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REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

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Natural Gas Shortage: The Role Of Imported Liquefied Natural Gas

A number of alternatives are open to the U.S. to cope with the growing natural gas shortage, but each is limited.

Importing liquefied natural gas could involve investing billions of dollars for constructing specialized tankers and receiving terminals. Large-scale liquefied natural gas imports will also present political, economic, and national security problems similar to those created by large oil imports.

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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To the President of the Senate and the
Speaker of the House of Representatives

This is one of a series of reports on energy resources available or necessary to meet U.S. demands. It discusses the role of liquefied natural gas imports in alleviating the growing natural gas shortage and the considerations involved in increased dependence on such imports.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of this report are being sent to the Director, Office of Management and Budget; Secretaries of State, the Interior, Commerce, and Transportation; Administrators of the Federal Energy and the Energy Research and Development Administrations; and Chairman of the Federal Power Commission.

Elmer B. Staats

Comptroller General
of the United States

Contents

ABBREVIATIONS

BTU	British Thermal Unit
FEA	Federal Energy Administration
FPC	Federal Power Commission
GAO	General Accounting Office
LNG	liquefied natural gas
MCF	thousand cubic feet
R/P	reserves-to-production

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NATURAL GAS SHORTAGE: THE ROLE OF IMPORTED LIQUEFIED NATURAL GAS

D I G E S T

Data and observations in this report will help the Congress and the executive branch evaluate the U.S. need for natural gas imports; the economic, political, and national security risks of relying on those imports; and possible alternatives.

GAS SUPPLY DWINDLING

Natural gas provides about 30 percent of total U.S. energy requirements and is vital to the Nation's economy.

Worldwide, natural gas reserves are plentiful--they represent a reserves-to-production ratio of 54.0, based on the 1974 production rate. Large consumers, like the U.S. and Japan, will deplete their own reserves more rapidly. U.S. natural gas reserves reflect a reserves-to-production ratio of only 10.8. (See p. 7.)

In general, countries having excess natural gas cannot use it effectively. However, this situation is changing as these countries develop export markets and gas-consuming industries. (See app. III.)

U.S. natural gas reserves have generally been declining since 1967 because new discoveries have not kept pace with domestic production. (See p. 12.)

The Nation is experiencing a gas shortage, which has forced pipeline companies and distributors to curtail deliveries and consumers to conserve. (See pp. 15 to 17.)

This shortage is expected to increase considerably. (See p. 22.)

ALTERNATIVES

Before alternative sources of energy can be developed fully in the U.S., problems associated with production, availability of water, impact on the environment, and sizable capital investment must be overcome. (See app. I.)

Increasing oil imports raises political, economic, and national security questions and may not be permitted by the Federal Government. (See p. 3.)

Deregulation of natural gas prices will have an uncertain effect on domestic gas production. Some studies essentially rule out the possibility of a large production increase in the near future. (See pp. 3 and 23.)

Consumers' conservation measures have reduced overall gas use by about 5 percent, but conservation alone cannot eliminate the gas shortfall. (See p. 17.)

Liquefied natural gas imports

Importing liquefied natural gas will likewise have limitations. Such imported gas is expected to contribute only minimally to the domestic supply until at least 1980 and will not be significant in meeting the short-term shortage. (See p. 4.)

To handle the possible level of liquefied natural gas imports in 1985, a capital investment of about $11 billion may be required to construct the necessary tankers and receiving terminals. (See pp. 26 to 31.)

The same political, economic, and national security risks created by large oil imports will probably exist if liquefied natural gas is imported on a large scale. (See pp. 29 to 31.)

The cost of liquefied natural gas imports could, by 1985, add about $4 billion annually to the U.S. balance-of-payments outflow. (See pp. 32 and 33.)

CHAPTER 1

INTRODUCTION

BACKGROUND

In the winter of 1973, the American people faced an energy crisis caused primarily by a shortage of crude oil used for heating oil and gasoline. Thermostats were turned down, highway speed limits were reduced, and other actions were taken to cut energy consumption and conserve energy resources. These conservation measures, coupled with relatively mild weather, reduced the severity of the shortage.

During the crisis the public's attention was directed toward gasoline and heating oil; little was said about another energy problem--the shortage of natural gas. However, shortages of natural gas in certain sections of the country will influence the economic growth of the United States and the lifestyle of its citizens.

Natural gas provides 30.4 percent of U.S. energy requirements, ranking second to petroleum. Its use has risen about fivefold in the last quarter century. This increased consumption can be largely attributed to natural gas' lower cost, cleanliness, and ease of handling compared with other primary energy sources, such as oil and coal.

About 44.7 million Americans depend upon natural gas to heat homes and apartments and to satisfy commercial and industrial requirements. In addition, about one-fourth of the electricity generated in the United States is fueled by natural gas; expressed in terms of population, this means that about 50 million Americans depend on natural gas to generate their electricity.

Presently, domestic natural gas production provides over 95 percent of the available supply in the United States. The remainder is imported, mainly via pipeline from Canada.

The Nation is experiencing a growing gas shortage--the quantity demanded exceeds the quantity supplied. The increasing difference between demand and supply (shortfall) has somewhat limited expansion of consumption in both the household-commercial and industrial sectors.

The natural gas shortage, however, has not been as evident to the American public as was the crude oil shortage, for two principal reasons:

--The shortage has been alleviated by curtailing the present gas supply to industrial and utility users, which are generally capable of using other energy sources, such as coal and oil.

--Residential builders have turned to other forms of heating, such as electricity, in new housing construction. Thus far, household users of natural gas have not been subjected to rationing.

The growing natural gas shortfall could be eliminated by reducing the demand for gas, increasing the available supply, or combining these two measures. Reducing demand would involve switching to alternative domestic sources of energy, including both conventional and nonconventional forms; increasing oil imports, which could be substituted for domestic gas use; or undertaking a gas conservation program. (See ch. 3.) Increasing the available supply would involve either increasing domestic gas production or importing gas via pipeline or in the form of liquefied natural gas (LNG) from foreign sources.

Various limitations associated with each of the above alternatives are discussed in the following paragraphs.

Alternative domestic sources of energy could affect future demand for or consumption of natural gas. These alternatives include the basic fossil fuels, oil and coal, and such nonconventional energy sources as oil from shale and tar sands and synthetic gas from coal. More distant alternatives include geothermal, nuclear, and solar energy.

There are problems, however, associated with developing each of these energy sources. For example, increased use of oil would more quickly deplete the Nation's already-dwindling crude oil reserves or create pressure to import additional foreign oil. Using coal as a natural gas substitute would necessitate increased coal production, with accompanying manpower, environmental, and health and safety problems. Greater use of oil and coal would also require a major capital investment for expanding facilities as well as for machinery and equipment to comply with U.S. environmental standards.

The development of alternative energy sources such as coal gasification, tar sands, and oil shale will be limited by such problems as the availability of water and large quantities of coal needed, environmental effects, and the sizable capital investment required. These and other problems have led most energy experts to agree that the United States cannot realistically expect increased supplies from nonconventional energy sources, except in the long term. 1/

Appendix I discusses in more detail some of the problems and limitations associated with the more common substitute and alternative energy sources that could alleviate the natural gas shortage.

To the extent that it is permitted by Federal Government policy, imported oil could be used to offset the growing natural gas shortfall. This alternative, however, brings to mind the 1973 Arab oil embargo and the political, economic, and national security consequences associated with increased dependency on foreign oil. Also, additional domestic pipeline distribution, refineries, and storage capacity would be required.

Finally, the natural gas shortfall could be offset by increasing domestic gas production or by importing gas to supplement domestic supplies. The prospects for a large increase in domestic gas production are remote, at least in the short term, according to the Project Independence report published in November 1974. This massive multiagency project, coordinated by the Federal Energy Administration (FEA), was initiated to evaluate the Nation's energy problems and provide a framework for developing a national energy policy.

