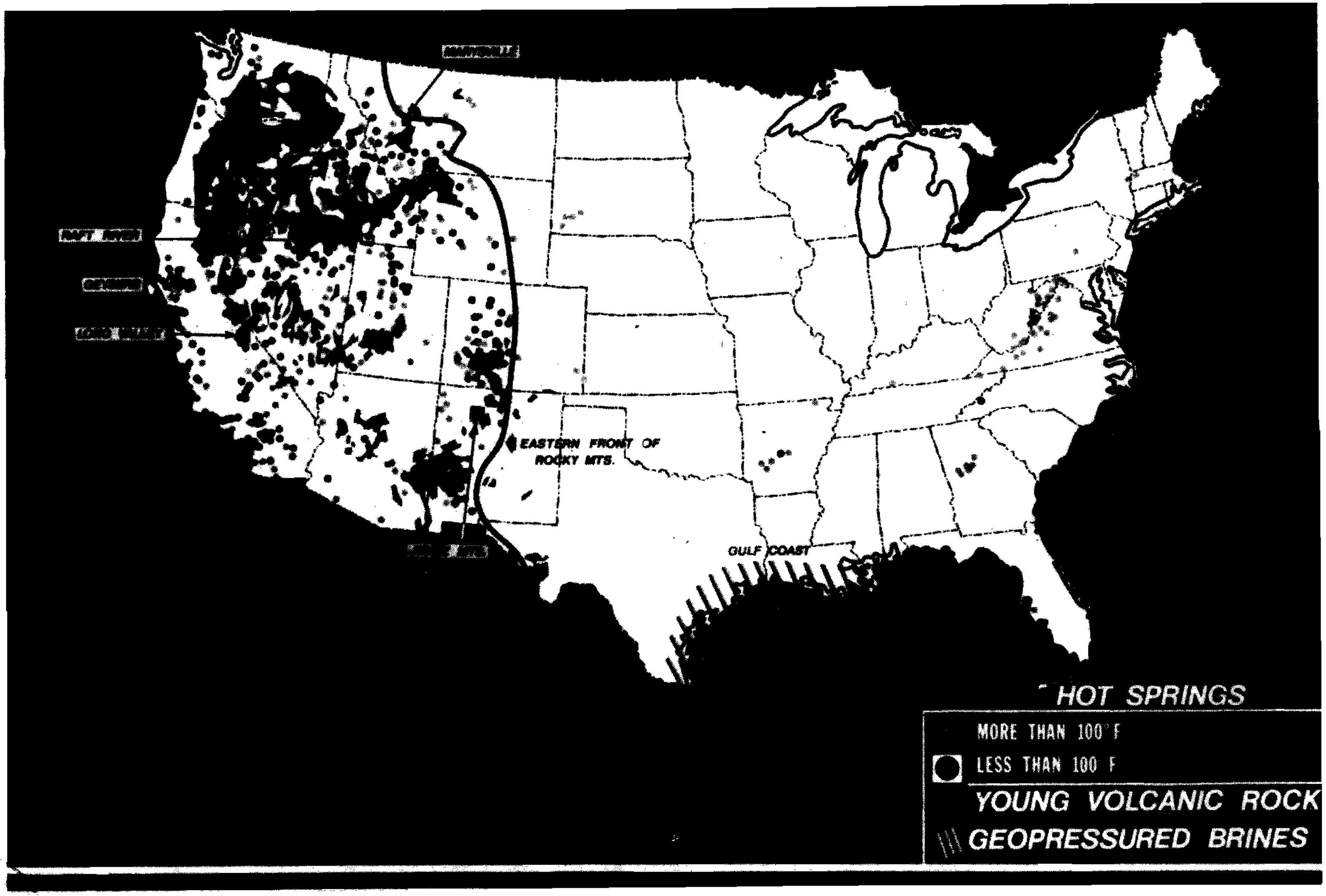


Figure 1

Source: FEA (3)

FEDERAL LEASING

- Geothermal Steam Act of 1970 - Permitted geothermal prospectors to lease Federal lands on a competitive (Known Geothermal Resource Areas) and non-competitive basis. Actual leasing program was established on January 1, 1974. (4)

<u>Competitive Leasing</u>

- o Leases of KGRA lots. (4)
- o KGRA are determined by the U.S. Geological Survey, but KGRA can also be declared by the Department of the Interior if two or more people apply for overlapping sections of lots. (4)
- o The Bureau of Land Management determines minimum bids. (4)
- o Actual competitive leases of KGRA - 32 leases for 47,370 acres issued as of November 1974. (5)

<u>Non-Competitive Leasing</u>

- o Not identified as KGRA. (4)
- o Generally cheaper than competitive leases since they have a fixed price per acre. (4)
- o No non-competitive leases have been issued as of November 1974. (5)

- Between January-November of 1974, 4,372 lease applications were made for a total of 9,403,429 acres. (5)
- The Bureau of Land Management proposed action to establish and meet goals for granting of leases as follows: (5)

		No. of leases	No. of acres leased
FY 1975	Non-competitive leases	1,000	2,000,000
	Competitive leases	200	400,000
FY 1976	Non-competitive leases	1,500	3,000,000
	Competitive leases	300	600,000

NON-ELECTRIC USES OF GEOTHERMAL ENERGY

- Figure 2 diagrams non-electric uses of geothermal energy.

POWER PRODUCTION (2)

- Steam-electric power production is currently the most important use for geothermal energy.

THREE COMMERCIALLY AVAILABLE PROCESSES

- Fuel cycle for hydrothermal extraction of geothermal heat for electric power generation is relatively simple- all steps of the fuel cycle take place at the power plant site.
- Power plant must be built at the site of the reservoir because geothermal heat cannot be transported without of potential energy losses.

Dry-Steam Process

- o A direct-single phase process where steam is obtained at the wellhead through a wellbore, filtered, and fed to a low-pressure turbine which drives a generator. See Figure 3.
- o Process requires no boiler.
- o Remaining condensate containing residue minerals is generally injected into less-productive steam wells.
- o Plants are less costly to build than other types of thermal power plants.

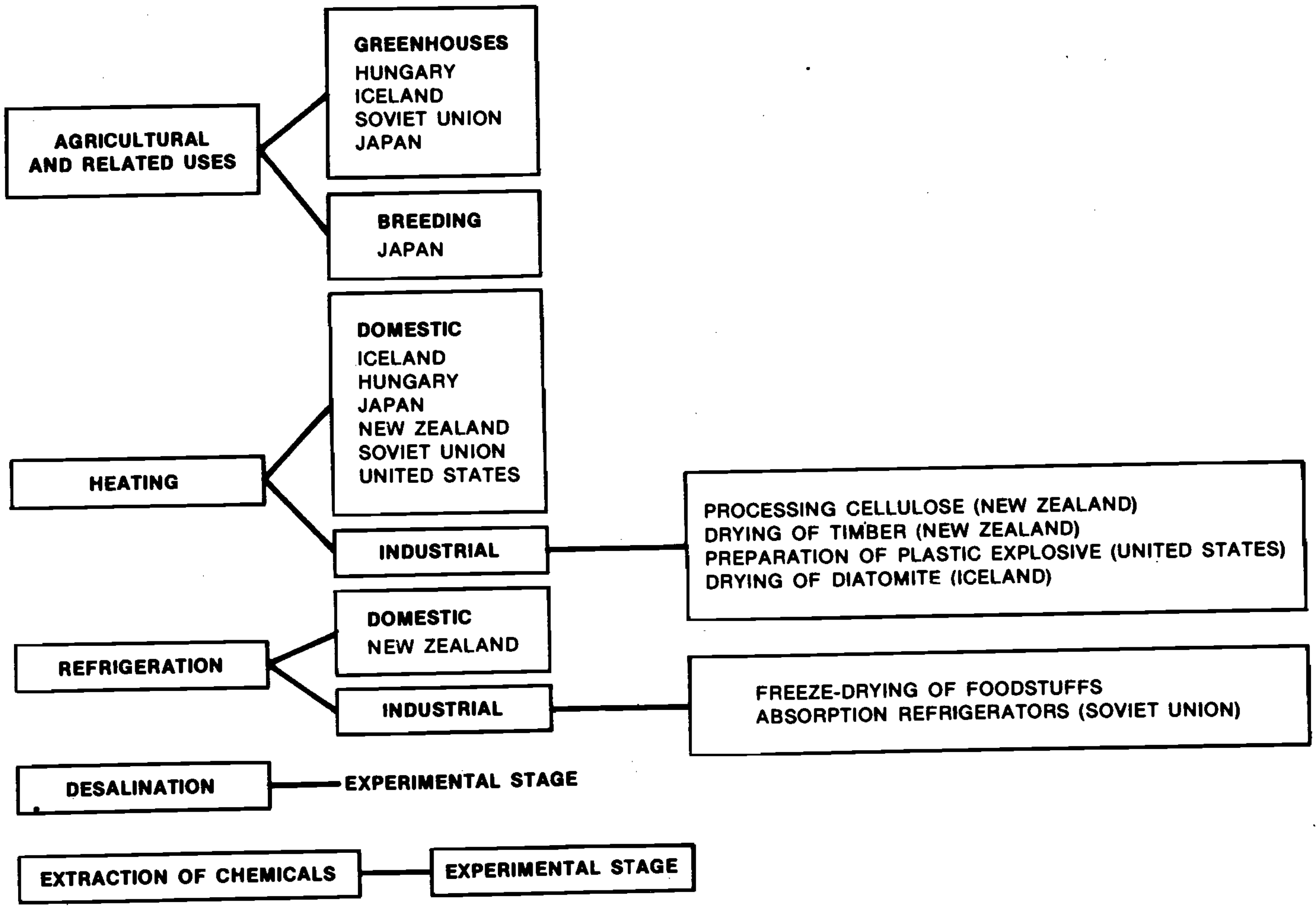
Hot-Water Process - 2 methods of power production

(1) Liquid-dominated reservoirs mixed with steam

- o Steam is produced in a separator by flashing the hot liquid at a reduced pressure and separating the two phases.

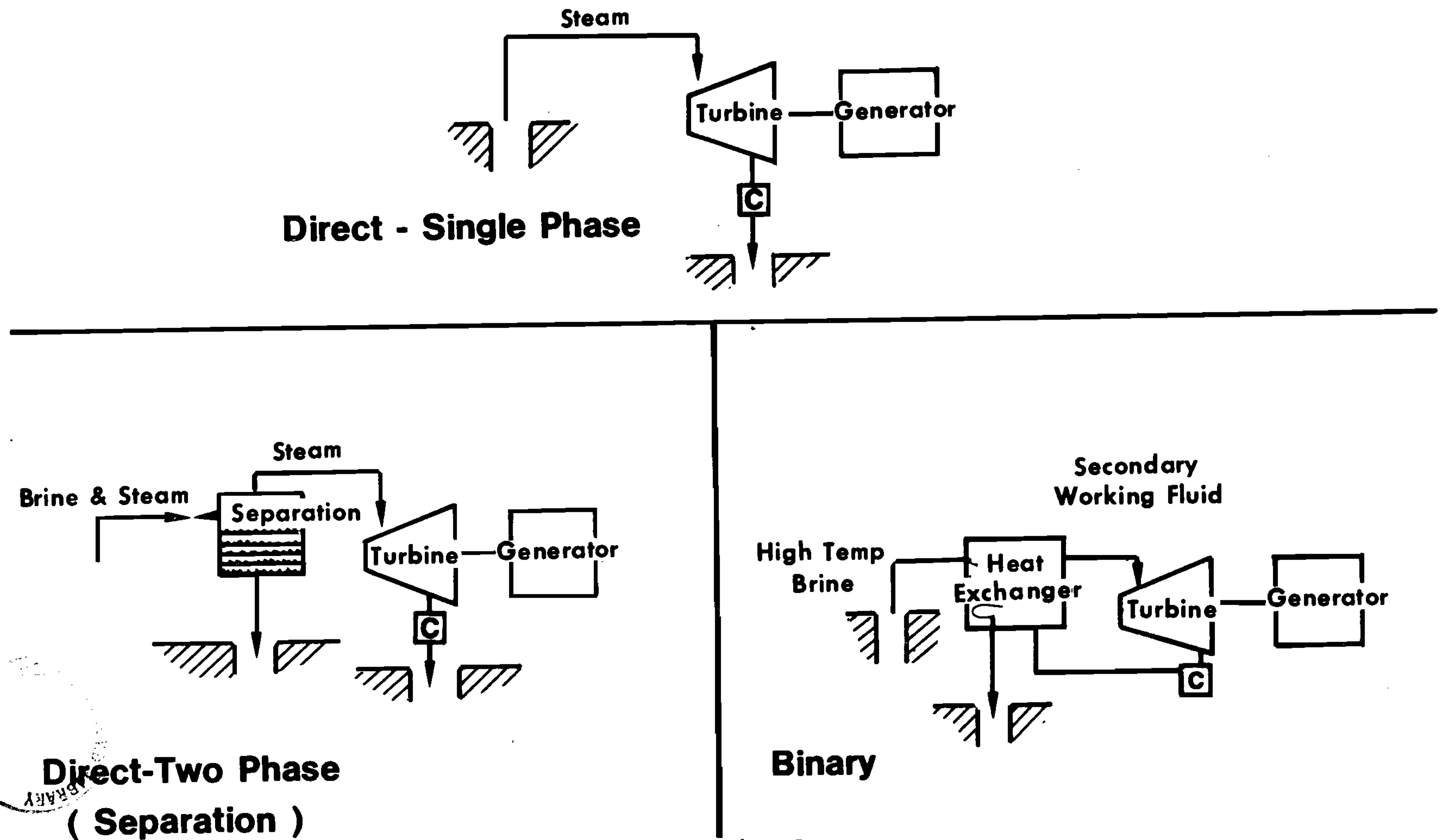
Figure 2

NON-ELECTRIC USES OF GEOTHERMAL ENERGY



Source: FEA (3)

Geothermal Conversion Processess



C – Cooling Tower

Source: FEA (6)

Figure 3

- o Steam then fed to a turbine.
- o 20 percent of the water is flashed to steam in <u>most</u> systems; the remaining water is reinjected into disposal well.
- o Commercial plants are currently operating using this type of process in Mexico, New Zealand, Japan, Iceland, and the U.S.S.R.
- o See Figure 3, Direct-Two Phase (Separation)

(2) Binary conversion - for relatively low temperature water deposits

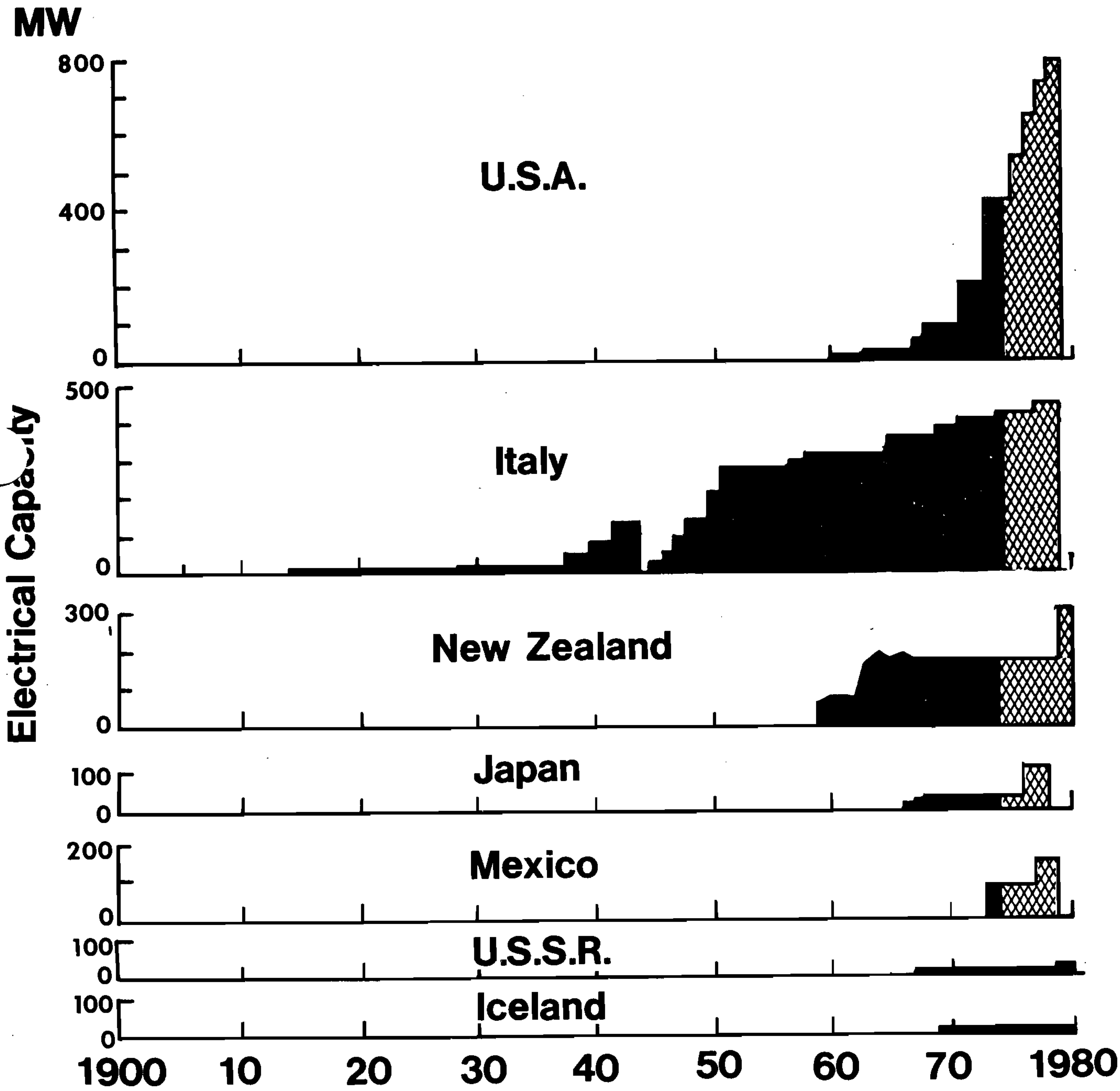
- o Heat must be transferred to a lower boiling point fluid such as isobutane which then drives the turbine.
- o Secondary fluid is continually recycled.
- o Such binary heat exchangers are being used in Japan and the U.S.S.R.
- o Binary process is potentially more efficient than the flashed steam process.
- o Since the great majority of known geothermal reservoirs are hot-water systems, the binary process appears important to the utilization of this large source of energy.
- o See Figure 3, Binary.

- No commercial power plants utilizing hot-water processes in operation - therefore, operational data is not available.
- Main difference between dry-steam and hot-water systems is the quantity of geothermal fluid which must be brought to the surface in order to produce a given amount of electrical power.

POTENTIAL POWER PRODUCTION OF GEOTHERMAL ENERGY

- <u>Figure 4</u> illustrates the growth of geothermal generating capacity.
- <u>Figure 5</u> provides estimates of potential electricity produced from geothermal energy (megawatts).

Growth of Geothermal Generating Capacity



Source: FEA (6)

Figure 5

ESTIMATES OF POTENTIAL ELECTRICITY PRODUCED FROM GEOTHERMAL ENERGY
(MWe)

Source	1972	1974	1985	1990	2000
Bureau of Mines (1972)	192	--	4,000	--	40,000
Dept. of Interior (1972)	192	--	19,000	--	75,000
National Petroleum Council (1972) Case I	--	--	19,000	--	--
National Petroleum Council (1972) Case IV	--	--	3,500	--	--
Geothermal Energy, W. Hickel (1972)	--	--	132,000	--	395,000
Rex and Howell (1973)	--	--	--	400,000	--
Calif. Div. of Oil & Gas 1972 (in SRI 1973)	--	--	--	--	7,500 (in Calif.)
SRI (1973)	--	--	11.800	--	4,400 (in Calif.)
Futures Group "Normal Program (1974)	--	396	9-11,000	--	55-200,000
Futures Group "Crash Program" (1974)	--	396	27-40,000	--	270-800,000

Source: FEA (3)

- Estimates of potential electric power production in the U.S. from geothermal resources vary from about 1 percent of the total electric capacity (circa year 2000) to about 30 percent. (6)

COMPARISON OF POWER PLANTS USING ALTERNATIVE ENERGY SOURCES See Figure 6.

COMMERCIAL GEOTHERMAL DEVELOPMENT IN THE U.S. (6)

- The Geysers
  - Magma Power Company and Thermal Power Company tapped the area in 1956.
  - Pacific, Gas, and Electric Company began purchasing the steam in 1960.
  - Current power output - 440 megawatts.
  - Projected development - By 1980 an estimated 1172 megawatts. Current plans by Pacific, Gas and Electric call for an additional 110 megawatts capacity to be added each year through 1986.
- Imperial Valley - Production test wells, binary system development (Chevron, Magma, San Diego Gas and Electric).
- Extensive testing and resource exploration are underway in the following states:

  Arizona
  Nevada
  New Mexico
  Oregon
  Utah

COMPARISON OF POWER PLANTS USING ALTERNATIVE ENERGY SOURCES

	GEOTHERMAL	FOSSIL	NUCLEAR
Present Maximum Unit Size	Small (110 MWe)	Very large (1200 MWe)	Very large (1200 MWe)
Fuel Preparation & Handling	Expensive but simple	Complex, expensive but unsophisticated	Very elaborate, sophisticated & expensive
Heat Production	Naturally occurring	Within combustion boiler	Within reactor vessel
Electric Generation	Similar	Similar	Similar
Cooling System #	Similar	Similar	Similar
Waste Disposal	Very simple, minimum risk, inexpensive	Moderately complex and expensive	Elaborate, sophisticated, expensive
Safety Complexity	Very minor, inexpensive	Moderate	Very severe, costly
Flexibility of Plant Location with respect to demand source	No flexibility, resource site dependent	High flexibility, cooling-water dependent	Fair flexibility, cooling-water dependent
Capital Cost ($/installed KW)	$200 (Dry Steam) $400 (Binary Systems)	$500-700 (Oil-fired)	$700-1000
Price of Electricity at Busbar (Mills/KWH)	11.0 (Dry Steam) 14.5 (Binary, 300°F) 12.5 (Binary, 500°F)	27.7 *	17.0 **

Complexity varies with size and location; geothermal can provide own cooling water.
* Assumes $7/BBl oil.
** Includes 2 mills for fuel.

Source: FEA (3)

Figure 6

TECHNICAL AREAS REQUIRING RESEARCH AND DEVELOPMENT (6) (3)

SOURCE EXPLORATION AND DEVELOPMENT

- Need for developing more sophisticated deep sampling techniques and devices.
- Lack of a practical technique for conducting gross exploration.
- Lack of understanding of the correlations between sets of geophysical data.
- Lack of understanding of a geochemical profile.
- Lack of geothermal data exchange center.
- Lack of coherent, verified, dynamic reservoir models.
- Need for improvement in geophysical exploration and appraisal techniques.
- Limited availability of deep drilling rigs.
- Lack of generalized, coherent static geological models.

RESERVOIR DEVELOPMENT

- Lack of practical technique for very deep and very hot drilling.
- Present acute shortage of tubular goods.
- Lack of demonstrated method for recovery of energy from hot dry rock.
- Lack of demonstrated method for recovery of magma.
- Non-existence of demonstrated downhole heat exchanger of sufficient capacity.
- Lack of effective method for inhibiting and correcting solids deposition in the formation.
- Non-existence of proven high-temperature deep-well pumps.

- Unknown effects of reinjection on the producing formation.
- Lack of knowledge of thermal stress-field inducted in a hot dry rock formation by massive injection and withdrawal of cold water.
- Lack of confirmed understanding of cause/effect relationship between fluid injection into the formation and the occurrence of earthquakes.
- Limited availability of drill rigs for deep to very deep drilling.
- Lack of coherent, verified, dynamic reservoir models.
- Lack of long-term case history data needed for field longevity predictions.

ENERGY CONVERSION

- Need for demonstration electric power plant for liquid-dominated moderate temperature resources.
- Need for demonstration electric power plant for heavy-brine reservoirs.
- Non-existence of proven prime mover on a predominantly liquid two-phase fluid capable of continuous operation.
- Lack of effective method for preventing scale deposits.
- Lack of demonstration electric power plant for geo-pressurized zones.
- Lack of demonstration electric power plant for hot dry rock.

ENVIRONMENTAL TECHNOLOGY

- Need to prevent groundwater contamination.
- Need to control harmful gaseous emissions.
- Need to dispose of liquid and solid wastes.

- Need for noise control.
- Need to understand relationship between fluid injection and earthquake induction.
- Need for developing techniques for dealing with land subsidence.

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XIII. PIPELINES

PIPELINES

U.S. OIL PIPELINES

HISTORICAL BACKGROUND ON OIL PIPELINE DEVELOPMENT (1)

- First successful crude pipeline built in 1864 by Samuel Van Syckel--a 2-inch wrought iron line covering five miles from production field to railroad station in Pennsylvania.

- Pipelines initially enjoyed the support of railroads because they fed oil to loading racks for rail transshipment. Transportation monopoly grew as railroads began buying and constructing pipelines of their own and dictating prices to producers and shippers.

- To protect the rights of privately owned pipelines, Pennsylvania and Ohio legislatures passed laws granting common carrier pipelines eminent domain in acquiring rights-of-way. Circumstances eventually led to the development of crude oil trunk pipelines to connect the field directly with the refineries.

- Successful construction and operation of a 6-inch pipeline in Pennsylvania in 1868 eventually forced the railroads to reduce their rates.

- Between 1901 and 1905 crude oil production shifted emphasis from Pennsylvania area to Texas, Kansas,'Oklahoma region, with subsequent construction of crude pipelines to connect with eastern lines.

- Product pipeline construction began in 1930 with Midwest growth in demand for refined products.

- Diversion of tank ships and Axis submarine activity during World War II necessitated construction of new, and rearrangement of existing pipelines. (Biggest projects was the Big Inch and Little Big Inch War Emergency Pipelines--WEP) wartime experience with large-diameter trunk lines proved their economic advantage and operating flexibility.

PETROLEUM PIPELINE TRANSMISSION

- Overall cost of crude oil transportation (as a percent of value of domestic crude oil at U.S. refineries) is small, historically less than 10 percent. (3)

- Pipelines generally operate at 85-90 percent of capacity, with spare capacity to accommodate changes in market demand.(2)

- Crude Oil and Product Pipeline Network. (See Figure 1)

Pipeline Mileage

- Predominant crude oil pipeline flow is from producing regions in the Southwest and Rocky Mountain areas to refineries in the Midwest and Great Lakes region, and from producing areas in Texas and New Mexico to the Gulf Coast. (3)

- Approximately 75 percent of the 228,000 miles of petroleum pipeline in the United States is regulated by the Interstate Commerce Commission (ICC). (2)

- Pipeline mileage statistics. (See Figure 2)

Pipeline Operation (6)

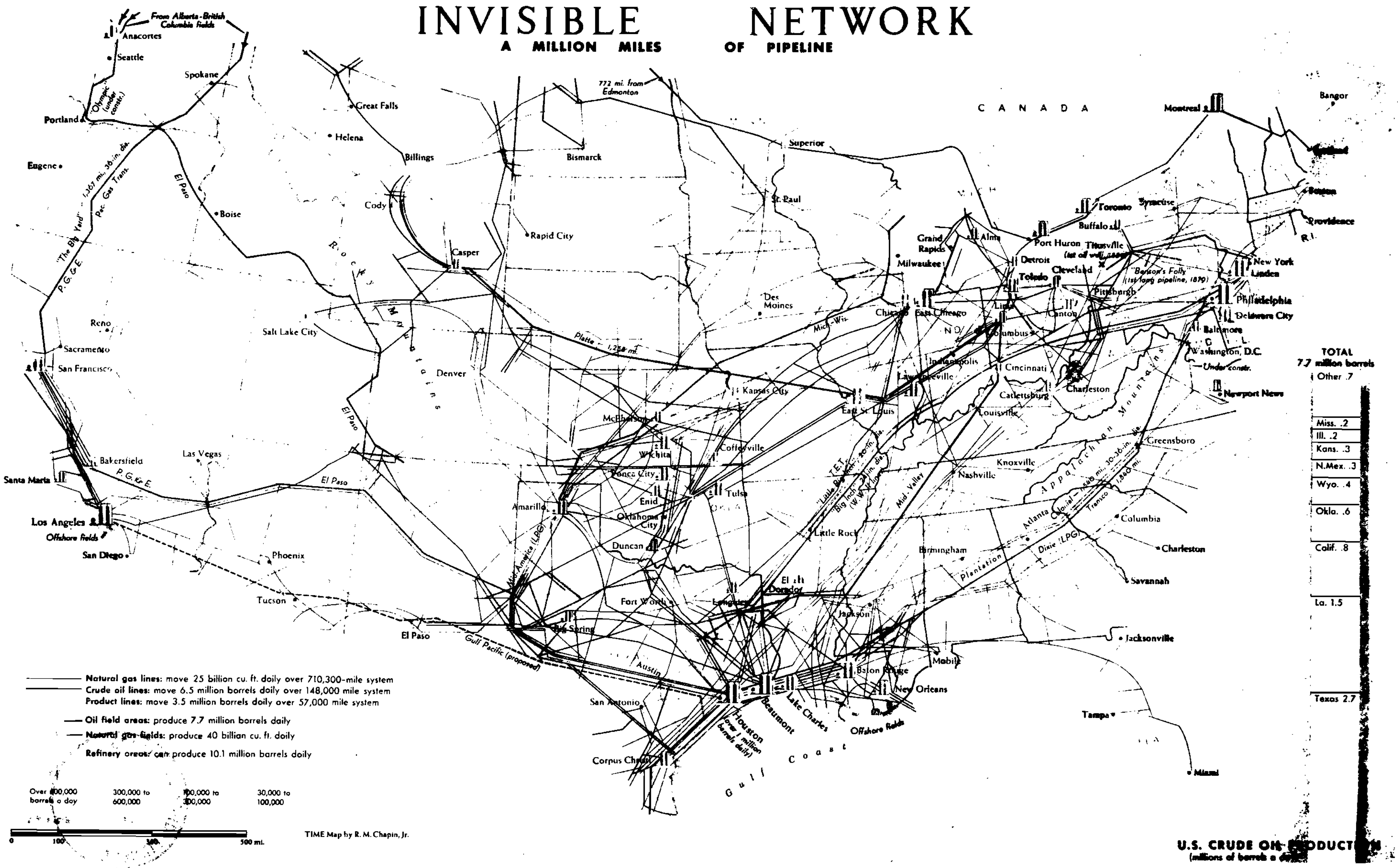
- Crude process:

    - At production field, oil is stripped of water, sediment, and gas before moving into the producer's lease tanks. Maximum allowable BS & W (basic sediment and water) is usually 1 percent, although this may vary according to agreement between the shipper and pipeline company.

    - Pipeline company's field gauger determines quality and quantity of each lot of oil.

    - Oil moves from the lease tanks to gathering lines--pipelines of small diameter.

    - From the gathering lines, crude is injected into trunkline or main pipeline. (Technological advances in high tensile steel have made possible diameters of 40 inches or more)



Source: Time (4)

Figure 1

Figure 2

TOTAL AND ICC-REGULATED PETROLEUM PIPELINE MILEAGE
(1962, 1967, & 1972)

Mileage	1962	1967	1972	Percent change 1962-72
ICC-regulated	155,053	165,478	173,532	+11.9
Gathering line (crude)	48,063	46,855	42,893	-10.8
Trunklines	101,945	112,368	124,458	+22.1
Crude oil	58,862	60,893	59,757	+1.5
Refined products	43,083	51,475	64,701	+50.2
Other	5,045	6,255	6,181	+22.5
Total	204,064	209,478	228,550	+12.0
ICC-regulated as percent of total	76.0	79.0	75.9	-

Source: ICC (5)

o At the end of the trunkline, distributing pipelines convey the crude oil to refineries.

o Tanks exist at every point, i.e. gathering lines, pumping stations, trunkline terminal, and refinery, to provide storage and a means for sampling, testing, and measuring the liquid volumes.

Product Pipeline Process:

o "Reverse Pipelining"--Product-line operations much like crude-line operation except, of course, that the cycle begins at the refinery.

o A "products cycle" determines the central scheduling and dispatching operations. The cycle is simply a designation of the order or sequence in which different products are to be batched through the lines

Unique Features of Pipeline Transportation (7)

- Only method in which only the cargo moves--therefore, no energy wasted in moving a carrier vehicle.
- Movement through continuous steel tube protects product from outside contamination.
- Only method which is a one-way movement where it is not necessary to return the carrier vehicle back to the starting point.
- Pipeline is underground and not influenced by storms and other conditions which might delay surface transportation.
- Pipeline can be laid as a straight line and--covers the shortest distance between two points.

Characteristic Problems of Pipelines (7)

- Because pipeline transports primarily oil products, fate tied to fortune of a single industry.
- Pipeline transportation is an industry of high capital investment, dependent on relatively low operating costs and high volume traffic over a long period to recover cost of facilities.

- Generally, the movement of shipments is in one direction, making the system less flexible than other modes of transportation.

- Pipe, once welded together and buried, has little recovery value; therefore, if declining traffic makes a particular section of a system unprofitable, it is not feasible to move the facilities.

REGULATION OF OIL PIPELINES (1)

- Pipelines first came under Federal regulation in 1906 with the passage of the Hepburn Amendment to the Interstate Commerce Act. The amendment declared pipelines common carriers and subject to the provisions of the Interstate Commerce Act and the jurisdiction of the ICC.

Present Federal Regulation of Oil Pipelines

- ICC-regulated oil pipelines are required to transport for all shippers who meet reasonable operating requirements. Rates charged for shipment must be just and reasonable.

- A company does not need Government approval or permit to build an oil pipeline.

- Shippers have the right to complain about discriminatory acts to the Commission, although very few complaints have been filed.

- Joint activities between pipeline companies are permitted, but tariffs and terms of shipment must be established and submitted to the ICC.

- Provisions of the Interstate Commerce Act which do not apply to oil pipelines:

    - Not required to obtain certificates of public convenience and necessity.

    - Not subject to regulations covering the issuance of securities, formation of interlocking directorates, mergers and consolidations, construction and abandonment of lines, or granting of credit.

    - Not subject to the commodities clause prohibiting transportation of the products of their owners.

- Pipeline safety authority resides in the Department of Transportation, Office of Pipeline Safety.
- The Federal Trade Commission prohibits monopolization of a particular market.
- No Federal taxes are specifically applicable to oil pipelines. Pipeline companies pay Federal income taxes.

Present State Laws and Regulations of Oil Pipelines

- States may impose common carrier status on oil pipelines engaged in intrastate business.
- States may allow oil pipeline companies to exercise the right of eminent domain.
- Oil producing States may require a crude purchaser to buy from all producers in a field without discrimination.
- Pipelines pay State sales or use taxes on pipe and equipment used, ad valorem taxes assessed against real property, and in many States, income taxes.

OWNERSHIP OF OIL PIPELINES (2)

- Nearly all crude oil trunk pipelines and most petroleum products pipelines are owned by refining companies.
- The 106 pipeline companies regulated by the ICC fall into seven basic categories. (See Figure 3)
- Pipeline transportation is one of the most highly concentrated of the transportation industries because of the limited number of shippers involved.
- Large oil companies are the logical investors in pipelines because they have the necessary source of supply and developed markets for the successful operation of a pipeline.
- Joint oil company ownership has the advantage of offering operational control because owners build pipelines where they need them most and proceed to use them for their own shipping.

SELECTED PIPELINE DATA BY OWNERSHIP GROUPS: 1972

Pipeline Carrier Corporate Groups	Operating Revenues(%)			Trunkline Mileage Owned(%)			Trunkline Traffic Handled(%)	
	Total	Crude Oil	Products	Total	Crude Oil	Products	Crude Oil	Products
Vertically Integrated Companies	45.9	65.9	24.5	52.0	71.1	34.3	63.7	38.7
Jointly Owned by Oil Companies	27.1	16.4	38.5	21.6	17.9	25.1	19.0	35.7
Affiliated with Railroads	9.2	1.5	17.6	11.4	1.9	20.3	2.9	15.1
Affiliated with Railroads & Oil Companies	0.5	1.0	-	0.9	1.8	-	0.6	-
Affiliated with Diversified Industrial Firms	5.1	0.5	10.1	7.0	0.9	12.6	0.6	-
Affiliated with Oil Companies & Manufacturing Companies	0.2	0.3	0.2	0.5	0.6	0.3	0.1	0.1
Independent Pipelines	6.8	11.3	2.0	3.1	4.1	2.2	7.1	1.4

Source: ICC (5)

Figure 3

- Some of the alleged anti-competitive activities of of the pipelines and pipeline companies:

    1. Dividend payments to owner-shippers resulting in an effectively lower tariff than for non-owners. (A practice limited by ICC regulation of the rate of return.)