In summary, FEA's study of the natural gas problem shows that, even if substantial increases in the wellhead price of natural gas are permitted, production will not increase greatly before 1980. A major constraint on increasing gas production in the immediate future is the lack of drilling rigs, piping, and skilled drilling crews. In addition, the leadtime to develop a new gas field--4 to 7 years--would essentially eliminate the possibility of increased production before 1980 even if exploration of new gas fields started immediately.

Importing gas to increase the supply will also pose problems. U.S. suppliers of pipeline gas are experiencing energy problems of their own. Therefore, the present level of pipeline gas imports could probably not be increased.

Plans are underway in the United States to import LNG by tanker. According to the Federal Power Commission (FPC), long-term LNG import projects filed with it and other projects under consideration envision the import of 3.8 trillion cubic

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1/ We have defined long term as the period beyond 1985; medium term, 1980-85; and short term, the present to 1980.

feet of LNG annually by 1985, assuming that all such projects are completed within a reasonable time frame.

Importing LNG will have a number of drawbacks. Indications are that only relatively small quantities will be available until the early 1980s. Consequently, LNG imports cannot be regarded as very significant in meeting the short-term gas shortfall. In addition, since many oil-rich countries are also rich in natural gas reserves, the same political, economic, and national security risks created by large oil imports will probably exist if LNG is imported on a large scale. Also, capital will be required for constructing specialized LNG tankers and additional facilities, such as LNG regasification and storage facilities (receiving terminals).

SCOPE

This report discusses the role of LNG imports as one means of alleviating the growing gas shortage and the considerations and issues involved in increased U.S. dependence on such imports. In preparing it, we conferred with Government and industry officials and consulted published reports from the Department of the Interior, FPC, FEA, the Maritime Administration, the American Gas Association, the National Petroleum Council, the Oil and Gas Journal, and congressional hearings and reports dealing with energy. Throughout this report, we used the latest published statistics available.

ROLE OF THE U.S. GOVERNMENT

Various U.S. Government agencies have different types of responsibility for insuring that the United States has enough natural gas to meet its energy needs.

FPC, under authority of the Natural Gas Act of June 21, 1938, as amended (15 U.S.C. 717-717w (1970)), regulates interstate gas sales and construction and operation of interstate pipelines and oversees the export and import of natural gas.

The Department of the Interior is responsible for formulating and administering programs for the management, conservation, and development of the Nation's natural resources. Within the Department, the Bureau of Land Management and the Geological Survey are closely involved in the natural gas problem.

The Bureau of Land Management has broad managerial authority over about 475 million acres of public land. The Secretary of the Interior, through the Bureau, may authorize the leasing of specified public lands, including Outer Continental Shelf lands, known or believed to contain energy development materials. In carrying out its leasing responsibilities, the Bureau attempts to achieve orderly and timely resource development, protect the environment, and receive fair market value.

As of December 31, 1974, the Geological Survey supervised more than 125,000 oil and gas leases covering about 97 million acres of Federal lands, including Indian lands and the Outer Continental Shelf.

FEA was created under the Federal Energy Administration Act of 1974 (Public Law 93-275). A major FEA objective is to formulate the strategy necessary to increase energy supplies in the long and short term.

The Energy Research and Development Administration was created under the Energy Reorganization Act of 1974 (Public Law 93-438) to bring together and direct Federal activities relating to research on and development of the various energy sources. Previously, major energy research and development programs had been administered by the Atomic Energy Commission, the Interior Department, the National Science Foundation, and the Environmental Protection Agency.

The Energy Resources Council, also created under the Energy Reorganization Act of 1974, is responsible for insuring communication and coordination among those Federal agencies responsible for developing, implementing, and managing energy policy. The Council is also an energy policy advisory board to the President and the Congress. The President recently named the Secretary of Commerce as Council Chairman; other Council members are heads of various Federal departments and agencies, certain members of the White House staff, and other members designated by the President.

Other Government agencies also play a role in the import of natural gas.

--The Department of State is responsible for (1) advising the President in the formulation and execution of foreign policy, (2) maintaining appropriate relations with foreign governments, and (3) promoting and protecting U.S. interests. U.S. relations with foreign countries having large natural gas deposits will be critically important if large natural gas imports become necessary.

--The Department of Commerce, through its Maritime Administration, administers programs to aid in the development, promotion, and operation of the U.S. Merchant Marine, including ship construction subsidy and ship operating subsidy programs. Specially constructed ships would be needed to transport LNG.

--The Department of Transportation, through the Coast Guard, helps to establish and enforce safety regulations pertaining to the shipment of LNG in ocean carriers and the general safety of operations at the marine terminals.

CHAPTER 2

NATURAL GAS IN THE WORLD

Natural gas is frequently associated geologically with oil deposits; therefore, oil-rich countries are usually rich in natural gas reserves as well.

The chart on the following page shows the distribution of world natural gas reserves and production in 1974 by major geographical areas. The United States, with about 9 percent of the world's gas reserves, produced about 48 percent of its production, while the Eastern Hemisphere, with about 85 percent of the reserves, produced about 40 percent.

The total proved reserves 1/ of 2,546.4 trillion cubic feet and total production of 46.5 trillion cubic feet represent a reserves-to-production (R/P) ratio of 54.8 as of the end of 1974. Although this R/P ratio should not be interpreted as meaning that the world has a 54.8-year supply of natural gas remaining, 2/ it does provide a general indication of the longevity of present reserves.

The 54.8 R/P ratio, however, is a worldwide calculation. Proved reserves and production in a number of countries reflect a much lower R/P ratio. This is especially true in the industrialized nations--notably the United States, Japan, and various European countries--where gas reserves have been declining each year. For example, the R/P ratios in the United States and Japan are only 10.8 and 17.8, respectively.

The transportation of natural gas has in the past been considerably limited by the natural barriers of each continent and the long distances involved. As a consequence, production and consumption of gas in North America was separate from that in South America, in Europe and Russia it was separate from Asia and Africa, and so on. Within

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1/Defined as the estimated quantity of natural gas which analysis or geological and engineering data demonstrates with reasonable certainty to be recoverable from known gas fields under existing economic and operating conditions.

2/This is true because natural gas reserves are not static. On the contrary, reserves change from year to year based on the volume of new gas discoveries and the level of gas production. In other words, they can either increase or decrease depending upon the relationship between the amount of gas added and the amount used.