    2. Establishing an agreed-upon transport cost, possibly differing from the real cost, through joint ownership and thus creating a form of price fixing.

    3. Scheduling pipeline operations so as to severely limit the surplus oil market relied upon by independent refiners, terminal operators, and, in the case of product pipelines, non-branded retail dealers.

    4. Indirectly limiting non-owner exploration efforts because of non-owner uncertainty about getting oil to the consuming market.

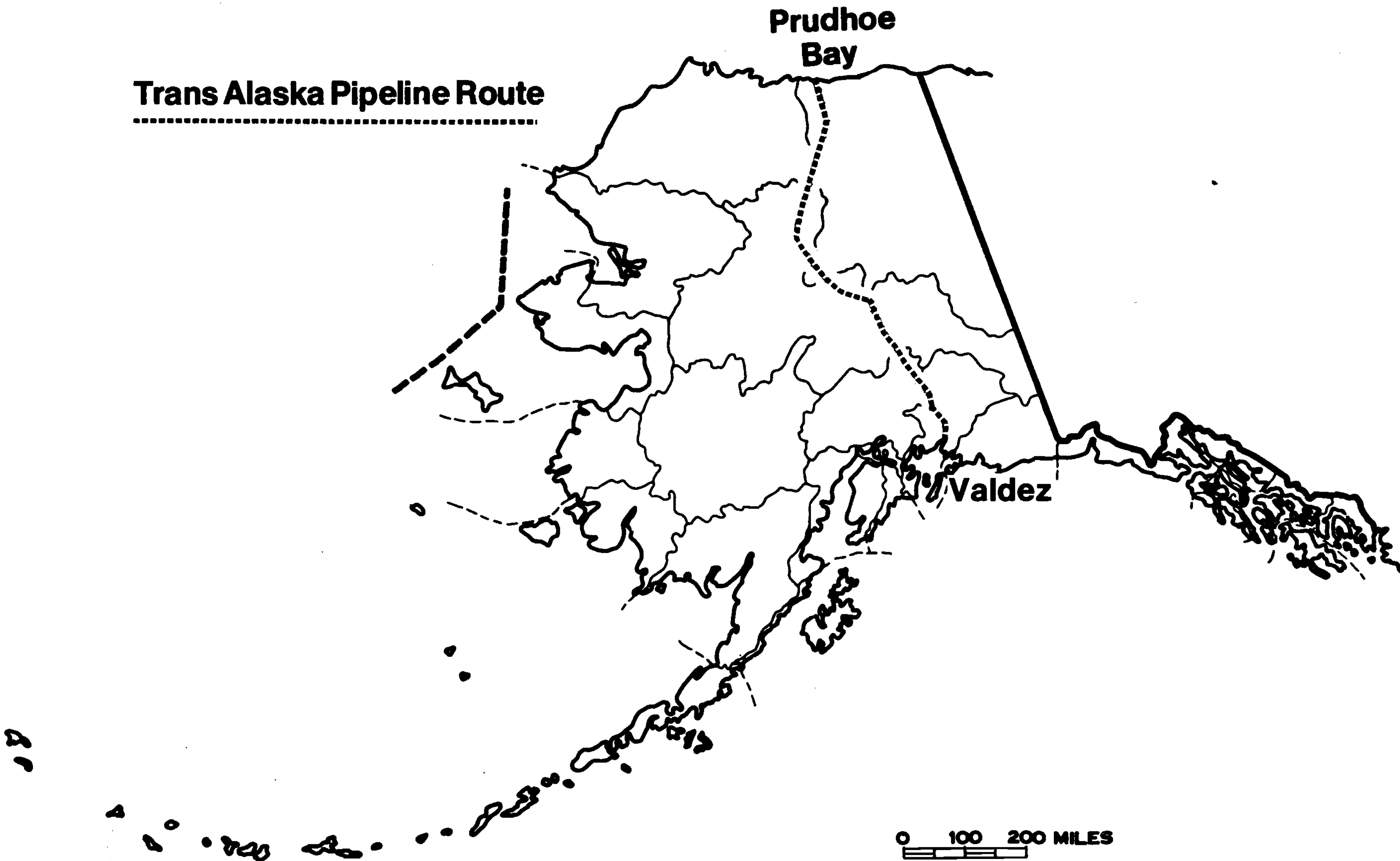
TRANS-ALASKA PIPELINE (3)

- Discovery of crude reserves at Prudhoe Bay announced in February of 1968.
- Trans-Alaska Pipeline Authorization Act passed in November of 1973
- Defense Production Act Invoked in 1974 to assure adequate material and equipment to complete the pipeline.
- Alyeska - a consortium of seven companies granted permission to construct the pipeline system, and responsible for its operation and maintenance.

  Sohio Pipe Line Company
  ARCO Pipe Line Company
  Exxon Pipeline Company
  Mobil Alaska Pipeline Company
  Union Alaska Pipeline Company
  Phillips Petroleum Company
  Amerada Hess Corporation

- Pipeline to be 798 miles long and 48 inches in diameter, extending from Prudhoe Bay to Valdez, Alaska. See Figure 4
- $6 billion project - largest privately financed undertaking in history.
- Initial capacity of 600,000 bbl/d expanded to 1.2 million bbl/d -- ultimate capacity will be 2 million bbl/d.
- Completion currently scheduled for fourth quarter of 1977.
- Valdez terminal to have three docks (two fixed, one floating) to accommodate tankers ranging in size from 16,000 to 250,000 DWT.

Figure 4



Source: Alyeska (8)

NATURAL GAS PIPELINES

HISTORICAL BACKGROUND ON NATURAL GAS PIPELINES

- Natural gas was piped through bamboo some 2,400 years ago in China. It was transported for the first time in the United States through hollow logs at Fredonia, New York in 1821. Forty-one years later a cast-iron pipe with a 2-inch diameter extended about five miles from a nearby well to Titusville, Pennsylvania. In 1880 the first compressor station was built and the line carried 4 million cubic feet of natural gas per day and served 250 domestic and industrial users. Steel pipe first became available in 1887. (9)

- During 1872-1890 period pipelines generally extended only for short distances with diameters less than eight inches. They relied mainly on well pressure, supplemented sometimes by pump at the wellhead. The first high pressure (525 psi) natural gas pipeline was constructed in 1891 and covered 120 miles from northern Indiana to Chicago. With new developments, natural gas was being burned in 17 states around 1900. (1)

- First use of a large diameter long distance pipeline was a 16-inch diameter line of 135 miles serving Fort Worth and Dallas, Texas. (9)

- First long distance all-welded pipeline was a 217-mile line from northern Louisiana to Beaumont, Texas. Some of the old bolted pipelines lost between 20 and 40 percent of the gas in transit through leakage. This pipeline used acetylene welding to join the pipe lengths. (Modern natural gas pipeline leakage is less than 1 percent.) (1)

- In 1931, the first 1,000-mile line was completed from the Texas Panhandle to Chicago, a 24-inch diameter welded steel line owned by the Natural Gas Pipeline Company of America. Following this period, the U.S. network increased to 163,000 miles of natural gas lines and Texas has replaced West Virginia as the leading source of gas supply. The end of WWII brought a tremendous expansion in long natural gas pipelines. Natural gas consumption increased from 738 billion cubic feet in 1940 to 10.6 trillion in 1957--today it is over 23 Tcf. (9)

NATURAL GAS TRANSMISSION

- The natural gas transmission network now extends throughout the lower 48 States and across the borders into Mexico and Canada. See Figure 5.

- Some 100 interstate pipeline companies transport approximately 65 percent of the total gas production, with the remaining 35 percent being carried by intrastate companies. (1)

- Figure 6 shows the rapid and steady growth in gas pipeline mileage, assets, and revenues since 1945. The rate of return on net investment has remained consistently at 7 percent or higher in the last decade.

- Cost of transporting gas is about 2 cents per Mcf per 100 miles, of which over 90 percent represents fixed charges, and 10 percent operating and maintenance costs - this is for a typical 30-inch diameter, 1,000 mile pipeline operating during 1973 at an average pressure of 800 psi and at a 95 percent load factor. (3)

- Cost is sensitive to load factor (average daily load/ maximum day load) - cost per Mcf of gas transmission at 50 percent load factor is almost double the cost of transmission at 100 percent load factor. (3)

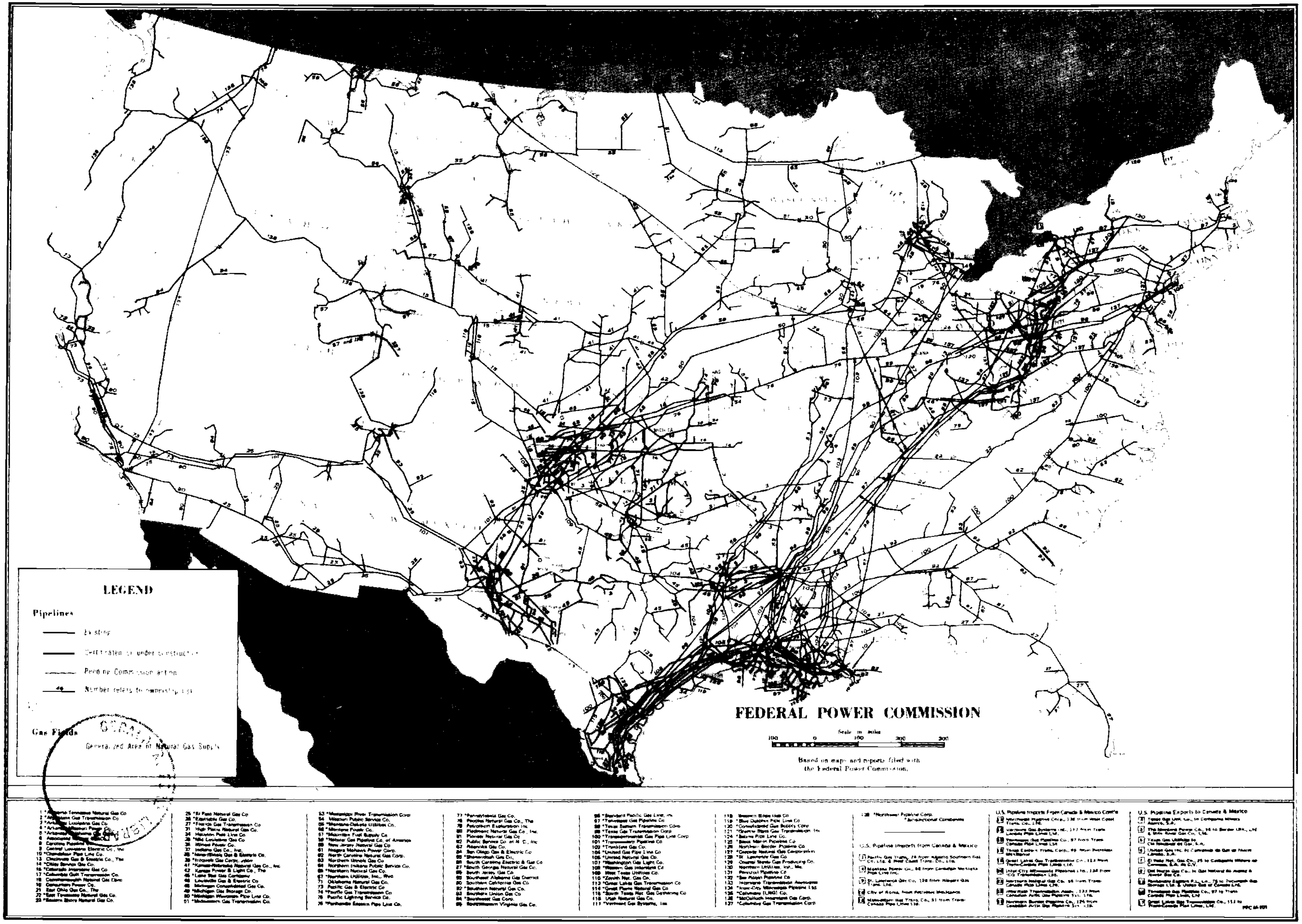
REGULATION OF NATURAL GAS PIPELINES (1)

Local Level

- Natural gas distribution was regulated on a local level long before it was sold on an interstate basis.

- All States have utilitiy commissions whose jurisdiction is concentrated more on local gas distribution and marketing functions than gas transmission. Local gas

Figure 5



For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 · Price 25 cents

Source: FPC (10)

SELECTED NATURAL GAS TRANSMISSION INDUSTRY STATISTICS

Year	Miles of pipeline	Compressor horsepower, thousands	Pipeline construction, millions of dollars	Assets, millions of dollars	Operating revenues, millions of dollars
1945	77,000	--	120	1,024	226
1950	109,000	3,500	716	2,150	563
1955	142,000	4,350	593	4,985	1,655
1960	181,000	6,359	848	8,695	3,190
1965	210,000	7,736	770	10,240	4,088
1970	252,000	9,692	1,019	14,517	5,928
1971	256,500	10,763	842	16,121	6,955
1972	260,200	10,976	678	16,136	7,390

Source: AGA (11)

Figure 6

transmission regulation in the past has been concerned most with eminent domain and safety regulation but with the gas curtailment situation the state commissions are becoming more involved.

Federal Regulation

- The Federal Power Commission has had the power to regulate interstate natural gas pipelines since the passage of the Natural Gas Act in 1938.
- Major functions of FPC regulation:
    1. Issue certificates for the construction, extension, acquisition, operation, or abandonment of natural gas pipelines.
    2. Investigate the need for, and direct connections between natural gas companies and the local distributor.
    3. Regulation of rates for sales of gas to interstate pipeline, interstate natural gas sales for resale, and transportation of gas in interstate commerce.
    4. Audit accounts of natural gas transportation companies for compliance.
    5. Collection and analysis of information on natural gas companies subject to FPC jurisdiction.
- Natural Gas Act prohibits state regulation of the price at which pipeline companies can sell interstate gas to distributors.
- Hinshaw Amendment (1954) to the Natural Gas Act exempted natural gas companies with strictly intrastate activities from FPC regulation providing they are subject to regulation by a state commission. About 35-40 percent of the natural gas in the United States is produced and consumed in the same state.
- Natural gas transmission lines are viewed as natural monopolies by Federal and State Governments. The FPC regulates them as public utilities although they are privately owned.
- Regulatory responsibility related to pipeline safety of natural gas pipelines is assigned to the Department of Transportation.

OWNERSHIP OF THE NATURAL GAS INDUSTRY (2)

- Most pipelines are independently owned but a few are controlled by holding companies.

- Recent trend among pipeline companies to diversify their operations by moving into a variety of other businesses, particularly those "vertical" to the pipeline business, i.e. gas producing companies, compressor and pipeline manfacturing companies, chemical and fertilizer companies, etc.

- About two-thirds of the marketed natural gas is transported through pipelines owned and operated by 33 major interstate pipeline companies. These companies account for almost 90 percent of total gas transported by FPC regulated companies, almost 100 percent of city-gas sales and 70 percent of main-line industrial sales. (9)

- Virtually all of the largest interstate natural gas pipeline companies are involved in exploration and development operations to obtain gas supplies, either directly or through corporate affiliates. (2)

PROPOSED NATURAL GAS PIPELINES FROM THE ARCTIC (3)

- Estimated proved recoverable natural gas reserves from Prudhoe Bay field estimated at 26 trillion cubic feet. These are oil well gas reserves and subject to the oil production at Prudhoe Bay.

- Two companies have filed application with the FPC for permits to construct and operate systems to transport natural gas from the North Slope of Alaska to the lower 48 States (Arctic Gas & El Paso Natural Gas Company.)

- FPC will have ultimate decision-making power and the Department of the Interior will be responsible for issuing right-of-way permits. (Both agencies will cooperate on a joint environmental impact statement on both the Arctic Gas and El Paso proposals.)

Arctic Gas

- Consortium of 20 American and Canadian member companies (including Sohio, Atlantic Richfield, and Exxon) which control the bulk of proven oil and gas reserves on Alaska's North Slope.

- Plans for a 2600-mile pipeline system to transport 4.5 billion cubic feet per day of natural gas from Alaska's North Slope and Canada's MacKenzie Delta to Southern Canada. Three systems planned:

    1. A 200-mile, 48-inch pipeline from Prudhoe Bay to Canadian border.

    2. A 1500-mile, 48-inch pipeline from the Alaskan border up the MacKenzie Valley to Caroline, Alberta, north of Calgary.

    3. Latter system split into two 42-inch pipelines, one southwest to southern British Columbia, the other southeast to southern Saskatchewan.

- Three projects proposed to transport gas from southern Canada to U.S. markets:

    1. Pacific Gas Transmission Company extension of pipeline to San Francisco area - 600-mile pipeline.

    2. Interstate Transmission Association plans for an extension of pipeline to the Los Angeles area - 900-mile pipeline.

    3. Northern Border Pipeline - 1600-mile pipeline to the Midwest.

- All Alaskan gas would be transported to U.S. markets; MacKenzie Delta gas offered first to Canadian market, with excess offered for sale in the United State.

El Paso Natural Gas Company

- Plans to move 3.5 billion cubic feet of natural gas per day from Prudhoe Bay to U.S. markets via a pipeline-tanker route.

- The 809-mile, 42-inch pipeline would be laid within the utility corridor already approved by the U.S. Government for Alaskan oil pipeline, terminating at Point Gravina on Price William Sound.
- At port site, gas would be liquified and transported aboard refrigerated tankers to southern California.
- El Paso pipeline would be independent of Canada.
- Western LNG Terminal Company has construction plans for three marine terminals and vaporization plants in southern California.

COAL SLURRY PIPELINES

BACKGROUND

- Slurry pipelines are used for the transport of solid materials in water--solid particles must be kept in suspension by a turbulent flow of water to prevent a settling out of the coal and pipeline clogs. (For coal with a specific gravity of 1.4 and an 8 mesh maximum particle size, the mixture will remain in homogeneous suspension for concentrations of 45-50 percent coal at a speed of 5 feet per second.) (14)

- Pumping stations are usually 40 to 80 miles apart, depending on the terrain. (14)

- Pipelines have little overload capability above rated capacity--coal slurry lines can be run satisfactorily down to 60 percent rated capacity. Capacity can be increased by looping although a looped line never performs with the efficiency of a properly sized single line. (14)

- Construction of coal slurry pipelines faces two major obstacles: (13)

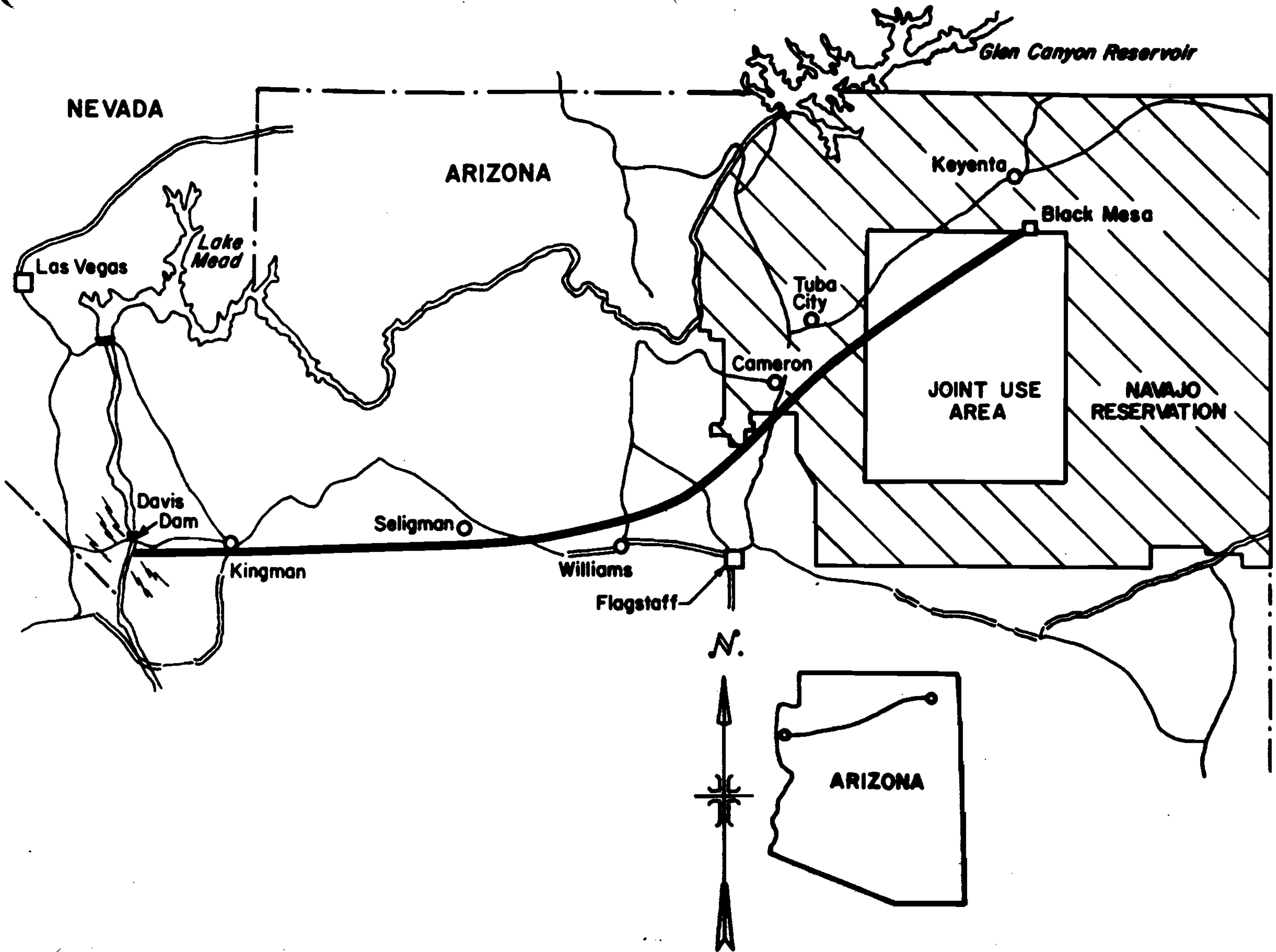
    1. Lack of the right of eminent domain.

    2. Problems related to water requirements for the operation of the slurry pipeline. At a 50 percent concentration, each ton of coal requires 250 gallons of accompanying water.

- Consolidated Coal Company Pipeline in Ohio operated a successful coal slurry line (10-inch diameter, 108 miles long) from 1957 to 1963. Built in response to rising coal freight rates, the line was eventually forced to close when rail rates declined. (12)

- Black Mesa Pipeline in Arizona is the only coal slurry pipeline currently in operation. The 1,500 MWe Mohave generating station operated by Southern California Edison is supplied with approximately 5 million tons of coal by the Peabody Coal Company through the slurry line. The 274 mile, 18-inch pipeline follows the most direct route--with no nearby railroad in existence, rail transport would have required construction of 150 miles of additional rail facilities. (See Figure 7) (13)

Figure 7



Map Showing Route of Black Mesa Coal Slurry Line.

Source: BOM (13)

FURTHER SLURRY PIPELINE DEVELOPMENT (14)

Currently Proposed Slurry Pipelines

- The Energy Transportation Systems Inc. pipeline is the most advanced proposal, running from coal fields near Gillette, Wyoming, to a utilities complex serving Arkansas, Louisiana, and Mississippi.
- Nevada Power pipeline from coal fields near Alton, Utah, to utilities at St. George, Utah, and Arrow Canyon (near Las Vegas) Nevada.
- Salt River System between Star Lake, New Mexico and St. Johns, Arizona.

Apparent Advantages to Slurry Transportation

- Lower operating costs, particularly at capacities in the range of 20-25 million tons per year. Present rail rates for unit trains are between 0.8 and 1.0 cents per ton-mile while slurry pipelines offer rates of between 0.5 and 0.7 cents per ton-mile.
- Lower circuity of some proposed lines by cutting across east-west rail routes. Without the power of eminent domain, though, slurry pipelines might experience problems obtaining rights-of-way to cross competing rail lines.
- Because the pipeline is a closed system, there is minimal dust loss or contamination of the environment.
- Most pipelines are buried, and therefore do not occupy land surface or create surface obstructions.

Slurry Pipelines in the East

- Inhibiting Factors
    - o Eastern rail network dense enough to insure rail competition to pipelines without need for extensive new construction.

- o Eastern coal production characterized by large numbers of relatively small mines with diverse ownership, making it difficult to insure the large, constant volumes required for slurry pipelines.

- o Eastern coal of generally low moisture content--can be burned by power plant as shipped by rail. Western coal, with higher moisture content, requires some sort of pre-drying before burning.

- Factors in Favor of Eastern Development

  - o Water is generally more plentiful, a problem affecting Western coal slurry proposals.

  - o Many Eastern railroads are in poor financial and physical shape, less advanced in unit train methods.

  - o Mine mouth desulfurization could result in a finely ground, wet product most readily transported in slurry form.

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XIV. TANKERS AND DEEP-WATER PORTS

TANKERS AND DEEPWATER PORTS

TANKERS

BACKGROUND

- Oil Tanker Prototype - Gluckhauf (1886), 300 feet long and 3,000 DWT carrying capacity. (4)
- World's largest tanker - S.S. Globtik Tokyo at 476,292 DWT (compared with largest at end of WWII - 18,000 DWT). (4)
- 80 percent of the oil tanker is below waterline when fully loaded. (5)
- Average DWT size of tankers - Increased from 18,000 DWT in 1958 to 57,300 in 1973. (5)
- About one-half of U.S. imports have consisted of refined products arriving in small tankers from the Caribbean. (5)

WORLD TANKER FLEET

- Fleet size in DWT (1974): (7)

Tankers	231,908,046
Combination Carriers	39,463,575
Total	271,371,621

- Oil companies own about one-third of total world fleet and control about 40 percent under long-term charter. (7)
- 85 percent of world fleet either wholly-owned or controlled by long-term charter. (7)
  - o 40 percent owned
  - o 45 percent chartered

- 15 percent of world fleet ship on short-term charters. (7)

OPEC Fleet

- At the end of 1973, OPEC countries owned a very small percentage of the world's tanker fleet (1.73 percent). (7)

Oil tankers in service	1,856,392 DWT
Oil tankers on order	1,789,000 DWT
Total	3,645,392 DWT

- AMPTC (Arab Maritime Petroleum Tanker Company) (7)

  o Established under a 50-year contract in 1972 by Abu Dhabi, Algeria, Bahrain, Kuwait, Libya, Qatar, and Saudi Arabia.

  o Funding. Saudi Arabia and Kuwait providing $500 million (2/4/74) for future tanker purchases--10 million DWT by 1982. (By comparison, U.S. flag tankers totaled about 9.6 million DWT in 1973.)

  o Carrying Capacity. Projected 2 million barrels per day of oil, or 11 percent of pre-embargo Arab oil production.

- KOTC (Kuwait Oil Tanker Company) (7)

  o Present Capacity. 800,000 DWT .

  o KOTC is the largest Arab shipping company. Its capacity is roughly less than .4 percent of that of the total world fleet.

- In December 1974, Saudi Arabia, the world's largest exporter of oil, gave "preference" to Saudi tankers, i.e., all exports of Saudi oil must be carried in tankers owned by Saudi companies over foreign companies whenever financial and other terms are equal. The first two Saudi Arabian registered tanker companies approved are:

1. The Saudi Maritime Co., Ltd. (or Samarco) is a joint venture. Participants:

   o Prince Mohamed Bin Fahad Bin Abdul Aziz (son of Interior Minister Prince Fahad), controlling 20 percent.

   o Haji Abdulla Alirez & Co., 35 percent.

   o Fairfield Maxwell, Ltd., New York, 15 percent.

   o Mobil Oil Co., 30 percent.

2. The Saudi Arabian Shipping Co. Participants:

   o Prince Abdullah al-Faisal (one of King Faisal's sons), 60 percent.

   o Mitsui OSK Lines, Japan, 40 percent.

New Tanker Construction (7)

Scheduled Date of Completion	No.	DWT	T-2 Equivalents
1974	181	25,233,100	1,758
1975	383	54,461,100	3,783
1976	345	56,891,400	3,929
1977	236	45,111,700	3,087
1978	50	10,974,400	772
1979	7	1,965,000	134
Totals	1202	194,636,700	13,463

● During first 6 months of 1974:

   o Liberian flag tonnage increased by 5.8 million tons.

   o British fleet tonnage increased by 2 million tons.

   o The Japanese fleet added 1.8 million tons to its existing tonnage.

Carrying Capacity by Major Flags of Registry (7)

June 30, 1974

Flags of Registry	T-2 Equivalent	% of World
1. Liberia	4,498	26.74
2. United Kingdom	2,052	12.71
3. Japan	1,969	11.92
4. Norway	1,611	9.86
5. Greece	949	5.90
6. France	746	4.58
7. U.S.A.	578	4.18
8. Panama	552	3.45
9. Italy	418	2.58
10. U.S.S.R.	312	1.93
11. Denmark	289	1.75
12. Germany	280	1.73
13. All others	1,749	12.67
Total World	16,003	100.00

- American-built tankers haul only 5 percent of present U.S. Imports. (8)

U.S. TANKER PORTS (6)

Port	Maximum Vessel Size (DWT)
Anacortes, Washington	120,000
Anchorage, Alaska	35,000
Baltimore, Maryland	35,000
Baton Rouge, Louisiana	76,000
Baytown, Tennessee	75,000
Beaumont, Texas	50,000
Benica, California	45,000
Boston, Massachusetts	60,000
Corpus Christi, Texas	55,000
Delaware, Delaware	120,000
East Providence, Rhode Island	35,000
Ferndale, Washington	150,000
Freeport, Texas	40,000
Galveston, Texas	35,000
Good Hope, Louisiana	50,000
Hampton Roads, Virginia	40,000
Honolulu, Hawaii	35,000
Houston, Texas	120,000
Jacksonville, Florida	30,000
Lake Charles, Louisiana	50,000
Long Beach, California	120,000
Los Angeles, California	110,000
Miami, Florida	20,000
Mobile, Alabama	50,000
Nederland, Texas	50,000
Newark, New Jersey	25,000
New Orleans, Louisiana	50,000
New York, New York	120,000
Pascagoula, Mississippi	50,000
Philadelphia, Pennsylvania	120,000
Port Arthur, Texas	50,000
Port Everglades, Florida	50,000
Portland, Maine	110,000
Portland, Oregon	35,000
Richmond, California	35,000
San Diego, California	35,000
San Francisco, California	55,000
Savannah, Georgia	35,000
Tacoma, Washington	150,000
Texas City, Texas	35,000
Venice, California	50,000

- The United States does not currently have deepwater port facilities capable of handling supertankers.

STATISTICS ON MARINE OIL POLLUTION (3)

- 5 million tons of oil pollute oceans each year:
  - o 29 percent auto crankcase oil disposal.
  - o 28 percent tanker accidents of all types.
  - o 15 percent industrial machinery waste oil.
  - o 17 percent other vessels.
  - o 6 percent refinery/petroleum chemical plant disposal.
  - o 2 percent offshore production.
  - o 2 percent tank barges.
- The deballasting of tankers (which is intentional) accounts for approximately 70 percent of the tanker-caused oil pollution of the oceans today.

Accidental Marine Oil Spills

- 75 percent of all spills are caused by human error and 25 percent by technical failure. But, 75 percent of the total volume of spilled oil comes from technical failure and only 25 percent from human error.
- Larger vessels have a slightly higher probability of being involved in casualties than smaller vessels.
- The amount of oil pollution from collisions is not related to tanker size. (This does not take into account catastrophic accidents of tankers that are greater than 80,000 DWT.)
- 1,416 tanker casualties occurred over a 2-year period (1969-70).

  Some pollution occurred in at least 269 of these tanker accidents.

Causes	Oil Outflow
30% Collisions	49% Structural failure of ship
26% Groundings	29% Groundings
19% Structural failure	8% Collisions
9% Rammings	7% Explosions
7% Fires	14% Breakdowns
6% Explosions	1% Fires
3% Other	

- Because of their large size and low power, supertankers are very difficult to stop. A 200,000 DWT tanker moving at a speed of 16 knots takes 3-1/2 miles to stop, even when full stern power is applied, a factor greatly increasing chances of collision.

Major Tanker Casualties

- Tampico Maru - March 1957. Baja, California.
- Torrey Canyon - March 1967. Cornwall, England.
- West Falmouth Spill - September 16, 1969. West Falmouth Harbor, Massachusetts.
- San Francisco Oil Spill - January 18, 1971. San Francisco, California.
- Showa Maru - January 6, 1975. Buffalo Rock, Singapore Straits. (5)

DEEPWATER PORTS

TYPES OF FACILITIES

- Deepwater Ports Act of 1975 licenses deepwater ports designed to accommodate large cargo vessels (up to 750,000 DWT or more with drafts up to 100 feet).

- Two principal types: Mooring buoys and islands. (1)

    - Single Point Mooring (SPM) - also referred to as monobuoys. Flat cylindrical buoy with vertical axis. Held in place by chains attached to anchors or piles driven into ocean floor. Suitable for open sea conditions because of ship's flexibility.

    - Single Anchor Leg Mooring (SALM) - Variation of SPM. Very resistant to heavy seas and damage from ship action.

    - Conventional Mooring Buoy - Several buoys used to maintain the tanker in a given position. Requires moderate wind conditions.

    - Single Pile Mooring Pier - Tower fixed to the sea floor on which is mounted a long semi-submersible floating structure.

    - Sea Island - Platform-type structure which may be permanently attached to the bottom by pilings. Keeps ship restrained in position. Generally preferred for oil transfer from large tankers.

    - Artificial Island - Rock-filled dike around and within the perimeter of the facility, eventually settling out to form an island. Stone revetment armored with concrete units. Most expensive, but also most versatile of facilities.

- Life expectancy of facilities is at least 15-20 years.

POTENTIAL U.S. TERMINALS (2)

- Sites proposed or under strong consideration:
  - o Off Asbury Park, New Jersey
  - o Delaware Bay off Big Stone Beach (DBTC)
  - o Mississippi Delta near Southwest Pass (LOOP)
  - o Texas Gulf near Freeport (Seadock)
  - o Ameraport (Alabama-Mississippi)
  - o Estero Bay, California
  - o Puget Sound, Washington

ENVIRONMENTAL IMPACT (3)

- Environmental impacts result from the following aspects of building and operating deepwater port facilities:
  - o Actual construction
  - o Oil spills
  - o Tanker casualty
  - o Ballast pumping
  - o Ship effluents (sewage, garbage)
- Areas to be considered when analyzing environmental impact:
  - o Estuaries & wetlands
  - o Bottom sediment
  - o Marine biota
  - o Water quality
  - o Air quality
  - o Beaches
  - o Recreational activities
  - o Secondary activities (e.g., onshore crude oil delivery, refining and associated industry development)

SOURCES

(1) PROJECT INDEPENDENCE REPORT, November 1974, FEA.

(2) DEEPWATER PORTS, Final Environmental Impact Statement, Vol. I, April 1974, Department of the Interior.

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(4) SUPERSHIP, 1974, BY Noel Mostert, Alfred A. Knopf publisher.

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(6) INTERNATIONAL PETROLEUM ENCYCLOPEDIA, 1974, Petroleum Publishing Company.

(7) WORLD TANKER FLEET REVIEW, June 1974, John I. Jacobs & Co. Ltd.

(8) OIL & GAS JOURNAL, May 1, 1974, Petroleum Publishing Company.

(9) PETROLEUM INTELLIGENCE WEEKLY, December 9, 1974.

XV. INTERNATIONAL

INTERNATIONAL ENERGY AFFAIRS

ORGANIZATION OF PETROLEUM EXPORTING COUNTRIES (1)

- Organization of Petroleum Exporting Countries (OPEC) formed in September 1960 by Venezuela, Iraq, Saudi Arabia, Iran, and Kuwait.
- Membership has been expanded to 13 states:

1.	Qatar	(1961)
2.	Libya	(1962)
3.	Indonesia	(1962)
4.	Abu Dhabi (later United Arab Emirates)	(1967)
5.	Algeria	(1969)
6.	Nigeria	(1971)
7.	Ecuador	(1973)
8.	Gabon	(1974) (Associate)

- OPEC's principal aims are coordination and unification of petroleum policies of member countries to promote individual and collective interests.
- Because of diverse membership, OPEC policy concentrates on price, revenue, and other issues of concern to all members.
- Early OPEC successes were minimal--oil prices declined as result of unrestricted production.
- Resolution IX.61 of 1965 was designed to institute production programming, but was not successful.
- In early years, some tax and royalty measures were adopted to establish uniform procedures among members.