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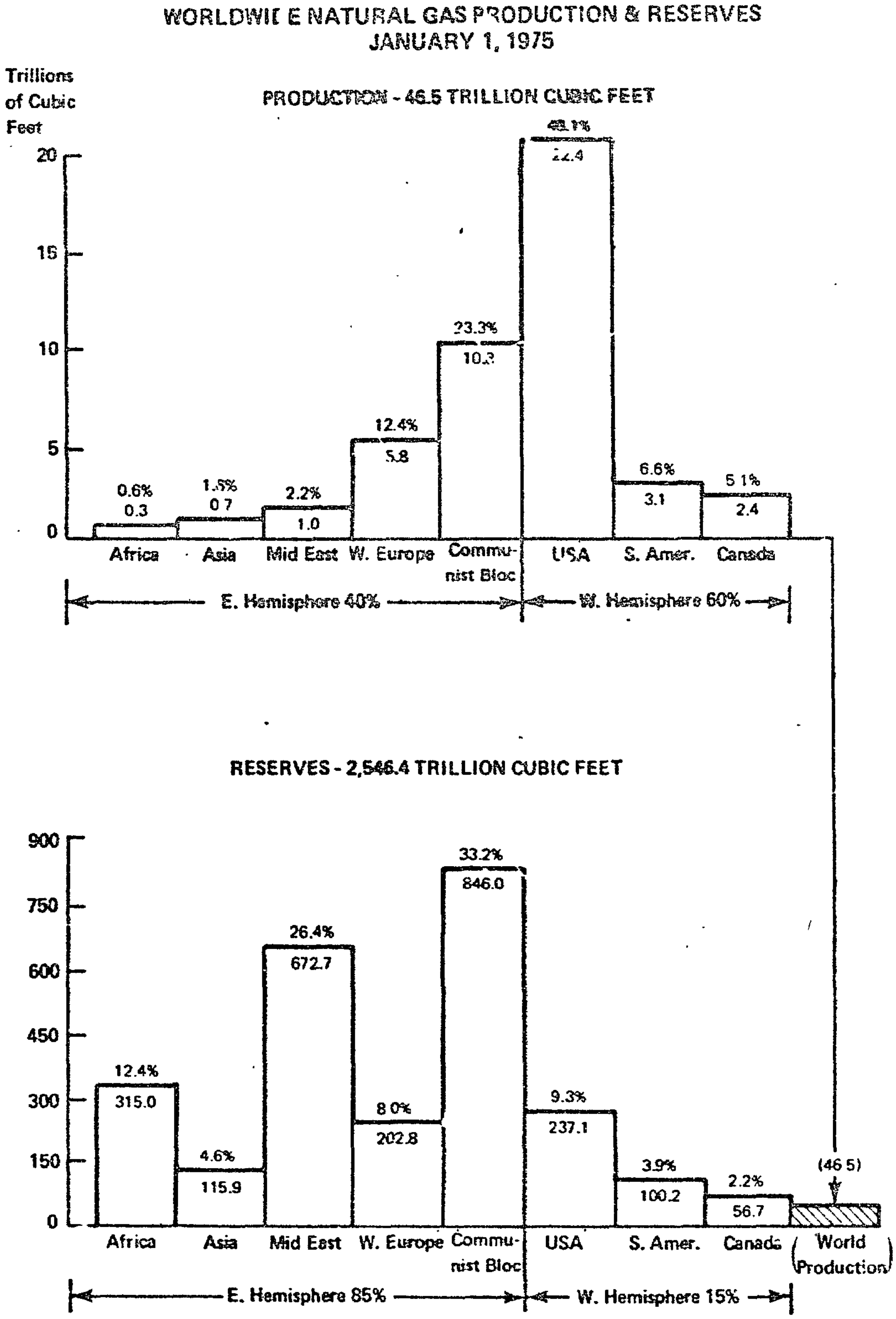


recent years, however, the movement of natural gas via pipeline has tended to break down barriers between Asia, Africa, and Europe. The Netherlands supplies natural gas to France and central Europe, and Communist Bloc European countries, including Russia, supply other European countries. In turn, Russia and other Communist Bloc European countries receive gas from Siberia and Iran. A sub-Mediterranean pipeline from Algeria to Italy is also under construction.

The discovery of natural gas is often a byproduct of the search for petroleum. Its consumption is a measure of the ability of the petroleum producer to find a market. For example, worldwide production of natural gas amounted to about 52 trillion cubic feet in 1972. Of this, about 42.6 trillion cubic feet (82 percent) was marketed; of the remainder (9.4 trillion cubic feet), about 6.4 trillion cubic feet was flared (burned off) and about 3 trillion cubic feet reinjected into the ground to pressurize petroleum fields and aid in oil recovery.

Gas and water injection is commonly used where oil fields have been depleted. In the United States, approximately 50 percent of the oil from older wells is recovered by water or gas injection and other methods of secondary recovery. This is one reason the cost of producing oil in the United States is generally higher than in the rest of the world.

The following table shows marketed, reinjected, and flared natural gas in 1972 by geographical area (the latest data available).

	Billions of cubic feet				Percent
	Total	Marketed	Reinjected	Flared	marketed
North America (note a)	28,063.5	25,980.8	1,588.5	494.2	93
South America	2,541.6	882.5	953.1	706.0	35
Africa	1,517.9	247.1	247.1	1,023.7	16
Europe	6,212.8	6,071.6	35.3	105.9	98
Far East	458.9	176.5	-	282.4	38
Middle East	4,377.2	988.4	176.5	3,212.3	23
U.S.S.R./Asia	8,825.0	8,295.5	-	529.5	94
Total	51,996.9	42,642.4	3,000.5	6,354.0	82
a/United States	24,004.0	22,521.4	1,235.5	247.1	94

Worldwide, natural gas is increasingly used both as a fuel and as a feedstock (i.e., raw material) in producing plastics, synthetics, fertilizers, and other petrochemical products (see app. III, p. 44). For example, Russia, Algeria, Saudi Arabia, Iran, Venezuela, and other countries have announced plans, initiated construction, or completed petrochemical plants and other projects which will use locally available gas as a fuel and feedstock.

CONCLUSIONS

Proved natural gas reserves in the world are plentiful, representing an R/P ratio of 54.8, based on the 1974 rate of production. The gas reserves of some countries, however, may not enjoy such longevity. This is especially true of industrialized countries and other big users of gas. High consumption rates and declining reserves in these countries indicate that natural gas supplies will be depleted more rapidly.

On the other hand, those countries with excess natural gas generally cannot effectively use it at present. As a result, much of the excess gas is being flared. This situation is gradually changing, however, as these countries develop export markets and industries which can use the natural gas for fuel and feedstocks.

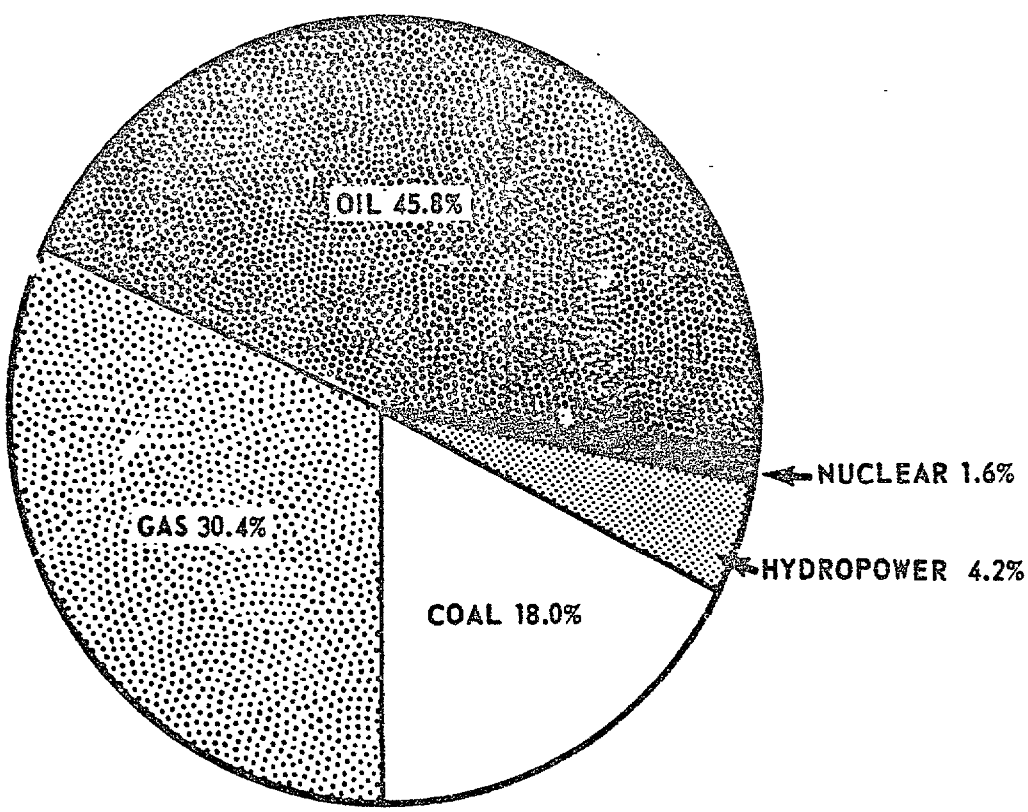
CHAPTER 3

NATURAL GAS IN THE UNITED STATES

The use of natural gas in the United States has risen rapidly over the last 50 years. With only 6 percent of the world's population, the United States produced for marketing about 22 trillion cubic feet and imported almost 1 trillion cubic feet in 1974.