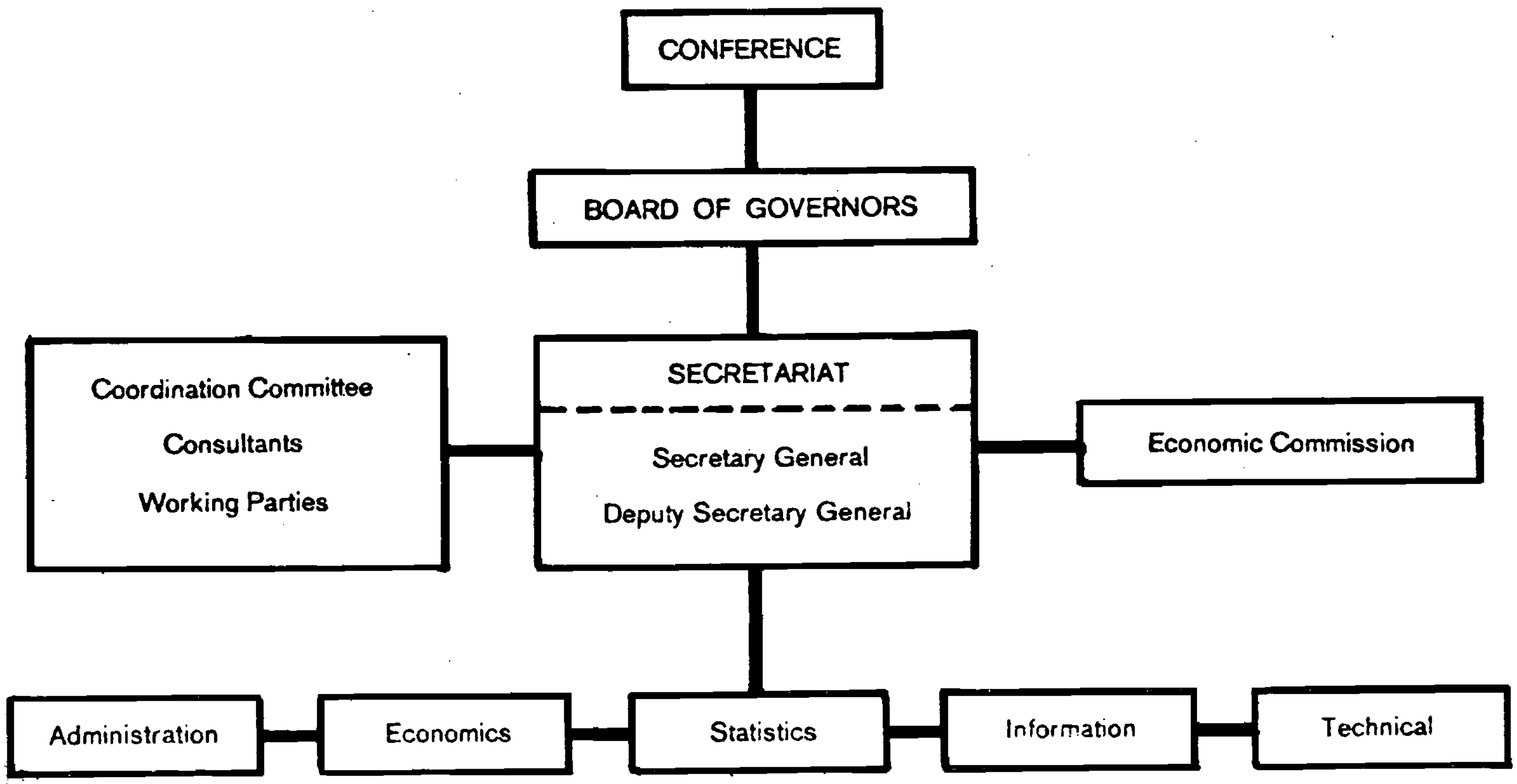
- In 1968 OPEC's importance increased with adoption of Resolution XVI.90 on uniform petroleum policies.
- Resolution called for:
    - o Government sovereignty over oil resources
    - o Substantial government participation in production
    - o Posted Prices to be determined by governments
    - o Reasonable renegotiation of contracts
    - o Disputes to be handled only by national courts
- The above points remain basis of OPEC policy.

PRICES

- In late 1973, OPEC quadrupled posted price of oil.
- Posted Price for 34° Arabian light had been increased as follows:

August 31, 1971	$1.800
August 1, 1973	3.066
October 16, 1973	5.119
January 1, 1974	11.651--retained each quarter of 1974, but rate of royalty, participation and buyback changed to increase average company costs and government take.
January 1, 1975	11.251--posted price reduced but real effect is 38¢ increase in the average government take over 1974 4th quarter and rise in company costs. Effective nine months barring 100% ownership of foreign oil companies.

Structure of OPEC



OPEC Countries: Crude Oil Production[1]

	1973			1974					
	Sep	Nov	Dec	1st Qtr	2d Qtr	Jul	Aug	Sep	Oct
	Thousand b/d								
Total	32,801	28,511	28,844	30,670	31,710	30,330	29,240	29,480	29,630
Saudi Arabia[2]	8,574	6,269	6,616	7,820	8,860	8,790	8,280	8,770	9,000
Iran	5,793	6,010	6,070	6,130	6,140	6,060	5,970	5,870	5,900
Venezuela	3,387	3,380	3,330	3,230	2,970	2,940	2,860	2,770	2,750
Kuwait[2]	3,520	2,582	2,556	2,840	2,850	2,280	2,080	2,240	2,300
Nigeria	2,100	2,240	2,260	2,250	2,300	2,200	2,300	2,310	2,300
Iraq	2,167	2,026	2,136	1,800	1,700	1,700	1,800	1,780	1,800
Indonesia	1,402	1,390	1,400	1,440	1,480	1,470	1,400	1,200	1,400
Abu Dhabi (UAE)	1,381	1,153	1,016	1,320	1,620	1,650	1,500	1,420	1,200
Libya	2,286	1,766	1,769	1,890	1,820	1,460	1,270	1,320	1,120
Algeria	1,100	880	860	970	980	900	850	850	900
Qatar	608	465	460	520	520	520	520	510	520
Dubai (UAE)	273	140	141	230	240	240	240	240	240
Ecuador	210	210	230	230	230	90	110	140	140
Sharjah (UAE)[3]	...	...	...	...	...	30	60	60	60
	Percent Changed from September 1973								
For all countries	...	-13	-12	-6	-3	-8	-11	-10	-10

1. Excluding production in Gabon, an associate member of OPEC. This production amounts to 160,000 b/d.
2. Including approximately one-half of Neutral Zone production.
3. Production began in mid-July at 50,000-60,000 b/d.

Figure 1

ORGANIZATION OF ARAB PETROLEUM EXPORTING COUNTRIES (1)

- Organization of Arab Petroleum Exporting Countries (OAPEC) was formed January 9, 1968 by Saudi Arabia, Kuwait, and Libya.

- All Arab countries are eligible if oil is their main source of revenue.

- OAPEC Secretary General is Dr. Ali Attiga.

- OAPEC headquarters is located in Kuwait.

- Current members include:

Algeria	Libya
Bahrain	Qatar
Egypt	Saudi Arabia
Iraq	Syria
Kuwait	United Arab Emirates (U.A.E.)

- Principal objectives:

    1. Coordination of politics of petroleum (except for prices and quantities).

    2. Promotion of exchanges and technical information among member states on questions concerning petroleum.

    3. Establishment of common projects on exploration, exploitation, transport and marketing of petroleum.

- General objective is "to maximize benefits derived by its members from their resources."

- Activities of OAPEC in joint ventures:

    1. Arab Society of Petroleum Transport - 1972; Headquarters in Kuwait; 9 members.

    2. Arab Society for Repair and Construction of Ships; Headquarters in Bahrain; 8 members.

3. Arab Petroleum Investment Corporation - to be established in 1975; Headquarters in Dammam, Saudi Arabia; capital of $1.2 billion; 10 members.

4. Petroleum Service Company--to be established in 1975 for research and exploitation.

Structure of OAPEC includes:

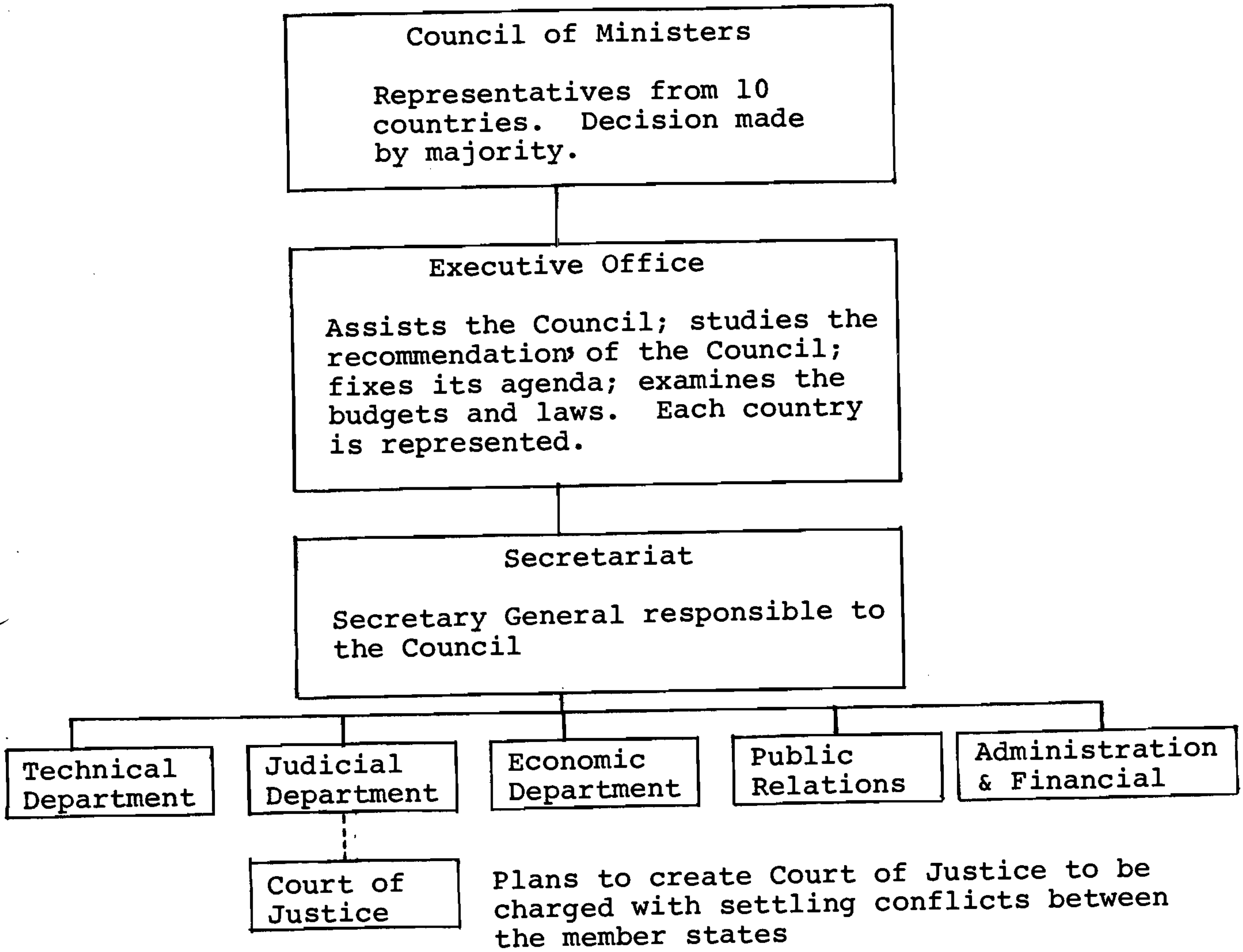


Figure 2

OAPEC Countries: Crude Oil Production

	1973			1974					
	Sep	Nov	Dec	1st Qtr	2d Qtr	Jul	Aug	Sep	Oct
	Thousand b/d								
Total	20,311	15,380	15,703	17,640	18,950	17,950	16,980	17,570	17,520
Saudi Arabia[1]	8,574	6,269	6,616	7,820	8,860	8,790	8,280	8,770	9,000
Kuwait[1]	3,520	2,582	2,556	2,840	2,850	2,280	2,080	2,240	2,300
Libya	2,286	1,766	1,769	1,890	1,820	1,460	1,270	1,320	1,120
Iraq	2,167	2,026	2,136	1,800	1,700	1,700	1,800	1,780	1,800
Abu Dhabi (UAE)	1,381	1,153	1,016	1,320	1,620	1,650	1,500	1,420	1,200
Algeria	1,100	880	860	970	980	900	850	850	900
Qatar	608	465	460	520	520	520	520	510	520
Dubai (UAE)	273	140	141	230	240	240	240	240	240
Sharjah (UAE)[2]	...	...	...	...	...	30	60	60	60
Other[3]	402	99	149	250	360	380	380	380	380
	Percent Change from September 1973								
For all countries	...	-24	-23	-13	-7	-12	-16	-13	-14

1. Including approximately one-half of Neutral Zone production.
2. Production began in mid-July at 50,000 - 60,000 b/d.
3. Including Bahrain, Egypt, and Syria.

ORGANIZATION LATINOAMERICANA DE ENERGIA (1)

- Organization Latinoamericana de Energia (OLADE) was proposed by Venezuela in 1973 to encourage increased energy production in Latin America, thus easing pressure on Venezuela to supply petroleum to its neighbors on concessionary terms.

- Since original proposals for OLADE, new administration has come to power in Venezuela and interest in program has waned.

- Government of Venezuela apparently believes financial burden it would be expected to bear would outweigh any benefits.

- Twelve nations have joined OLADE:

Bolivia	Cuba
Jamaica	Brazil
Ecuador	Chile
Peru	Dominican Republic
Trinidad and Tobago	Panama
Guyana	Honduras

- Uruguay and Haiti expected to become formal members soon.

- Outstanding problems are:

  1. No agreement exists among members on scope and goals of organization.

  2. Source of leadership and financing is needed--at present only Venezuela could play this role.

  3. OLADE deliberately excludes United States.

- Only if Venezuela changes its attitude and joins organization will OLADE gain in importance.

THE INTERNATIONAL ENERGY PROGRAM (2)
(IEP)

- Roots of IEP go back to Washington Energy Conference (February 1974) where 12 nations established the Energy Coordinating Group (ECG).
- Objective of ECG was to develop cooperative international action program to deal with world energy situation.
- Work of ECG culminated in agreement among 16 OECD (Organization for Economic Cooperation and Development) nations on an International Energy Program.
- IEP was formally adopted on November 18, 1974 in the International Energy Agency (IEA), established as an autonomous body within the framework of the OECD.
- Sixteen nations signed the agreement establishing the IEP:

Austria	Luxembourg
Belgium	The Netherlands
Canada	Spain
Denmark	Sweden
Federal Republic of Germany	Switzerland
Ireland	Turkey
Italy	United Kingdom
Japan	United States

- Purpose of the International Energy Program:

  1. To create a basis for major oil consuming nations to cooperate in energy matters.
  2. To promote more secure oil supplies on reasonable and equitable terms.
  3. To take common measures to meet oil supply emergencies and interruptions.
  4. To develop greater information on and a more active role for consultation with oil companies.

- IEP has four major elements:

  1. An emergency sharing arrangement to immediately reduce vulnerability to actual or threatened embargoes by the producers.

  2. A long-term cooperative program to reduce dependence on imported oil.

  3. An oil market information system aimed at improving knowledge of the functioning of the world oil market and establishing a framework for consultation with individual companies.

  4. A framework for coordinating our relations with producing countries and the less developed consuming countries and elaborating a common strategy for the eventual dialogue with the producing countries.

- Basic elements of emergency plan:

  1. Emergency Reserves: Stockpiling obligation requires each country to maintain at least 60 days of stocks (including standby oil producing capacity and fuel switching capability) based upon net oil imports as defined initially--stock level to be increased to 90 days later.

  2. Emergency Demand Restraint: Demand restraint commitment requires a standby program to reduce consumption mandatorily by 7 percent in event of the group's or individual country's supply reduction of 7 percent; a reduction to 10 percent when supply falls by 12 percent; and consultation on a further reduction when stock levels decline by 50 percent--substitution through stock drawdown may be used instead.

  3. Allocation of Oil: International allocation is stipulated when supplies are reduced to the group or to any one country by more than 7 percent.

  4. Oil Market Information System: Establish an information system consisting of two sections:

   1. General Section - monitors situation in international oil market and activities of oil companies.

   2. Special Section - designed to insure efficient operation of emergency measures described above.

5. <u>Consultation with Oil Companies</u>:

   1. Establish framework to consult with and request information of individual international oil companies.

   2. Share results on a cooperative basis.

   3. Evaluate results of discussions through a Standing Group on the Oil Market.

6. <u>Long-term Cooperation on Energy</u>:

   1. Conservation, including cooperative programs.

   2. Accelerated development of alternative energy sources (coal, domestic oil and gas, hydro, and nuclear), including investment protection measures.

   3. Energy R & D cooperative programs in coal technologies, solar, nuclear, fusion, waste utilization, etc.

   4. Uranium enrichment cooperation.

7. <u>Relations with Producers and Other Consumers</u>: Promote cooperative relations with oil producing countries and with other oil consuming countries including developing countries.

8. <u>Institutional Arrangements</u>:

   1. An International Energy Agency (IEA) was established and is housed as autonomous agency in OECD.

2. Structure of Agency:

   a. Governing Board - making most of the binding decisions
   b. Management Committee
   c. Standing Groups on Emergency Questions, the Oil Market, Long-term Cooperation, and Relations with Producer and Other Consumer Countries
   d. Secretariat - to assist the other organs

3. Voting procedures vary--they include unanimity (for amendments to Agreement and new members), qualified majority based on oil consumption voting weights values, and combination of weighted plus general country voting weights.

4. General voting weights of three are given each country for a total of 48; oil consumption weighted votes are percentages and equal to 100; and combined voting weights equal 148.

5. U.S. has combined voting weight of 51.

THE UNITED STATES-SOVIET AGREEMENT (1)

- U.S.-Soviet Agreement on Cooperation in Field of Energy was signed in Moscow in May 1974--is one of 11 agreements on various topics.

- Agreement has three parts:

  1. Eight projects (concerned mainly with advanced technologies such as magnetohydrodynamics and superconductivity) have been transferred to Energy Agreement from Technology Agreement of 1972.

     Project on oil pollution was transferred from Soviet Environmental Protection Agreement.

     Projects are funded and carried out by Interior, NSF, TVA, AEC, and U.S. Geological Survey.

  2. Energy Agreement provides for new R&D projects in energy-related technologies.

  3. Agreement calls for exchange of "relevant information, views and methods of forecasting concerning the national energy programs and outlooks of the respective countries, including all questions of mutual interest related to production, demand and consumption of the major forms of fuels and energy."

- At first meeting of Joint Committee of the Energy Agreement, chaired by FEA Administrator and Peter Neporozhniy, Soviet Minister of Power and Electrification, establishment of four temporary groups of experts in fields of oil, coal, gas and energy information and forecasting was agreed upon.

- These groups are to examine specific projects and other courses of action and present their findings at second meeting of Joint Committee in summer of 1975.

- Ongoing projects from other agreements will continue as before.

EXPORTS AND IMPORTS OF U.S. COAL (3)

Exports

- United States has historically been largest coal exporting nation in world and continued its leading role in 1974.
- U.S. coal production for 1973 totalled 596 million tons of bituminous and anthracite of which 55 million tons of coal and coal products were exported.
- Over 80 percent (41-42 million tons per year) of coal exports are under long-term contracts concluded by coal export companies.
- About 80 percent (41 million tons) of U.S. bituminous coal exports (75 percent of total exports) are of metallurgical coal and/or for metallurgical purposes.
- For first half of 1974, U.S. coal and coal products exports increased by four million tons (to 28.28 million short tons) over comparable period in 1973--total for 1974, however, will be reduced because of coal strike.
- United States is principal supplier of low ash, heavy coking coal upon which many industrialized countries are dependent for their steel industries.

U.S. Coal Exports to Japan

- Japan is currently largest single overseas customer for U.S. coal--imported 10.1 million tons of bituminous coal in 1973.
- U.S. is principal supplier of Japan's heavy coking coals with under eight percent ash content which is vital to its steel industry.
- Imports from U.S. furnished close to 37 percent of Japan's overall coal imports (as of October 1974).

U.S. Coal Exports to Canada

- Canada imported over 17 million tons of coal in 1973, and in first seven months of 1974 imported 8.194 million short tons or 25 percent of U.S. export total--a decrease of roughly eight percent over same period in 1973.
- Canadian steel industry is almost entirely dependent upon U.S. exports of high grade metallurgical coal.
- In 1973 Canada imported (totally for province of Ontario) seven million tons of Appalachian metallurgical coal.
- Additionally, Canada imported nine million tons of steam coal from U.S. in 1973--however, Canadians re-exported about 2.0 million tons of this coal in form of electric power to Niagara Mohawk and Detroit Edison Power companies.
- Electric power exports from Canada may have grown 2.5 million tons coal equivalent in 1974.

U.S. Coal Exports to European Community

- In 1973, U.S. shipments of coal to European community declined by 2.4 million tons to 14.3 million tons--around 90 percent of these were metallurgical coal.
- U.S. low ash, low volatile coal constitutes essential ingredient in coking coal blends of Italian, French, British, and Spanish steel industries.
- Prior to recent coal strike, U.S. coal exports to the EEC during 1974 were expected to increase by 2-3 million tons over 1973.

Constraints Affecting U.S. Coal Exports

- In short- and medium-term, U.S. coal exports cannot meet potential market demand unless the Nation develops resources on scale considerably larger than at present.
- Primary constraints affecting future levels of U.S. coal export capability are the same as those affecting domestic supply, that is, environmental, capital, logistic, and manpower constraints.

U.S. Imports of Coal

- Imports of coal by U.S. are minimal compared to exports, but are rising.

- 1972 imports (totally from Canada) were 230,000 tons (coal, coke, and briquets)--1973 imports (largely from West Germany, but also Canada, Czechoslavakia, Hungary, Italy, Poland, and United Kingdom) totalled 1.2 million tons--1974 imports will be considerably larger and include a number of new exporting countries.

Foreign Investment in U.S. Coal Industry

- Foreign investment in U.S. coal industry presently in excess of $300 million and growing rapidly.

- Degree to which U.S. coal exports represent captive production from foreign-owned or controlled investments should have important bearing on treatment of such production in times of domestic shortage.

- Foreign control of U.S. production capacity is not known exactly--Canadian interests are the largest--Canadian productive capacity yields about 12 million tons of annual production--additionally, Ontario Hydro has invested with U.S. Steel in new mine to be opened in Cumberland, Pennsylvania--investment valued at $38 million.

- Large but undetermined part of Canadian captive investment is in metallurgical coal.

- Over 80 percent of European, Japanese, and Canadian deals take form of long-term supply contracts rather than direct equity investments.

- Future investment in U.S. coal industry in all forms is likely to be substantial.

INTERNATIONAL NUCLEAR PROGRAMS (3)

- Atomic Energy Act of 1954 (as amended) provides for "...a program of international cooperation to promote the common defense and security and to make available to cooperating nations the benefits of peaceful applications of atomic energy as widely as expanding technology and considerations of the common defense and security will permit"--Atoms for Peace Program resulted.

- U.S. Government, through AEC, has undertaken promotion of international cooperation in peaceful applications of nuclear energy, under effective safeguards.

- Atoms for Peace Program provides for exchange with other nations of information on civil nuclear technology and the sale abroad of reactors and nuclear fuels for both research and power reactors.

- As of June 1974, there were 33 effective agreements for cooperation in the civil uses of atomic energy negotiated between the United States and other nations or groups of nations.

- An essential feature of agreements is that governments involved provide assurances that U.S.-supplied nuclear equipment, materials, and products are used only for peaceful purposes.

- Agreements are renegotiated or amended to meet changing conditions; e.g., to accommodate growing needs abroad for enriched uranium for power reactor fuel.

- Following Washington Energy Conference (February 1974), the United States took steps to increase activities concerned with international exchanges of information related to uranium supply, uranium enriching, and safeguards.

Recent Important Events in the International Nuclear Program

- Due to lack of assurance that adequate enrichment capacity will be available, AEC is no longer taking on contracts to supply enriched uranium to foreign nations--existing contracts will be honored.

- In February 1974, United States and USSR signed a Protocol on Cooperation in Controlled Thermonuclear Fusion and Plasma Physics Research--there is also a U.S./Soviet agreement covering nonfusion-type nuclear research.

- In March, AEC and German Federal Ministry for Research and Technology signed cooperative arrangement providing for exchange of information on nuclear reactor safety research and development--agreement deals primarily with information on safety of light water reactors and disposal of radioactive wastes.

- In April 1974, initial meeting of ad hoc group for Enriched Uranium Supply to consider uranium and uranium enriching cooperative activities which might be suitable as part of ECG supervised (or approved) activities was held--newly formed International Energy Agency will also include a uranium enrichment subgroup that will exchange information and plans on uranium supplies and construction of enrichment facilities.

- In June 1974, AEC signed provisional uranium enrichment contracts with Egypt, Israel, and Iran.

World Crude Oil Production
(Thousands of barrels/day)

Countries	Sep 1973 (Pre-Crisis Level)	1973	1974 1st Qtr	1974 2d Qtr	1974 Jul	1974 Aug	1974 Sep
World Total	58,080	55,685	56,160	57,190	55,940	54,810	54,890
Free World Total	47,892	45,820	45,620	46,600	45,200	44,070	44,150
Western Hemisphere	16,042	16,118	15,930	15,540	15,340	15,250	15,040
United States[1]	9,149	9,189	9,000	8,950	8,960	8,920	8,780
Venezuela	3,387	3,364	3,230	2,970	2,940	2,860	2,770
Canada[2]	1,745	1,798	1,860	1,750	1,680	1,650	1,640
Mexico	470	465	500	550	600	650	650
Ecuador	210	204	230	230	90	110	140
Other	1,081	1,098	1,110	1,090	1,070	1,060	1,060
Eastern Hemisphere	31,850	29,702	29,690	31,060	29,860	28,820	29.110
Western Europe	389	370	360	380	400	390	400
Middle East	22,977	21,158	21,280	22,610	21,940	21,120	21,560
Saudi Arabia	8,574	7,607	7,820	8,860	8,790	8,280	8,770
Iran	5,793	5,861	6,130	6,140	6,060	5,970	5,870
Kuwait	3,520	3,024	2,840	2,850	2,280	2,080	2,240
Iraq	2,167	1,964	1,800	1,700	1,700	1,800	1,780
Abu Dhabi (UAE)	1,381	1,298	1,320	1,620	1,650	1,500	1,420
Qatar	608	570	520	520	520	520	510
Oman	302	293	300	300	290	290	290
Dubai (UAE)	273	220	230	240	240	240	240
Sharjah (UAE)[3]	...	...	...	...	30	60	60
Other	359	321	320	380	380	380	380

1. Excluding an estimated 1.7 million b/d of natural gas liquids.
2. Excluding an estimated 300,000 b/d of natural gas liquids.
3. Production began in mid-July at 50,000-60,000 b/d.

Figure 3

World Crude Oil Production (continued)
(Thousands of barrels/day)

Countries	Sep 1973 (Pre-Crisis Level)	1973	1974 1st Qtr	1974 2d Qtr	1974 Jul	1974 Aug	1974 Sep
Africa	6,132	5,902	5,660	5,670	5,150	5,010	5,050
Nigeria	2,100	2,053	2,250	2,300	2,200	2,300	2,310
Libya	2,286	2,187	1,890	1,820	1,460	1,270	1,320
Algeria	1,100	1,070	970	980	900	850	850
Gabon	155	147	170	160	160	160	160
Angola/Cabinda	165	154	170	170	160	160	140
Other	326	291	210	240	270	270	270
Asia-Pacific	2,352	2,272	2,390	2,400	2,370	2,300	2,100
Indonesia	1,402	1,339	1,440	1,480	1,470	1,400	1,200
Other	950	933	950	920	900	900	900
Communist countries total	10,188	9,865	10,540	10,590	10,740	10,740	10,740
USSR	8,663	8,420	8,900	8,900	9,000	9,000	9,000
China	1,140	1,060	1,250	1,300	1.350	1,350	1,350
Romania	275	275	280	280	280	280	280
Other	110	110	110	110	110	110	110

Figure 4

Figure 5

WORLD CRUDE OIL REFINING CAPACITY
1 JANUARY 1974

	Thousand b/d	Percent of Total
Total	64,591.1	100.0
Eastern Hemisphere	41,353.8	64.0
Middle East	3,119.5	4.8
Saudi Arabia	676.0	1.0
Iran	660.0	1.0
Kuwait	566.0	0.9
Turkey	305.5	0.5
Bahrain	250.0	0.4
Iraq	168.5	0.3
Other	493.5	0.8
Africa	1,104.7	1.7
South Africa	331.0	0.5
Egypt	180.0	0.3
Other	593.9	0.9
Asia-Pacific	8,920.3	13.8
Japan	5,151.8	8.0
Singapore	699.6	1.1
Australia	681.0	1.1
India	499.1	0.8
Indonesia	427.7	0.7
South Korea	420.0	0.7
Other	1,041.1	1.6
Western Europe	18,109.3	28.0
Italy	3,880.6	6.0
France	3,140.0	4.9
West Germany	2,825.7	4.4
United Kingdom	2,762.1	4.3
Netherlands	1,825.5	2.8
Spain	1,163.0	1.8
Belgium	817.3	1.3
Greece	313.6	0.5
Sweden	248.0	0.4
Denmark	226.5	0.4
Austria	220.0	0.3
Finland	196.0	0.3
Norway	168.0	0.3
Switzerland	140.0	0.2
Portugal	110.0	0.2
Ireland	58.0	0.1
Cyprus	15.0	Negl.
Communist Countries	10,100.0	15.6
USSR	7,000.0	10.8
Eastern Europe	1,600.0	2.5
Other	1,500.0	2.3

Figure 5
(cont.)

WORLD CRUDE OIL REFINING CAPACITY 1 JANUARY 1974 (cont.)

	Thousand b/d	Percent of Total
Total		
Western Hemisphere	23.237.3	36.0
North America	16,718.6	25.9
United States	14,216.3	22.0
Canada	1,877.3	2.9
Mexico	625.0	1.0
Latin America	6,518.7	10.1
Venezuela	1,531.6	2.4
Netherlands Antilles	945.0	1.5
Brazil	791.8	1.2
Argentina	623.6	1.0
Virgin Islands	590.0	0.9
Bahamas	500.0	0.8
Trinidad & Tobago	461.0	0.7
Other	1,075.7	1.7

1973 Estimated Oil Imports by Source[1]

(Thousands of barrels/day
Percent of Imports)

		Non-Arab Countries					
Country	Total	Iran	Vene-zuela	Indo-nesia	Canada	Nigeria	Other
United States	4,610	420	1,840	250	1,100	550	450
%	74.4	6.8	29.7	4.0	17.7	8.9	7.3
Japan	3,010	1,730	10	840	...	100	330
%	55.7	32.0	0.2	15.6	...	1.9	6.1
Canada	780	180	470	Negl.	...	80	50
%	78.0	18.0	47.0	Negl.	...	8.0	5.0
Western Europe	4,600	2,150	320	Negl.	...	1,130	1,000
%	30.3	14.1	2.1	Negl.	...	7.4	6.6
United Kingdom	850	460	80	Negl.	...	180	130
%	36.5	19.7	3.4	Negl.	...	7.7	5.6
West Germany	640	270	40	Negl.	...	200	130
%	28.4	12.0	1.8	Negl.	...	8.9	5.8
Italy	510	330	20	...	...	10	150
%	20.9	13.5	0.8	...	...	0.4	6.1
France	710	220	40	...	...	250	200
%	25.5	7.9	1.4	...	...	9.0	7.2
Netherlands[2]	750	440	50	...	...	220	40
%	35.9	21.1	2.4	...	...	10.5	1.9
Belgium-Luxembourg	170	100	20	...	...	30	20
%	23.6	13.9	2.8	...	...	4.2	2.8
Spain	180	120	40	...	...	10	10
%	18.0	12.0	4.0	...	...	1.0	1.0
Other	790	210	30	...	...	230	320
%	49.7	13.2	1.9	...	...	14.5	20.1

1. This table allocates imports on a direct and indirect basis-i.e., refined products from export refineries are traced to the source of the crude oil.
2. Excluding oil transshipped to other West European countries.

Figure 6

Figure 7

1973 Estimated Oil Imports by Source[1]
(Thousands of barrels/day
Percent of Imports)

Country	Total Arab and Non-Arab	Arab Countries							
		Total	Saudi Arabia	Kuwait	Libya	Iraq	Abu Dhabi	Al-geria	Other
United States	6,200	1,590	590	160	350	50	160	140	140
%	100.0	25.6	9.5	2.6	5.6	0.8	2.6	2.3	2.3
Japan	5,400	2,390	1,240	540	20	Negl.	430	...	160
%	100.0	44.3	23.0	10.0	0.4	Negl.	8.0	...	3.0
Canada	1,000	220	80	Negl.	40	20	60	...	20
%	100.0	22.0	8.0	Negl.	4.0	2.0	6.0	...	2.0
Western Europe	15,200	10,600	4,000	1,700	1,590	1,160	600	780	770
%	100.0	69.7	26.3	11.2	10.5	7.6	3.9	5.1	5.1
United Kingdom	2,330	1,480	550	400	240	60	50	50	130
%	100.0	63.5	23.6	17.2	10.3	2.6	2.1	2.1	5.6
West Germany	2,250	1,610	480	90	550	30	110	280	70
%	100.0	71.6	21.3	4.0	24.4	1.3	4.9	12.4	3.1
Italy	2,440	1,930	630	200	460	430	...	...	210
%	100.0	79.1	25.8	8.2	18.9	17.6	...	...	8.6
France	2,780	2,070	620	320	130	380	290	230	100
%	100.0	74.5	22.3	11.5	4.7	13.7	10.4	8.3	3.6
Netherlands[2]	2,090	1,340	690	380	60	10	80	20	100
%	100.0	64.1	33.0	18.2	2.9	0.5	3.8	1.0	4.8
Belgium-Luxembourg	720	550	290	120	30	30	10	50	20
%	100.0	76.4	40.3	16.7	4.2	4.2	1.4	6.9	2.8
Spain	1,000	820	470	90	40	50	...	110	60
%	100.0	82.0	47.0	9.0	4.0	5.0	...	11.0	6.0
Other	1,590	800	270	100	80	170	60	40	80
%	100.0	50.3	17.0	6.3	5.3	10.7	3.8	2.5	5.0

1. This table allocates imports on a direct and indirect basis-i.e., refined products from export refineries are traced to the source of the crude oil.
2. Excluding oil transshipped to other West European countries.