As shown in the following chart, natural gas provided 30.4 percent of U.S. energy needs in 1974.

SOURCES OF U.S. ENERGY



RESERVES

Proved reserves of natural gas have been declining since 1967, except for 1970 when a large discovery of new reserves was made on the Alaskan north slope.

Total proved reserves have declined from 290.75 trillion cubic feet in 1970 to 237.13 trillion cubic feet in 1974, a decrease of over 18 percent. This has occurred because new gas field discoveries have not been keeping pace with the natural gas production.

The following table shows the history of natural gas production and reserves and the resulting R/P ratios since 1923.

	Marketed production	Yearend proved reserves	R/P ratio
	(trillions of cubic feet)		
1923	1.01	15.00	14.9
1928	1.57	23.00	14.6
1933	1.56	46.00	29.5
1938	2.30	70.00	30.4
1943	3.41	110.00	32.3
1948	5.15	173.87	33.8
1953	8.40	211.45	25.2
1958	11.03	254.14	23.0
1963	14.75	277.66	18.8
1968	19.32	287.35	14.9
1969	20.70	275.11	13.3
1970	21.92	290.75	13.3
1971	22.49	278.80	12.4
1972	22.89	266.08	11.6
1973	22.65	249.95	11.0
1974	a/21.90	237.13	10.8

a/ Preliminary.

Sources: DeGolyer & MacNaughton, Twentieth Century Petroleum Statistics, 1973 (1923-72 statistics); American Gas Association and Bureau of Mines (1973-74 statistics).

The proved reserves at the end of 1974 included about 26 trillion cubic feet in the Prudhoe Bay area on the Alaskan north slope. These recently discovered but largely unexplored gas fields are almost inaccessible now because of transportation problems. According to Government experts, the future production in Alaska will only partially offset declining production in the productive gas fields of the continental United States.

The proved reserve figure of 237.13 trillion cubic feet also includes about 35 trillion cubic feet of gas located offshore in the Gulf of Mexico. There are presently no proved natural gas reserves offshore along the U.S. east coast and only limited offshore reserves along the west coast. In 1974, offshore gas production accounted for approximately 19 percent of the U.S. natural gas supply.

A number of estimates have been made of the undiscovered, recoverable natural gas resources 1/ in the United States. These estimates are, at best, orders of magnitude of the gas resources that might be discovered in a given area and are subject to change with time and with application of new geological data and techniques.

The following table shows the estimates of the undiscovered, recoverable natural gas resources onshore and offshore as reported in the most recent studies by the Poter Gas Committee, the National Academy of Sciences, and the U.S. Geological Survey. The year of the study is shown in parentheses.

Source	Estimate (trillions of cubic feet)
Gas Committee (1973)	1,146
National Academy (1975)	530
Geological Survey (1975)	322-655

It is estimated that about one-fifth of the undiscovered, recoverable natural gas in the United States will come from offshore areas.

1/ Defined as gas that has been identified, but cannot be extracted because of economic or technological factors, and gas yet to be discovered.

IMPORTS

The United States has imported gas via pipeline from both Canada and Mexico for a number of years. It has also exported small quantities to these same countries. The United States is a net importer of gas from Canada and net exporter to Mexico. Canada is the United States' major source of natural gas imports; gas imports from Mexico are small, amounting to only about 0.02 percent of total Canadian imports.

In 1974, Canada produced about 2.4 trillion cubic feet of natural gas, exported about 960 billion cubic feet (all of which came to the United States), and at the end of the year had proved reserves estimated at 56.7 trillion cubic feet. The 960 billion cubic feet represented about 4.4 percent of U.S. consumption in 1974.

Since 1973, Canada has been reassessing its position on natural resources, with a view toward limiting its exports in the face of the rising domestic demand. In late 1973, Canada raised export prices for natural gas from $0.32 to $0.61 per thousand cubic feet (MCF). The Canadian Government raised the export price to $1 per MCF effective January 1, 1975, raised it again to $1.40 per MCF effective August 1, 1975, and has announced another increase to $1.60 per MCF effective November 1, 1975 (prices in Canadian dollars).

These increases will make the price of gas more nearly comparable to that of oil at an equivalent heat value and are in line with Canada's policy that the price of natural gas should reflect its economic value in the marketplace in relation to alternative energy sources.

At present, Canada's National Energy Board is conducting hearings on future domestic gas requirements in Canada. In general, the Board has ruled that natural gas can be exported only to the extent that it exceeds the country's projected future domestic needs. Specific means by which Canada's future gas requirements will be protected are being discussed at the hearings, but no final decision has yet been reached.

CONSUMPTION

In 1973, about 24 trillion cubic feet of natural gas was produced in the United States, of which 22.6 trillion cubic feet was marketed. Of the remainder (1.4 trillion cubic ft.), about 1.2 trillion cubic feet was used in the field to repressure existing oil wells, and the rest, mostly residue gas, was blown to the air. An additional 1 trillion cubic feet was imported.

Appendix II shows that the average number of residential, commercial, and industrial customers as well as the annual consumption of gas per customer have increased considerably since 1955. Declines in gas consumption per customer began primarily in 1973 and reflect both the worsening shortage of natural gas and the general state of the economy (e.g., fewer residential housing starts, reductions in industrial output, etc.)

In 1974, an average of 40.5 million residential customers consumed about 121 million British Thermal Units (BTUs) 1/ of gas per customer. In the same year, an average of 3.4 million commercial customers and 200,000 industrial customers consumed, per customer, 690 million and 39,285 million BTUs, respectively.

American Gas Association statistics show that in 1974 commercial and industrial users, representing about 8 percent of total gas customers, consumed about 65 percent of total gas sales but accounted for only 52 percent of total revenues to the gas utility. Electrical generating plants have, since 1950, increased their use of natural gas almost 500 percent and in 1973 accounted for about 44 percent of the gas used by industry.

Large volume customers enjoy lower unit pricing because it is less expensive to distribute large volumes of gas to a single customer than small volumes to thousands of customers. Large volume commercial and industrial customers are often furnished gas under interruptible supply contracts at lower unit prices because they accept the risk that their gas deliveries will be cut off with minimal notice under certain conditions, such as extreme cold weather and breaks in major distribution lines. This risk forces these customers to maintain facilities that can burn either gas or a second fuel, such as oil or coal. In terms of volumes of gas delivered, interruptible supply contracts covered approximately 6 percent of commercial users and 42 percent of industrial users in 1973. Electrical generating plants, classified as industrial users, had about 36 percent of their gas supply covered under interruptible supply contracts.

CURTAILMENTS

The current natural gas shortage has been most clearly manifested in curtailments of service by pipeline companies and distributors. Due to the short supply of natural gas,

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1/A BTU is the measurement of the quantity of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit at or near its point of maximum density.

many pipeline companies and distributors have been forced to curtail gas service, by either not adding new customers or reducing the gas supply to present customers who receive gas under interruptible supply contracts.

A February 1975 FPC news release shows an increasing trend in the curtailment of gas service during the past 5 years.