Figure 8

Trends in Oil Consumption in Major Countries[1]
(Thousands of barrels/day)

Country		1972	1973	1974
United States	Jan	16,722	18,667	17,270
	Feb	17,846	18,941	17,371
	Mar	16,849	17,193	16,045
	Apr	15,516	15,925	15,919
	May	14,790	16,603	15,624
	Jun	15,602	16,471	16,459
	Jul	14,814	16,437	16,156
	Aug	15,929	17,414	16,332
	Sep	15,475	16,620	
	Oct	16,440	17,095	
	Nov	17,592	18,434	
	Dec	18,732	17,129	
Canada	Jan	1,536	1,667	1,830
	Feb	1,793	1,748	1,864
	Mar	1,612	1,584	1,658
	Apr	1,367	1,432	1,568
	May	1,374	1,486	1,573
	Jun	1,334	1,470	
	Jul	1,294	1,490	
	Aug	1,394	1,558	
	Sep	1,402	1,427	
	Oct	1,577	1,680	
	Nov	1,685	1,801	
	Dec	1,782	1,828	
Japan	Jan	3,632	4,121	4,274
	Feb	4,207	4,532	4,718
	Mar	3,907	4,450	4,532
	Apr	3,408	4,008	3,813
	May	3,219	3,822	3,716
	Jun	3,238	3,950	3,768
	Jul	3,283	3,783	
	Aug	3,380	3,790	
	Sep	3,415	3,813	
	Oct	3,570	4,212	
	Nov	4,035	4,562	
	Dec	4,521	4,716	
Western Europe Austria	Jan	189	220	237
	Feb	221	225	220
	Mar	212	224	161
	Apr	183	204	169

Trends in Oil Consumption in Major Countries[1] (Continued)
(Thousands of barrels/day)

Country		1972	1973	1974
Western Europe				
Austria (continued)	May	174	210	173
	Jun	181	200	168
	Jul	179	221	
	Aug	187	222	
	Sep	213	227	
	Oct	227	253	
	Nov	246	276	
	Dec	230	234	
Belgium/Luxembourg	Jan	535	543	512
	Feb	591	589	528
	Mar	546	570	392
	Apr	470	565	383
	May	454	483	419
	Jun	464	463	
	Jul	346	359	
	Aug	367	389	
	Sep	479	465	
	Oct	484	556	
	Nov	563	558	
	Dec	530	503	
France	Jan	2,276	2,743	2,499
	Feb	2,450	2,687	2,346
	Mar	2,100	2,528	2,224
	Apr	1,848	2,296	1,959
	May	1,743	1,890	1,904
	Jun	1,597	1,685	2,097
	Jul	1,444	1,566	1,696
	Aug	1,441	1,495	1,508
	Sep	1,950	1,932	
	Oct	2,106	2,482	
	Nov	2,332	2,593	
	Dec	2,574	2,768	
Italy[2]	Jan	1,720	1,781	1,768
	Feb	1,756	1,866	1,720
	Mar	1,450	1,710	1,573
	Apr	1,169	1,420	1,368
	May	1,138	1,285	1,310

Trends in Oil Consumption in Major Countries[1] (Continued)
(Thousands of barrels/day)

Country		1972	1973	1974
Western Europe				
Italy[3] (continued)	Jun	1,101	1,225	1,191
	Jul	1,175	1,303	
	Aug	1,129	1,255	
	Sep	1,450	1,462	
	Oct	1,650	1,610	
	Nov	1,702	1,661	
	Dec	1,899	1,710	
Netherlands	Jan	509	584	468
	Feb	591	586	522
	Mar	557	542	438
	Apr	512	541	430
	May	453	475	432
	Jun	430	436	427
	Jul	374	408	
	Aug	435	437	
	Sep	440	485	
	Oct	515	594	
	Nov	581	503	
	Dec	567	505	
Spain	Jan	483	539	592
	Feb	508	568	641
	Mar	461	564	561
	Apr	447	537	599
	May	444	523	624
	Jun	472	530	612
	Jul	457	466	
	Aug	462	667	
	Sep	477	576	
	Oct	459	669	
	Nov	500	646	
	Dec	515	681	
United Kingdom	Jan	2,121	2,315	2,054
	Feb	2,401	2,256	2,137
	Mar	2,249	2,214	2,048
	Apr	2,027	2,018	1,885
	May	1,851	1,913	1,704
	Jun	1,745	1,670	1,580
	Jul	1,519	1,619	(est.) 1,489
	Aug	1,527	1,594	(est.) 1,480
	Sep	1,703	1,724	

Figure 8 (cont.)

Trends in Oil Consumption in Major Countries[1] (Continued)
(Thousands of barrels/day)

Country		1972	1973	1974
Western Europe				
United Kingdom				
(continued)	Oct	1,959	2,150	
	Nov	2,194	2,258	
	Dec	2,132	1,906	
West Germany	Jan	2,545	2,868	2,556
	Feb	2,803	2,850	1,969
	Mar	2,525	2,707	2,173
	Apr	2,347	2,809	2,539
	May	2,335	2,546	2,403
	Jun	2,632	2,674	2,414
	Jul	2,188	2,196	2,551
	Aug	2,444	2,738	2,437 (est.)
	Sep	2,487	2,618	
	Oct	2,522	2,969	
	Nov	2,667	2,883	
	Dec	2,783	2,481	

1. Except for the United States, inland consumption excludes bunkers, refinery fuel, and losses.
2. Principal products only.

SOURCES

(1) DIVISION OF PRODUCER COUNTRY AFFAIRS, December 1974, Office of Producer Country and Organization Affairs, International Energy Production and Logistics, International Energy Affairs, FEA

(2) OFFICE OF CONSUMER COUNTRY AND INTERNATIONAL ORGANIZATION AFFAIRS, December 1974 International Energy Consumption and Resources, International Energy Affairs, FEA

(3) DIVISION OF ENERGY RESOURCE DEVELOPMENT, December 1974, Office of International Energy Resources, International Energy Affairs, FEA

GLOSSARY

GLOSSARY

A

- Agglomerating (or the agglomerating index) - Indicates the coking or caking properties of bituminous coal. It is determined by examination of the residue in the crucible incident to the volatile matter determination according to an ASTM procedure. (1)

- Aliphatic - An organic petrochemical whose molecular arrangement of carbon atoms is in a straight chain (in a row). (2)

- Alkylation - A refinery process for chemically combining an isoparaffin and olefin in the presence of a catalyst. Sulfuric acid and hydrofluoric acid are the most commonly used catalysts. (3)

- API Gravity - The standard American Petroleum Institute method for specifying the density of crude oil. The gravity of a crude oil depends on its hydrocarbon composition. High API gravity normally yields more distillate; low API gravity, more residual fuel. Gravity and production yields are not always correlated, nor is gravity the only determinant of crude oil value. (4)

- Aromatic - An organic petrochemical whose molecular arrangement of carbon atoms is in a circular ring. (2)

- Auger Mine - A type of mining where a large screw is bored horizontally into a seam of coal. The diameter of the well which is drilled can be as large as 4 or 6 feet. (1)

B

- Ballast - Any heavy material carried by the ship to insure stability (usually water). (5)

- Bare-boat Charter - Charterer merely hires vessel and provides a crew and defrays operating costs. (14)

- Barrel-mile - A unit of measurement of pipeline shipment of oil which signifies one barrel moved one mile. (7)

B cont'd.

- Batch - A tender or shipment of a single product which is handled through the pipeline without mixing with preceding or following tenders. (7)

- Batching - Pumping shipments or tenders or batches of a product through the line without mixing with other tenders. (7)

- Berm - A strip of coal left in place temporarily for use in hauling or stripping. A layer of large rock or other relatively heavy stable material placed at the outside bottom of the spoil pile to help hold the pile in position (a toe wall). Also used similarly, higher in the spoils, for the same purpose. (11)

- Breeder Reactor - A reactor that produces fissionable fuel as well as consuming it, especially one that creates more than it consumes. The new fissionable material is created by capture in fertile materials of neutrons from fission. The process by which this occurs is known as breeding. (6)

- Big Inch - Colloquialism for a 24-inch crude oil line constructed by the United States Government from Texas to the East Coast during World War II. (7)

- Booster Station - A station whose function it is to receive oil through a main pipeline and to transmit it to the next station. It receives no oil from any other source nor does it have a tank farm. (7)

- BS&W - Basic sediment and water. Generally pipeline regulation limits the contents of BS&W to 1 per cent of the volume of oil. (7)

- Btu - The amount of heat required to raise the temperature of one pound of water one degree F.

C

- Catalytic Cracking Unit - A refinery process unit that converts a high boiling range fraction of petroleum (gas oil) to gasoline, olefin feed for alkylation, distillate, fuel oil and fuel gas by use of a catalyst and high temperature. (3)

- Catalytic Reforming - A catalytic process used to improve the antiknock quality of low octane gasoline by conversion of naphthenes and paraffins into higher octane aromatics, such as benzene, toluene and xylenes. (3)

- Centrifuge - A device used for separating water and oil in routine tests. It operates on the principle of differential gravities and centrifugal force. (7)

- Christmas Tree - The valve assembly at the top of tubing strings and casing of a gas well or an oil well to provide primary pressure reduction, production rate control and shut-in service. (9)

- Coal Fines - Small coal particles, dust. (10)

- Coal Seam - A layer, vein, or deposit of coal. A stratigraphic part of the earth's surface containing coal. (11)

- Coal Slurry - A mixture of crushed coal and water. It may be used in connection with coal-waste disposal, but is more likely to be in reference to a method that is used to transport coal to market. At present, there is only one coal-slurry pipeline in operation, running from Black Mesa, Arizona to Mohave, Nevada. Several proposed coal slurry pipelines are under study. (1)

- Coking Coal - A bituminous coal that has the property of forming coke when heated in the absence of air. This property can be measured in several ways. The most common is the free-swelling index in which a 1 gram sample is heated until the volatile matter is driven off. The resultant residue or "button" is compared to a standard series of button profiles and the average of four tests reported on a scale ranging from 1 thru 9. For example, a coal with a #1 or #2 button would have little or no coking value. But a coal in the #6 to #9 range would probably make good coke, if the ash and sulfur contents were low. (1)

C cont'd.

- Combination Carrier - Category of ships distinct from tankers, although sometimes used for oil transportation depending upon their availability. (5)

- Common Carrier - Any transportation system available for use by the public for transporting cargo. Almost all pipelines are common carriers. (7)

- Contract of Affreightment - Variation of voyage chartering contracted for transport, given tonnage of cargo from 1 port to another at a rate per ton of cargo delivered. (5)

- Controlled Crude Oil - Domestically produced crude petroleum that is subject to the ceiling price for crude oil. For a particular property which is not a stripper-well lease, the volume of controlled oil equals the base production control level minus an amount of released oil equal to the new oil production from that property. (4)

- Crude Oil - A mixture of hydrocarbons that exists in the liquid phase in natural underground reservoirs and remains a liquid at atmospheric pressure after passing through surface separating facilities. For statistical purposes, volumes reported as crude oil include:

  1. Liquids technically defined as crude oil;
  2. Small amounts of hydrocarbons (technically known as "lease condensate") that exist in the gaseous phase in natural underground reservoirs but are liquid at atmospheric pressure after being recovered from oil well (casing-head) gas in lease separators; and
  3. Small amounts of nonhydrocarbons produced with the oil. (4)

- Crude Oil Domestic Production - The volume of crude oil flowing out of the ground. Domestic production is measured at the wellhead and includes lease condensate. (4)

- Crude Oil Runs to Stills - The volume of domestic and foreign crude piped to the distillation unit. Runs to stills are measured at the input to the distillation unit. (4)

C cont'd.

- Crude Oil Stocks - Crude held at refineries and in pipelines. Also stocks held on leases (storage facilities adjacent to the wells). (4)

- Crude Unit - First processing equipment which crude oil reaches after it enters a refinery. Separates the crude oil into at least four different boiling range fractions. (3)

D

- Deadweight Tonnage (DWT) - The carrying capacity of a ship in long tons (2240 pounds) excluding the weight of the ship but including the weight of the cargo, passengers, supplies, fuel, and ballast that bring the ship down to her load line. (8)

- Directional Drilling - Drilling a well at a controlled angle instead of straight down. (4)

- Distillate Fuel Oil - The lighter fuel oils distilled off during the refining process. Included are products known as ASTM grades Nos. 1 and 2 heating oils, diesel fuels, and No. 4 fuel oil. The major uses of distillate fuel oils include heating, fuel for on- and off-highway diesel engines, and railroad diesel fuel. Minor quantities of distillate fuel oils produced and/or held as stocks at natural gas processing plants are not included in this series. (4)

- Domestic Non-controlled Crude Oil - That portion of domestic crude oil production including new, released, and stripper oil which may be sold at a price exceeding the ceiling price. (4)

- Draft - Depth of water displaced by the tanker. (5)

E

- Enhanced Oil Recovery - Oil that is recovered using techniques beyond water flooding and pressure maintenance. These techniques may be applied to reservoirs producing under primary or secondary recovery mechanisms. They include all chemical additive types, thermal applications, use of carbon dioxide, miscible hydrocarbon injection, and variations of each singularly or in combination. (4)

E

- Entrained-bed - Finely divided coal is entrained in a flow of air. (10)

F

- Field - An area consisting of a single reservoir pool or multiple reservoirs all grouped on or related to a geological structural feature and/or stratigraphic condition. A few unique pool nomenclature problems may arise. (12)

- Fission - The splitting of a heavy nucleus into two approximately equal parts (which are nuclei of lighter elements), accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously, but usually is caused by nuclear absorption of gamma rays, neutrons, or other particles. (6)

- Fixed-bed - Coal supported on fixed grates. (10)

- Fixed Carbon (FC) - The carbon content of a coal sample, (measured difference), obtained by subtracting the sum of the percentages of moisture, ash, and volatile matter from 100. (1)

- Flare - Burning of gas for the purpose of safe disposal. (9)

- Floating Rigs - "Semisubmersible" and "drillship". The former is partially submerged (for stability), and the latter floating. Used in water depths up to 1,300 feet. Greater depths require propellors and thrusters added to rigs. Use platforms which enable crew to drill enough wells in different directions to cover hundreds of acres beneath a single platform. (13)

- Floating Tank - A tank whose main gate valve is open to the main line at a station. Oil from the main line may enter the tank and leave it as pumping rates in the line vary. (7)

- Fluidized Bed - Finely divided coal, supported on an upward flowing column of air, behaves like a fluid. (10)

- Fusion - The formation of a heavier nucleus from two lighter ones (such as hydrogen isotopes), with the attendant release of energy. ((6)

G

- Gathering Line - A pipeline usually of small diameter used in gathering crude oil from the oil field to a point on a main pipeline. (7)

H

- Half life - Period of time it takes for half the atoms of a radioactive isotope to disintegrate to another nuclear form. Half life of uranium 238 is 4.5 billion years. (8)
- Handy Tankers ("tankers") - Vessels of around 38,000 DWT. Loaded draft of approximately 36 feet. (5)
- Highwall - The unexcavated face of exposed overburden and coal in a surface mine or the face or bank on the uphill side of a contour strip mine excavation. (11)
- Hydro-fracturing - Opens underground channels for trapped hydrocarbons by forcing pellet-laden fluid into rock formations. Pellets serve as propping agents to keep new fissures open. (4)
- Hydro-treated - undergoes hydrogenation; reaction of carbonaceous material with hydrogen. (10)

I

- In Situ Combustion - Heating oil to increase its mobility by decreasing its viscosity. Heat is applied by igniting the oil sand or tar sand and keeping the combustion zone active by the injection of air. (12)
- Intermediate Tankers ("Intermediate") - Vessels around 85,000 DWT. Largest class now delivering imports to U.S. Loaded draft of approximately 46 feet. (5)
- Interruptible Service - Low priority service offered to customers under schedules or contracts which anticipate and permit interruption on short notice, generally in peak-load seasons, by reason of the claim of firm service customers and higher priority users. Unlike Off-Peak Service, gas is available at any time of the year if the supply is sufficient. (9)
- Isotope - Different forms of the same atom distinguishable only by their different atomic weights, caused by different numbers of neutrons in the nucleus of the atom. All forms have the same chemical property.

J

- Jobber - A petroleum distributor who purchases refined product from a refiner or terminal operator for the purpose of reselling to retail outlets and commercial accounts or for the purpose of retailing through his own retail outlets. (4)

- Jobber Margin - The difference between the price at which a jobber purchases refined product from a refiner or terminal operator and the price at which the jobber sells to retail outlets. This does not reflect margins obtained by jobbers through retail sales or commercial accounts. (4)

K

- Kerogen - The oil-yielding organic component of oil shale. (4)

L

- Landed Cost - The cost of imported crude oil equal to actual cost of crude at point of origin plus transportation cost to the United States. (4)

- Liquefied Natural Gas (LNG) - Natural gas that has been cooled to about -160°C for shipment or storage as a liquid. Liquefaction greatly reduces the volume of the gas, and thus reduces the cost of shipment and storage, even though high pressure cryogenic containers must be used. (15)

- Liquefied Petroleum Gas (LPG) - Also known as "bottled gas," liquefied petroleum gas consists primarily of propanes and butanes recovered from natural gas and in the refining of petroleum. It has an energy content of 2000 to 3500 Btu per standard cubic foot. LPG is widely used as a fuel for internal combustion engines in applications where pollution must be minimized, such as in buildings and mines, but the largest use is as a substitute for natural gas in areas not served by pipelines. (15)

- Little Inch - Colloquial for 22-inch products line constructed by the United States Government from Texas to the eastern seaboard as a war emergency measure to counterbalance submarine sinking of tankers on the Gulf and Atlantic coasts. (7)

L cont'd.

- Longwall Stripping - Longwall mining accomplished in areas of shallow cover where surface mining might normally have been conducted. The outby end, where the longwall controls, pumps, and face conveyor discharge end are located, is located in a ditch that is exposed to the surface. Roof chocks are used to protect the mining area and the roof (or overburden) is allowed to settle into the mined out section. (11)

- Low Wall - The vertical wall, on the downslope side of the mining operation, consisting of the deposit being mined and some overlying rock and soil strata. (11)

M

- Main Line - A trunk pipe line. (7)

- Metallurgical Coal - The usual connotation is that of a high-grade bituminous coking coal which is in strong demand by the steel industry for use in the production of coke. A broader, more accurate definition is: any coal that is used in a metallurgical process (ferrous and non-ferrous) to produce heat or carbon input to the process. (1)

- Methanation - Reaction, over a catalyst, by which synthesis gas is converted to pipeline gas. (10)

- Miscible Displacement Recovery - The use of various solvents to increase the flow of crude oil through reservoir rock. (12)

- Mobile, Self-elevating Rig - Can be towed to location; used in waters of up to 250 feet in depth; platform "jacked up" to safe operating level above the sea. (13)

- Mountain Top Removal - In this mining method, 100 percent of the overburden covering a coal seam is removed in order to recover 100 percent of the mineral. Excess spoil material is hauled to a nearby hollow to create a valley fill. (11)

N

- Natural Gas - A mixture of hydrocarbon compounds and small quantities of various non-hydrocarbons existing in the gaseous phase or in solution (liquid natural gas or LNG) with oil in natural underground reservoirs at reservoir conditions. The principal hydrocarbons usually contained in the mixture are methane, ethane, propane, butanes, and pentanes, and the typical non-hydrocarbons gases, which may be found in reservoir natural gas, are carbon dioxide, helium, hydrogen sulhide, and nitrogen. Natural gas is usually classified in two categories, based on the type of occurance in the reservoir:

    - o Non-associated Gas - Free natural gas not in contact with crude oil in the reservoir.