Net Curtailments (note a)

Year	Trillions of cubic feet
b/1970	.018
1971	.286
1972	.649
1973	1.131
1974	1.679

a/Total curtailments less curtailments by one pipeline company to another.

b/Curtailments of gas deliveries first reported in November 1970.

The Chairman of FPC has stated that the gas curtailments will vary in impact in various regions in the United States depending upon the supply posture of specific pipeline suppliers serving a given region.

We have examined the adequacy of FPC's regulation of interstate natural gas pipeline companies' curtailment activities (RED-76-18, Sept. 19, 1975).

STORAGE FACILITIES

In an effort to insure a continuing and stable supply of gas for the consumer market throughout the year, gas companies have increased the number of natural gas storage facilities, including those that store LNG. At the end of 1973, over 6 trillion cubic feet of underground storage capacity was available for natural gas, and 36 LNG plants with associated storage facilities provided an additional 35.9 billion cubic feet of gas capacity. These storage facilities give the gas companies a readily accessible source of gas for periods of peak consumption. Peak load problems usually occur in the winter, when the regular gas supply is insufficient to satisfy total requirements.

The ability to draw down on the storage facilities during peak consumption periods and replenish the facilities during nonpeak periods has made gas a highly reliable primary fuel, even to major consumers. For example, gas consumption, which peaks in the winter months, falls in summer by about 90 percent. This allows cyclical replenishing of storage facilities.

CONSERVATION

While energy conservation by itself cannot solve the energy problem, it can increase the availability of natural gas and other forms of energy to meet higher priority demands. Government and industry spokesmen believe conservation can be achieved largely by cooperation among the public, Government, and industry to reduce energy waste without major hardship or inconvenience. A major oil company recently made a series of studies of various aspects of the energy situation. One study, "The National Energy Problem--Potential Energy Savings," listed conservation measures which could be taken in three stages--in the short term, by 1980, and by 1990. The study showed that potential energy savings through natural gas conservation measures, such as modified heating and cooling standards and more efficient industrial processes, would by 1990 amount to about 2 trillion cubic feet of gas a year.

To date, however, conservation savings with respect to total natural gas use have been minimal. An official of the American Gas Association said in May 1975 that conservation measures by gas consumers during the 1973-74 heating season had reduced gas use about 5 percent. By sector, gas use was reduced 7 percent by residential users, 7 percent by commercial users, and 2 percent by industrial users. Conservation by industry is less noticeable since gas conserved is often converted to other uses within the same plant. Indications are that overall savings in gas use during the 1974-75 heating season will again amount to 5 percent.

COST OF GAS COMPARED TO CRUDE OIL AND COAL

During 1968-74, the prices of all three fossil fuels increased considerably, as shown in the following chart. The average price of crude oil is a composite of domestic and imported prices.

	1968	1974	Percent increase
Natural gas, interstate (MCF)	$0.16	$ 0.302	89
Crude oil (barrel)	2.94	8.75	198
Coal, bituminous (ton)	4.67	15.00	221

More recently quoted prices of natural gas, crude oil, and coal are about $0.51 per MCF, $12 per barrel, and $19 per ton, respectively.

Using the standard average heating values of the three fossil fuels as established by the Bureau of Mines,1/ the cost of 1 million BTUs at 1974 prices is computed to be about $0.29 for natural gas at the wellhead, $1.51 for crude oil, and $0.50 for coal.

This disparity can be partially attributed to the higher costs associated with processing, transporting, and handling crude oil and coal. However, the primary reason natural gas has cost less and increased less in price over the years compared to crude oil and coal is that the price of most natural gas has been regulated, as discussed in the forthcoming section.

The price of imported gas varies considerably. Pipeline gas from Canada is imported, dependent upon contract, at prices ranging up to $1.40 per MCF. Effective November 1, 1975, the maximum price of Canadian pipeline gas imports will rise to $1.60 per MCF. One approved contract for importing LNG from Arzew, Algeria (El Paso I), quotes an average price of $1.03 per MCF landed at the U.S. terminal. Regasifying the LNG and delivering the gas to the main distribution point are expected to increase the price to about $1.35 per MCF. Other applications have been filed with FPC for importing LNG. The most recent one, calling for the import of LNG from Sumatra, Indonesia, indicates a price of $2.50 per MCF landed at the U.S. terminal (subject to various price escalations) and $2.85 per MCF regasified and delivered to the main distribution point. These estimates reflect the prices that will be in effect during the third through fifth year of operations in Indonesia. Generally, there has been an upward trend in the prices quoted in pending LNG contracts.

1/Natural gas has an average gross heat content of about 1,032 BTUs per cubic foot; crude oil, 5.8 million BTUs per barrel; and bituminous coal, 26.2 million BTUs per ton.

Regulation of fossil fuel prices

The rate schedules of domestically produced and transported interstate gas--currently about 60 percent of the gas produced in the United States--has been controlled by FPC for the past 20 years. In June 1974, FPC approved a nationwide increase in the maximum allowable wellhead price of natural gas from an average of about 21.6 cents per MCF to 42 cents, which was subsequently raised to 50 cents. Recent price escalations have raised the price to 51 cents per MCF.

FPC also approves the rate schedules of imported gas through the issuance of Presidential Permits. Presidential Permits for importing natural gas are not necessarily subject to the price restrictions imposed on the sale and transportation of domestic gas. However, a Presidential Permit will not be issued unless FPC and the Secretaries of State and Defense agree that the issuance of a permit will be consistent with the public interest.

The price of natural gas produced and consumed in intrastate sale is not regulated by FPC. According to an FPC official, wellhead prices of intrastate gas generally vary from $0.50 to $2.00 per MCF compared with the interstate price of $0.22 to $0.55 per MCF.

A number of proposals have been made in the Congress in past years to deregulate the price of natural gas. The current administration is supporting deregulation bills now in the Congress. Proponents of these measures point out that natural market forces would tend to establish gas prices at or near the competitive pricing for other forms of energy.

Deregulation is expected to result in a higher gas price, which will serve as an incentive for companies to explore for and develop additional gas fields to alleviate present and future gas shortages. It is debatable, however, how soon and to what extent deregulation will increase domestic gas supplies. As discussed in chapter 1, FEA's Project Independence report essentially ruled out any large increase in gas production in the short term.

A higher gas price may have other effects. To the extent that it curbs natural gas consumption and encourages more frugal use of the fuel, it will serve as a conservation mechanism. A higher price may also change the relationship between natural gas and alternative sources of gas, including LNG and synthetic gas from coal. By reducing the price disparities between natural gas and its alternatives, an upward adjustment in gas prices would tend to make these alternatives more competitive with gas and their development more commercially viable. This hypothesis, of course, is based on the assumption that there will still be a gas shortfall after deregulation.

A January 1975 FPC study, "A Preliminary Evaluation of the Cost of Natural Gas Deregulation," concluded that for the most part gas consumers would save money under an "average case" deregulation proposal (see following paragraph). This conclusion is premised on a steady increase in savings of alternative fuel costs as higher gas prices elicit more supply and curtail consumer demand. By 1985, these savings would exceed increased payments to gas producers by about $3.5 billion, representing a net overall benefit to consumers.

An FPC task force analyzed three deregulation proposals--total deregulation, including renegotiation of existing contracts; deregulation of new gas (gas not previously dedicated to interstate commerce) and gas under expiring interstate sales contracts; 1/ and deregulation of new gas only.

Under varying assumptions of prices and supply results, the task force concluded that the total deregulation impact could range from a net cost of $2.4 billion to a net benefit of $7.5 billion. The other two proposals project results ranging from a net cost of $1.9 billion to a net benefit of $7.4 billion. The study also concluded that by 1985 the difference in cost among the three proposals would be almost completely obliterated.

Crude oil and coal have not been subjected to such rigorous price regulation. However, crude oil prices are controlled to an extent. In August 1973, to stimulate increased oil production through price incentive, the Cost of Living Council 2/ established a two-tier price structure for crude oil. The structure placed a ceiling price on domestically produced crude oil which equaled production in the same month of 1972, the base year. When production exceeds that of the base period, the so-called new oil and an equivalent amount of old oil can be sold at prices above the ceiling. In June 1975, prices under this system ranged from $5.25 (old oil) to about $12 (new oil) a barrel. The average price of domestic oil was about $8.40 a barrel, well below the cost of imported crude oil.

1/ This is the "average case" proposal.

2/ In 1974, the petroleum pricing responsibilities of the Cost of Living Council were absorbed by FEA.

Coal prices are not presently regulated. In 1974, the average price for bituminous coal was $15 per ton. A Bureau of Mines official estimated that bituminous coal was selling for about $19 per ton as of June 1975.

FUTURE DEMAND AND AVAILABLE SUPPLY

Any study of future U.S. gas demand and available gas supply must consider how much will be available and, if demand exceeds supply, what alternatives are available to meet the shortfall.

The answers to these apparently simple questions are influenced by complex, interacting variables. These variables--some measurable and predictable, others not--include

--the price and availability of natural gas and alternative fuels;

--population trends;

--desired lifestyle trends, both economic and geographic;

--general level of economic activity;

--personal income; and

--potential Federal, State, and local influence upon the above areas.

The history of each variable has affected gas demand or supply. For example, development of Federal, State, or local laws and regulations has influenced prices or the availability of natural gas or alternative fuels; likewise, the amount of gas consumption has increased as lifestyles have changed.

The annual growth of natural gas use since 1948 has averaged about 7 percent, while use of all fossil fuels and all energy sources has averaged 3.8 percent and 3.5 percent, respectively.

Since 1968 a number of Government and industry studies have been made concerning future gas demand and available supply under varying assumptions. The demand projections in these studies, however, were based on natural gas prices prevailing at the time and, consequently, may not provide the most realistic picture of future natural gas shortfalls.

The January 1975 FPC study on the cost of deregulation estimated the magnitude of future natural gas shortfalls, allowing for gradual price increases each year for flowing gas and new gas (including sales under the new national rate set forth in FPC Opinion No. 699-H). Two alternative supply assumptions were used in making the estimates: (1) level production of 22.6 trillion cubic feet (1973 marketed production) each year, with each year's increment of new gas exactly offsetting the declining production from existing wells, and (2) level annual increments of 1.2 trillion cubic feet of new gas in the interstate market and 0.55 trillion cubic feet of new gas in the intrastate market, with total intrastate production held constant at 9.0 trillion cubic feet per year.

Based on these varying assumptions of prices and supply results, FPC estimated that the natural gas shortfall by 1985 could range from 7.5 trillion to 11.2 trillion cubic feet.

A December 1974 FPC staff report stated: "The long term prospects for domestic natural gas production through 1985 appear to be worsening at an unexpectedly accelerating pace." To support this position, the report noted that yearly production could decrease to between 7.3 and 17.4 trillion cubic feet, far short of the 1973 level of 22.6 trillion cubic feet.

One criterion used in making such projections is the finding rate for gas per foot of well drilled. For example, in 1967 about 21 million feet of wells were drilled, and the finding rate was 831 MCF of gas per foot of well drilled. In almost every year since 1967, the finding rate has decreased. In 1973 about 35.6 million feet of wells were drilled, but the finding rate was only 104 MCF of gas per foot drilled. Another indicator, the average size of newly found pools of gas, shows that in 1967 the average pool of gas was 42 billion cubic feet; in 1973, it was 9 billion cubic feet.

CONCLUSIONS

The accelerated use of natural gas in the United States over the past 25 years has led to shortages of this vital resource. Proved reserves of gas have been declining almost every year since 1967 because new gas discoveries have not been keeping pace with production and consumption. At the end of 1974, the proved reserves of 237.13 trillion cubic feet represented an R/P ratio of 10.8, based on the 1974 rate of production.

The natural gas shortage is manifested in several forms, including (1) increasing curtailments of gas deliveries to industrial users under existing contracts, (2) failures among potential consumers to obtain supplies at the going price, and (3) gas conservation by users.

Proponents of gas deregulation contend that the low sales price of gas at the wellhead has created the current shortage by reducing the economic incentives for producers to seek new natural gas discoveries. However, the extent to which deregulation would affect future gas supplies is uncertain. Still, the continuing demand for natural gas in the face of declining proved reserves indicates that the price of natural gas (which is presently regulated well below the cost of other fossil fuels) could increase appreciably and still be competitive with coal and oil. Deregulation may also alter the future demand and supply picture of natural gas and its alternatives by providing a higher price for gas.

A number of studies have been made concerning future gas demand and available supply. These studies, made under varying assumptions, indicate that the natural gas shortfall in 1985 will be sizable, possibly as high as 11.2 trillion cubic feet. Regardless of what assumptions are used, experts generally agree that, if the historical trends continue, the United States has reached the era of diminishing returns on the discovery and production of natural gas. One alternative which could help to alleviate the resulting shortfall is obtaining LNG from foreign sources.

CHAPTER 4

CONSIDERATIONS AND ISSUES RELATED TO INCREASING LNG IMPORTS

BACKGROUND

Movement of natural gas within a continent is a relatively easy task, with tremendous volumes traveling by pipeline from the wellhead to extraction plants, to the distributor, and finally to the consumer. But ocean shipment of natural gas is another matter, involving billions of dollars in investment in liquefaction plants, special ship carriers, and offloading terminals.

Raw natural gas--natural gas as it is produced in its native state at the wellhead, water saturated and often containing liquid hydrocarbons and various impurities--is processed for transoceanic shipment through an extraction plant to reduce or remove impurities and heavy hydrocarbons. The gas then goes to a liquefaction plant, normally located at or near the ocean terminal, where it is reduced to a liquid. The liquefaction process reduces the temperature of the natural gas to about -258 degrees Fahrenheit at approximately sea level atmospheric pressure, converting the natural gas to LNG. LNG occupies approximately one six-hundredth of the volume of the gas in its natural, gaseous state.

The state of the art in large liquefaction plants is comparatively new, and the present costs of these plants vary considerably depending upon the engineering design, location, and local economic conditions. An FEA official said that, as a rule of thumb, a plant capable of producing 1 billion cubic feet of LNG daily could cost from $500 to $600 million. A liquefaction plant requires an estimated 3 to 4 years to build. Appendix III shows current and planned investment as of late 1974 in LNG facilities in selected foreign countries.

The transportation of natural gas by tankers is a critical part of the international energy supply line. Providing a bulk ocean carrier which will transport natural gas in its gaseous state is impractical due to the gas' light weight and high volume. In its condensed form, however, LNG is physically feasible for transocean shipments to meet world demands.

To ready it for shipment, the LNG is piped into what amount to giant size, heavily insulated thermos bottles aboard the LNG tanker. Due to a slow but steady warming of the LNG in the thermos bottle, a condition called boil-off constantly occurs. To keep pressure from building up, the LNG that has become gaseous in the boil-off is vented into the atmosphere or a portion of it is used to operate auxiliary machinery and dual-fuel main propulsion systems. Currently, LNG carriers dedicated to trade do not have onboard liquefaction for reliquefying boil-off.

The boil-off presently averages about 0.25 percent of the total gas cargo a day. This may seem a small percentage, but in large LNG carriers the loss could be considerable. For example, during a voyage from Algeria to New York City, a distance of about 3,300 miles, the loss in large carriers would be about 60 million cubic feet of gas.