    - o Associated - Dissolved gas which is the combined volume of gas which appears in the reservoir as either free gas (associated) or as gas in solution with the crude oil (dissolved.) (4)

- Natural Gas Liquids - Natural gas liquids are those hydrocarbons in the reservoir natural gas which are separated from the natural gas as liquids either in the reservoir through the process of retro-grade condensation or at the surface through the process of condensation, absorption or adsorption or other methods in field separators, scrubbers, gas processing plants and cycling plants. Generally such liquids consist of propane and heavier hydrocarbons expressed in stock tank barrels and are commonly referred to as condensate, natural gasoline and liquefied petroleum gases. Where hydrocarbon components lighter than propane are recovered as liquids these components are also included in the natural gas liquids reserves and production statistics. Natural gas liquids reserves are calculated by the use of a factor applied to the total volume of recoverable gas. Such factor, usually expressed in stock tank barrels per million cubic feet of gas, is based on the recovery efficiency of installed or planned processing facilities. Such factors may be judged from laboratory gas analyses adjusted to surface processing facility efficiency or obtained from actual plant or separator production statistics. The calculation of proved recoverable reserves of natural gas liquids takes into consideration the effect of retro-grade condensation in the reservoir where applicable. (4)

N cont'd.

- New Oil - The volume of domestic crude petroleum produced from a property in a specific month which exceeds the base production control level for that property. (4)

O

- Off-Peak - The period during a day, week, month or year when the load being delivered by a gas system is not at or near the maximum volume delivered by that system for the corresponding period of time. (9)

- Off-Peak Service - Service made available on special schedules or contracts but only for a specified part of the year during the off-peak season. Compare Interruptible Service. (9)

- Offset Well - A well drilled near the boundary of a lease opposite a completed well on an adjacent lease. The purpose is to prevent drainage away from the lease. (4)

- Oil, Light - Generally, all oils lighter than residual fuel oils No. 5 and 6. Oils that have a low specific gravity, usually products of controlled distillation of crude oil, but also including by-product benzol and toluol. (9)

- Oil, Reforming - Step in producing carbureted water gas in which a fraction of the carburetion oil is cracked to useful gas in the water gas carburetor and super-heater. (9)

- Oil Scrubbing - The removal of certain impurities from manufactured or natural gas by passing the gas through an oil spray or bubbling the gas through an oil bath. (9)

- Oil Shale - A dolomitic marlstone yielding up to 60 gallons of shale per ton of rock. The rock's common name, "oil shale," emphasizes the oil-yielding properties. (4)

- Old Oil - Same as controlled crude oil. (4)

- Original Oil or Gas in Place - Estimated total volume of oil or gas contained in field, prior to production and without regard to recoverability. (4)

P

- Pipeline Oil - Crude oil whose basic sediment and water content is low enough to make the oil acceptable for pipeline shipment. (7)

- Primary Recovery - Oil and gas production from reservoirs that occurs naturally without any addition of pressure or displacement driving force. (12)

- Producing, Shut-in - Classification assigned to leases upon which at least one well has been drilled that is capable of producing oil or gas in commercial quantities but is not now producing. (13)

- Products Cycle - The sequence or order in which a number of different products are batched through a pipeline. (7)

- Products Line - A pipeline used for the shipment of refined products. (7)

- PSI - Pounds per square inch. (7)

- PU(239) - Results from bombarding U(238) with neutrons. Can serve as a fuel to generate electricity just as U(235). (8)

R

- Rates, Demand - The term "demand rate" applies to any method of charge for gas service which is based upon, or is a function of, the rate of use, or size, of the customer's installation or maximum demand (expressed in Mcf or therms) during a given period of time.

  Flat. The term "flat demand rate" applies to a charge for gas service based upon the customer's installation of gas-consuming devices. This is usually so much per Mcf or per therm, per month or per year. Sometimes this type of rate is nominally so much per fixture (as gas lamps) per year, or per month, but estimated demand and quantity of gas likely to be used play an important part in the determination. Such a rate may be modified by the "block" or "step" methods.

  Hopkinson. The term "Hopkinson demand rate" applies to that method of charge which consists of a demand charge, based upon demand (either estimated or measured) or connected load, plus a commodity charge, based upon the quantity of gas used.

R cont'd.

Block Hopkinson. Either the demand charge or the commodity charge or both, in a Hopkinson demand rate, may be the block form.

Three part or three charge. Any of the foregoing types of rates may be modified by the addition of a customer charge. When such a charge is introduced in the Hopkinson demand rate, it becomes a "three part rate," or "three charge rate," which consists of a charge per customer or per meter plus demand and commodity charges.

Wright. The term "Wright demand rate" applies to that method of charge which was the first to recognize load factor conditions by inclusion of demand costs in an initial high rate per Mcf or therm, applicable to a certain number of hours use of a customer's load, all excess consumption being at a lower rate. (9)

- Rates, Meter - The term "meter rate" is applicable to any method of charge for gas service based solely upon quantity, such as Mcf or therms used.

Block. The term "block" indicates that a certain specified price per unit is charged for all or any part of a block of such units, and reduced prices per unit are charged for all or any part of succeeding blocks of such units, each such reduced price per unit applying only to a particular block or portion thereof.

Step. The term "step" indicates that a certain specified price per unit is charged for the entire consumption, the rate or price depending on the particular step within which the total consumption falls.

Straight-Line (Flat). The term "straight-line" indicates that the price charged per unit is constant, i.e., does not vary on account of an increase or decrease in the number of units. (9)

- Rate, Zone - A rate schedule restricted in its availability to a particular geographic area. (9)

- Rehabilitation - Implies that the land will be returned to a form and productivity in conformity with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values. (11)

R cont'd.

- Released Oil - That portion of the base production control level for a property which is equal to the volume of new oil produced in that month and which may be sold above the ceiling price. The amount of released oil may not exceed the base production control level for that property. (12)

- Reserves

Extensions to Reserves - As applies to natural gas, a discovery in one year normally is delineated by the drilling of both extension and development wells during subsequent years. Drilling usually continues until the productive limits of the field or reservoirs are defined. Increases in the proved area of reservoirs result in appropriate adjustments to estimates of recoverable reserves and such changes are recorded under extensions. Changes resulting from a reduction in the estimate of the proved area are recorded under revisions. (8)

Inferred Reserves - As applies to coal, those that rely solely on geological inference. They usually cover much larger areas and are therefore subject to larger probable error. (1)

Measured Reserves - Synonymous with proved reserves. (1)

Mineable Reserves - As applies to coal, those reserves that are considered to be capable of mining under current economic conditions and known technology. The Bureau of Mines, for example, considers all measured and indicated bituminous and anthracite coal reserves occuring in depths from 0 to 1000 feet with a seam thickness 28 inches or greater to be "mineable". In the case of lignite and sub-bituminous the minimum seam thickness is 60 inches. USBM-Total reserve base is 434 Billion Tons. (1)

Other Reserves - Those not covered by the definitions of sandstone and carbonate. Included in this reserve type are igneous, shale, and metamorphic rocks. Gas may occur in these normally in permiable, low porosity type rocks when they are fractured or weathered.

Possible and Indicated Reserves - In coal, less assured than probable or proved, but where there is a very strong likelihood that such reserves exist. (1)

R cont'd.

Proved Reserves - As applies to natural gas, proved reserves are defined as the current estimated quantity of natural gas which analysis of geologic and engineering data demonstrate with reasonable certainty to be recoverable in the future from known oil and gas reservoirs under existing economic and operating conditions. Reservoirs are considered proved that have demonstrated the ability to produce by either actual production or conclusive formation test. (8)

Proved Reserve - Usually an assured reserve as to quantity and quality. In coal, generally accomplished by core drilling. Also, amount expected to be recovered from mines using current technology and economics. (1)

Probable Reserve - As applies to coal, when core drilling has not taken place but where nearby mining operations in the same seam indicate that similar quality and seam conditions prevail. (1)

Recoverable Reserve - The proportion of coal that can be recovered from an individual deposit (the reserve). It varies in a range from 40 to 90 percent according to the characteristics of the coal bed, the mining method, legal restraints and restrictions because of natural and manmade features. Mining experience in the United States has indicated that on a national basis at least one-half of the in-place coals can be recovered. Based on this, our recoverable reserves are one-half of "mineable" or approximately 217 billion tons. (1)

Revisions to Reserves - In natural gas, the drilling of additional wells in a reservoir not only delineates the productive area but also provides additional basic geological and engineering data. Estimates of porosity, interstitial water, pay thickness and other reservoir factors may be revised by new data. Analysis of the producing history of a reservoir, including production of oil, gas and water, and pressure performance results in more accurate concepts concerning the producing mechanism, recovery efficiency and the performance of the reservoir. The composite of this new and improved information will yield more precise estimates of the ultimate recoveries and remaining reserves and result in revisions to previous estimates. Changes in reserve estimates brought about by the application of cycling or other recovery techniques are included in the revision of reserves. Also, changes in reserves resulting from a reduction in the estimate of the proved area are included in revisions. (8)

R cont'd.

- Reservoir Lithology - Refers to rock structure characteristics where reservoirs are found. Usually found in three classes:

  Sandstone Reservoir - Consists of a sedimentary rock composed predominately of quartz or other non-carbonate mineral or rock detritus. Included in this reservoir type are unconsolidated sand, sandstone, graywacke, arkose and granite wash.

  Carbonate Reservoir - A sedimentary rock composed predominately of calcite (limestone) and/or dolomite.

  Other Reservoirs - Those not covered by the definition of sandstone and carbonate. Included in this reservoir type are igneous and metamorphic rocks and some sedimentary rocks such as fractured shale. (4)

- Residual Fuel Oil - The heavier oils that remain after the distillate fuel oils and lighter hydrocarbons are boiled off in refinery operations. Included are products known as ASTM grades Nos. 5 and 6 oil, heavy diesel oil, Navy Special Oil, Bunker C oil, and acid sludge and pitch used as refiner fuels. Residual fuel oil is used for the produciton of electric power, for heating, and for various industrial purposes. (4)

- Resources - As they relate to coal, would be all the known and geologically inferred coal. Such an estimate does not take into consideration economics, depth of seams nor their thickness and does not attempt to estimate recovery. Coal Resources = 1600 billion tons (USGS) (1)

- Retorting - The heating process used in the extraction of oil from oil shale. (10)

- Reverse Combustion - (A form of in situ combustion) The formation is ignited at the producing well and the combustion zone moves countercurrent to the injected air and reservoir fluid stream. Because oil flows into a zone already heated, there is no tendency for it to congeal and decrease permeability. (12)

- Rotary Drilling - "Bit" with sharp teeth bored into ground with the use of heavy pressure and rotation of the drill pipe. Cuttings are circulated out of the hole with a fluid. As the hole gets deeper, additional lengths of pipe are added. When the bit dulls, entire length of pipe is removed, unjoined, then replaced. Average well requires many such repetitions. (12)

- Run-of-mine coal - coal of assorted sizes, not separated. (14)

S

- Secondary Coal Recovery - This is analogous to "mining the pillars" in deep mining in that the coal is taken on the retreat or after primary mining has been completed. When the final cut has been made in an open-cut coal mine the coal seam remains exposed in the bank and three methods are used to recover as much of the coal as can be economically won (a) coal augers, (b) push-button miner and (c) punch mining by underground machines. (11)

- Secondary Recovery (Oil) - Oil recovered in addition to primary recovery attributed to water injected for the purpose of driving additional oil from the reservoir or gas injected to maintain pressure and subsequently drive additional oil from the reservoir. There is no secondary recovery applicable to natural gas recovery. Gas recovery can only be stimulated by some outside force that will open up the reservoir and allow primary forces to drive it to the wellbore. (12)

- Shot - A charge of high explosives, usually nitro-glycerine, deposited in a well to shatter the reservoir rock and to expedite recovery of oil. (See Hydro Fracturing) (12)

- Shaft Mine - One where the coal seam is reached by a vertical shaft which may vary in depth from less than 100 feet to several thousand feet. A mine in which the main entry or access is by means of a shaft. (11)

- Spent Shale - The residue from retorting that may be in the form of a dusty rock or a fine dust, depending on the retorting method. Spent shale volume is greater than the original volume and approximately 85% (by weight) processed oil shale becomes "spent shale". (10)

- Steam Coal - Any coal that is used to make heat and power. These include coking and non-coking coals that usually do not meet the needs of the metallurgical industries. All utility coal, most other industrial coal and some special needs such as the cement industry, could be classified as "steam coal". (1)

o Steamflooding - Steam displacement (or steam drive) follows the same basic principle as the waterflood. Steam pressure is fed into special injection wells, both to heat the oil in place and to drive it to producing wells.

o Steam Soaking - Steam is used as a stimulation medium to heat the area of the reservoir around the wellbore. Steam under pressure is injected down the casing or tubing of a producing well. A typical steam injection lasts for 5 to 8 days. Following the injection period, the well is returned to production.

S cont'd.

- <u>Strip Mine</u> -Refers to a procedure of mining which entails the complete removal of all material from over the product to be mined in a series of rows or strips; also referred to as "open cut," "open pit," or "surface mine." (11)

- <u>Stripper Well</u> - A well whose average daily production of crude petroleum and petroleum condensates, including natural gas liquids, per well did not exceed 10 barrels per day for field during the preceding calendar month. (12)

- <u>Submersible Barge</u> - Sits on ocean floor while drilling, then pumped out and floated for transportation to new drill site. (13)

- <u>Subsidence Break</u> - The fracture in the rocks overlying a coal seam or mineral deposit as a result of its removal by mining operations. The subsidence break usually extends from the face upwards and backwards over the unworked area. (11)

- <u>Surface Mining or Contour Stripping</u> - The removal of overburden and mining from a coal seam that outcrops or approaches the surface at approximately the same elevation, in steep or mountainous areas. (11)

T

- <u>T-2 Equivalent</u> - Benchmark measure for comparing tanker carrying capacity. A T-2 WWII tank ship is defined as a 16,765 DWT vessel with a service speed of 14.5 knots, draft of 30 feet and length of 503 feet. (5)

- <u>Tank Battery</u> - A group of tanks to which crude oil flows from producing oil wells. (7)

- <u>Tank Farm</u> - One or more tanks connected to a pipeline and a pumping station by means of which oil is unloaded in tanks or withdrawn from them. (7)

- <u>Tar Sand</u> - Any sedimentary rock that contains bitumen (general name for various solid and semisolid hydrocarbons) or other heavy petroleum material that cannot be recovered by conventional petroleum recovery methods. (12)

- <u>Terminal</u> - A point to which oil is transported through pipelines. It usually includes a tank farm and may include tanker loading facilities. (7)

T cont'd.

- Tertiary Recovery - Recovery, usually via enhanced recovery methods, of oil beyond and after the application of standard secondary recovery methods of oil recovery. In common practice, the term is also often applied when the enhanced recovery methods are applied without the prior application of secondary recovery techniques. (12)

- Thermal Recovery - Any petroleum-recovery process which utilizes heat to thin viscous oil in underground formation and allows it to flow more readily towards producing wells. (See In Situ Combustion and Steam Flooding) (12)

- Time Charter - Owner provides fully-manned and equipped vessel and defrays all expenses of operation, except bunkers consumed and port dues and charges. (14)

- Tipple - A structure built over a mine shaft to allow human access to the underground mine. Also provides a means to raise or lower supplies to the underground shaft. Another section of the tipple encloses the air shaft to the mine. (1)

- Trunk Line - A main pipeline. (7)

U

- U(233) - Another isotope of uranium, produced from thorium. Suitable for nuclear fission. Particularly suitable for use in reactors. (16)

- U(238) - A natural isotope, can be converted into a more easily fissionable element (plutonium 239) by a process called "breeding". Represents 99.28 percent of all natural uranium. (8)

- U(235) - An isotope of uranium directly suitable for nuclear fission. Used in bombs and power plants. Only 0.7 percent of all uranium. (16)

- U_3O_8 - A crude concentrate containing 75 percent or more uranium produced from uranium ore by mechanical and chemical means. Often known as "yellow cake." (8)

- Unit Train - A string of locomotives and cars used exclusively for bulk shipment of minerals or coal from the mine to a single point of consumption. Because all the cars go to one destination, the locomotives can be distributed more efficiently throughout the train, there is no expense of assembling the train, and the overall cost of operation is substantially lower than for a conventional train.

V

- Vacuum Unit - A unit operated below atmospheric pressure which allows vaporization of more of the heavier gas oil molecules from the crude residue without thermal disintegration of the molecules. (3)

- Valve, Relief - An automatic valve designed to discharge when a preset pressure and/or temperature condition is reached.

  a. Pressure Relief Valve. An automatic valve which opens and closes a relief vent, depending on whether the pressure is above or below a predetermined value.

  b. Temperature Relief Valve.

  1. Fusible Type. A valve which opens and keeps open a relief vent by the melting or softening of a fusible element at a predetermined temperature.

  2. Manual Reset Type. A valve which automatically opens a relief vent at a predetermined temperature and which must be manually returned to the closed position.

  3. Reseating or Self-Closing Type. An automatic valve which opens and closes a relief vent, when the temperature reaches a predetermined value.

  c. Vacuum Relief Valve. An automatic valve which opens or closes a vent for relieving a vacuum, depending on whether the vacuum is above or below a predetermined value. Frequently used in a hot water supply system. (9)

- Very Large Crude Carriers (VLCC's - 250,000 DWT) - Have become world standard for moving crude oil over long distances. Require deepwater ports because their loaded drafts are approximately 65-70 feet. (5)

- VLCC's or ULCC's (VLCC's - 400,000 DWT; Ultra Large Crude Carriers) - Approximate loaded draft of 80 feet. (5)

- Volatile Matter - A measure of the gases and tars in a coal sample. It is determined by heating 1 gram sample @ 950°C for seven minutes. The weight loss minus the weight of moisture determined at 105°C times 100 equals the percentage of volatile matter. (1)

V cont'd.

- Voyage Charter - Owner transports cargo from one port to another at an agreed rate per ton loaded, all expenses operating accounted for by owner of vessel. (14)

W

- Waterflooding - A secondary-recovery operation in which water is injected into a petroleum reservoir to create a water drive to increase production by sweeping oil left behind toward producing wells. (12)

- Weathering - The tendency of a coal lump to break up when exposed to air for a relatively short time. This is usually found in the lower rank coal such as sub-bituminous and lignite. (1)

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