LNG tankers are expected to operate at or near maximum design speed of 20 knots for approximately 50 weeks a year. The ship would be in repair status the remainder of the time. An LNG tanker is a specialized carrier, and no probable way presently exists to use it to carry other commodities because of the residual cold temperature of the tanks after offloading and the necessity to clean the tanks if other commodities were carried.

COST OF LNG SHIPS

Due to the technical problems associated with handling low temperature LNG, the cost of an LNG carrier is higher than that of other bulk carriers of similar size. In late 1972, the cost of an LNG ship contracted for in the United States without price escalation was $106 million. A 1974 quotation for a similar ship was $135 million. The estimated 1980 cost of constructing an LNG tanker of the type now being constructed ranges as high as $170 million to $200 million.

The Maritime Administration is currently subsidizing LNG tanker construction costs for the difference between U.S. and foreign construction costs for a similar type and sized ship. The subsidies have ranged from 26 percent to about 15 percent in some contracts. The lower subsidy probably reflects, in part, the higher rate of increase in foreign construction costs relative to increases in U.S. construction costs. For example, France, the world leader in LNG ship construction, was faced with a 30- to 50-percent cost escalation in 1971 alone, due largely to rapidly increasing labor costs.

At the end of 1973, two U.S. shipyards had orders for 10 LNG tankers scheduled for delivery during 1975-78. Total contract costs of these ships are about $946 million, of which about $140 million will be provided through Government subsidy on six of the ships. In addition, another U.S. shipyard has a similar contract for $309 million for three ships, including a Government subsidy of about $51 million. In 1974, a Maritime Administration official indicated that 7 applications for about 24 ships with an estimated total cost of $2.2 billion (including subsidies) were under consideration. None of the LNG tankers contracted for in the United States have yet been completed.

Capital investment required

An estimate of the capital investment for ships must consider how much gas has to be imported, the cargo capacity of the ship, and the distance between foreign suppliers and the United States.

In chapter 3, we pointed out that the natural gas shortfall by 1985 could range from 7.5 trillion to 11.2 trillion cubic feet. As discussed in chapter 1, long-term LNG import projects filed with FPC and other tentative projects envision the import of 3.8 trillion cubic feet of LNG annually by 1985. However, this level may not be attainable. First, it is uncertain whether all the projects now under consideration will be completed (only two long-term LNG projects have been approved thus far). Second, LNG is a supply-limited energy source. Although discussions are underway with a number of countries which could supply LNG to the United States, only a few countries have taken concrete steps to enter the world LNG export market and only two are now planning to export LNG to the United States. We have, therefore, adjusted the 3.8-trillion-cubic-feet projection downward to 3 trillion cubic feet, which still may be somewhat optimistic. If this level of LNG imports is attained by 1985, approximately 53 LNG tankers costing at least $6.6 billion would be required.

In making calculations, we have assumed that each ship costs $125 million, has a capacity of 125,000 cubic meters (2.65 billion cubic feet), will average 20 knots enroute, and will average one round trip each 16 days during 50 weeks of the year.

AVAILABILITY OF SHIP CONSTRUCTION FACILITIES

The leadtime required for an LNG tanker of 125,000-cubic-meter capacity has been estimated at about 3 years from the date constructi n starts to operational status. This estimate must be qualified by recognizing that LNG tankers must fit into the overall construction priorities of the shipbuilding industry and that their size (870- to 950-foot length and 135- to 145-foot beam), almost that of a U.S. Navy aircraft carrier, limits their construction to the largest shipyards.

This situation may be alleviated somewhat by the current worldwide surplus of crude oil tankers, which has resulted in a lessened demand for such tankers and may free shipyards for building LNG carriers.

The first LNG tanker began in service in early 1959, and about 16 were operating in world trade by January 1974. The first ship was slow (9.5 knots) and, by today's standards, small. The cargo capacity was approximately 110 million cubic feet of natural gas at atmospheric pressure. Today, several ships are planned or under construction that will operate at 20 knots and have a cargo capacity of approximately 125,000 cubic meters, or 2.65 billion cubic feet. These ships may someday be dwarfed by tankers of 250,000-cubic-meter capacity and higher speeds as the technology associated with this new industry advances.

The size of LNG carriers built in or offloading cargo in the United States is limited because (1) the depth of most U.S. ports ranges from 35 to 40 feet, just sufficient to accept the draft of a 125,000-cubic-meter-capacity LNG tanker and (2) few U.S. shipyards can build a ship much larger than the LNG tankers now under construction.

According to an October 1973 report by the Commission on American Shipbuilding, about 34 shipbuilding ways in the United States were capable of handling construction of ships 600 feet or longer and 80 feet or wider. However, only 13 of the 34 could build an LNG tanker of approximately 125,000-cubic-meter capacity without expanding the length or width of present facilities.

The shipbuilding industry has already programed a $500 million expansion of existing U.S. facilities to improve shipyard productivity.

The 13 tankers on order or under construction (see p. 26) will surely tie up existing facilities. If keels for new LNG tankers are laid immediately after the launching of the first 13 tankers, the scarcity of shipbuilding ways will limit the rapid expansion of a domestically constructed LNG tanker fleet.

If the United States continues to build other types of large ships, the U.S shipbuilding industry must increase its capacity to handle the routine large-ship orders it has filled in the past and the incremental increase of LNG tankers.

U.S. shipyard production is a minor factor in international shipbuilding. The Commission on American Shipbuilding reported in October 1973 that U.S. shipyards had 3.3 percent of the world's commercial shipbuilding orders and were constructing 2.6 percent of the world's total commercial tonnage. In contrast, Japan had about 45 percent of the world's tonnage on order or under construction at the end of 1972. Of more than 50 facilities throughout the world capable of building a ship of over 250,000 dead weight tons, the United States has only 1.

LNG SHIP RECEIVING TERMINALS

Essentially, an LNG receiving terminal consists of a mooring buoy or wharf space for the LNG carrier during offloading, cryogenic pumps, insulated pipelines to shore, and an insulated battery of storage tanks with a capacity about double the amount that can be carried by the largest ship that can be offloaded at the terminal.

After the LNG is changed back to its gaseous state at a regasification plant, it is pumped into gas mains in the distribution system. If warranted, the gas may be processed through additional purification steps and blended with other natural gas to maximize its uniformity or to raise or lower its BTU content before it enters the distribution mains.

A major consideration in establishing a receiving terminal is the availability of deep-water ports capable of handling large, deep-draft, oceangoing ships. For example, several LNG ships under construction range from 870 to 950 feet in length, 133 to 145 feet in beam, and 33 to 38 feet in draft.

Approximately 30 seacoast ports in the United States, excluding Alaska, are capable of handling ships with a draft of 30 feet or more. However, without additional channel dredging, 4 of the 30 ports could not accept an LNG tanker with a 33-foot draft and only 17 could handle one with a 38-foot draft.

The Boston and New York City areas each have one operational LNG receiving terminal at present. Another east coast terminal has been completed, but is not yet operational due to a lack of regulatory approvals. The gas industry also has several other receiving terminal projects under development, including four on the east coast, one on the gulf coast, and three on the west coast. Six of these are being designed and two are under construction.

U.S. receiving terminals require an estimated 48 months to construct. Construction costs vary with the terminals' processing capacity. The following table shows the total construction costs, design capacities, and construction costs per unit of capacity of three recently proposed LNG receiving terminals on the west coast. The costs (in 1974 dollars) include investments in pipeline facilities to transport gas from the terminals to transmission facilities.

Terminal	Construction cost	Daily processing capacity (MCF)	Cost per MCF of capacity daily
A	$665,918,000	2,810,000	$237
B	259,307,000	521,600	497
C	164,624,000	400,000	412
Average unit cost	-	-	382

Assuming an average daily processing capacity of 1.5 million MCF, the estimated average cost of constructing an LNG receiving terminal is about $573 million ($382 times 1.5 million cubic feet).

National security risks involved in siting terminals and choosing sources of supply

A potential problem in siting receiving terminals is that importing large volumes of gas to relatively few receiving terminals may cause national security problems. Of course, this problem is not presently significant because the United States is essentially self-sufficient in natural gas. However, if the natural gas supply falls substantially behind demand as projected and imported LNG becomes essential to the gas supply, the diversification of receiving terminals to minimize the impact of any supply interruption will become necessary.

For example, if an urban area builds up a dependence on LNG as part of its normal gas supply, rather than as a supplement to the supply at peak consumption periods, any supply interruption could cause serious problems. Factors that could cause such an interruption include:

--Foreign policy and economic differences between the exporting and importing country (similar to the recent petroleum embargo by several major oil-exporting countries).

--Mechanical breakdown of the supply line either at source, enroute, or at destination.

--Labor-management problems.

The first two factors may be particularly applicable to an LNG import program, especially during its initial stage when the suppliers will be few. The only countries planning to export LNG via tankers to the United States in the near future are Algeria 1/ and Indonesia, both members of the Organization of Petroleum Exporting Countries. Other potential suppliers of LNG are also members of this organization. Consequently, U.S. vulnerability to an LNG supply disruption would be extremely great in the event of a political confrontation similar to that surrounding the Arab oil embargo of 1973. Moreover, LNG imports will be dependent on a complex supply system consisting of liquefication plants, specialized tankers, and receiving terminals. The state of the art in these LNG facilities is comparatively new, so the likelihood of a supply disruption caused by technical problems would likewise be great. This possibility is supported by recent technical problems with Algerian LNG facilities that have disrupted operations several times.

In addition to alleviating any LNG supply disruption, the geographical dispersion of receiving terminals will reduce the transit time by providing terminals closer to the various LNG sources. For example, LNG imported from South America could be shipped to the gulf coast instead of the east coast. The shorter distance involved would reduce not only transit time, but also the number of ships required.

As shown in the following table, the completed and operational LNG receiving terminals, along with those under construction or planned, will apparently satisfy the diversification

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1/ Algeria has exported small quantities of LNG to the United States in the past under contracts with the Distrigas Corporation and the Boston Gas Company.

requirement, considering distribution, national security, and availability of existing U.S. deep-water ports.

	Total	Completed and/or operational	Planned or under construction
East coast	7	3	4
West coast	3	-	3
Gulf coast	1	-	1
Total	11	3	8

On the basis of an estimated $573 million facility at each port, the total cost of the eight facilities planned or under construction would be about $4.58 billion.

A diversity of LNG sources is essential to maintain national security. An important U.S. goal is not only to limit total energy imports, but also to avoid disproportionate energy imports from any region of the world. The United States, however, may be limited in its quest for such diversity. As mentioned earlier, LNG is a supply-limited energy source. Thus, if the need for LNG imports persists, the United States may simply have to settle for whatever suppliers are available.

SAFETY AND ENVIRONMENTAL PROBLEMS

Safety hazards arise from transporting, handling, and storing any liquid or gaseous fuel. LNG is no exception. Due to its extremely low temperature, it can cause cryogenic burns on human flesh. If spilled on metal it can make the metal brittle to the point of structural failure, causing damage to ships or other equipment. After vaporization, LNG is readily combustible.

No LNG ships have been lost through fire or collision since such ships began operating in 1959. Two major accidents, both of unknown causes, have occurred in LNG plants in the United States. The first, in 1944, killed 133 persons; the other, in 1973, killed 40.

The Coast Guard has made extensive tests on LNG hazards and promulgated safety regulations to increase the safety of LNG carriers and facilities.

Environmental hazards connected with LNG are considered minimal. In its low temperature, liquid state, it will damage objects upon which it is spilled. In the gaseous state, it burns with slight atmospheric pollution compared with other fossil fuels.

IMPACT OF LNG IMPORTS ON U.S. BALANCE OF PAYMENTS

Another factor which warrants consideration in evaluating LNG imports is their impact on the U.S. balance of payments. This impact will be negative, but in terms of the international trade projected between now and 1990, it will probably be small.

The U.S. balance of payments has not been greatly affected in past years by natural gas imports. For example, since 1967 the cost of natural gas imports has been rising on the average about $55 million a year. In 1974, natural gas worth about $505 million was imported, mainly from Canada. This represented about 0.5 percent of the total value of 1974 U.S. imports. Increases in the price of Canadian natural gas will increase the cost of gas imports considerably in 1975 (see p. 14), assuming that the level of Canadian gas imports remains relatively stable.

As stated previously, LNG imports under approved, planned, and tentative projects could reach 3 trillion cubic feet annually by 1985. (See p. 26.) These projects are long term, involving imports over 20 years or more. Consequently, the prices quoted in today's contracts represent a financial commitment that U.S. importers and, ultimately, domestic gas consumers must endure until the end of the century.

Prices will vary with each project. The approved El Paso I project will import Algerian LNG at an estimated price of $0.36 per MCF at the port of embarkation (i.e., F.O.B Algeria). It is estimated that LNG imported from Indonesia will carry a price of about $1.40 per MCF at the port of embarkation. If an average of $0.90 per MCF is used, the foreign exchange costs for purchases of LNG, based on imports of 3 trillion cubic feet, could amount to about $2.7 billion annually, excluding transportation charges.

The above price estimates are in 1974 dollars. Escalation clauses in pending LNG contracts make the likelihood of subsequent price increases great. In addition, the recent decision by the Organization of Petroleum Exporting Countries to coordinate natural gas pricing policies among member states so that such policies are in line with its oil pricing policy raises further questions concerning the price vulnerability of imported LNG.

Transportation charges for LNG under approved, planned, and tentative projects could amount to about $2 billion annually, based on estimates by gas companies involved in the El Paso I LNG project. However, the amount that would actually be added to U.S. foreign exchange costs is not known. The effect on the balance of payments would be proportional to the number of foreign-flag versus U.S.-flag vessels used to transport the LNG. Both Russia and Algeria have indicated that at least 50 percent of their LNG exports must be carried on their ships. If it is assumed that half of the 3 trillion cubic feet of LNG imports projected for 1985 will be transported on foreign-flag vessels, the foreign exchange costs for transportation charges would be about $1 billion annually. The total U.S. balance-of-payments outflow, therefore, could reach about $3.7 billion annually.

How much LNG costs, where tankers are built, and whether U.S. or foreign shippers handle the cargo will all have a bearing on the U.S. balance of payments.

CONCLUSIONS

Developing a complete LNG program will clearly require considerable capital investment in the United States and in gas-exporting countries. Both plans and actual construction of LNG facilities involving the expenditure of billions of dollars are proceeding. In the United States, about $11 billion may be required to build the necessary LNG tankers and receiving terminals, assuming that 3 trillion cubic feet of LNG will be imported annually by 1985.

These imports could add about $4 billion annually to the U.S. balance-of-payments outflow for the duration of the projects.

In addition to the financial considerations, LNG imports will have political and national security ramifications. The possibility of supply interruptions caused by political confrontations or technical problems will make diversifying U.S. receiving terminals and, if possible, LNG sources a necessity if LNG is imported on a large scale.

CHAPTER 5

SUMMARY

Energy, like raw materials, skilled manpower, equipment, capital, and technology, is an essential contributor to the economic growth of this country.

Choices made regarding the mix of energy sources to meet the U.S. energy demand now and in the future must inevitably take into account U.S. domestic and foreign policies, national security, the delivered cost of the product to the consumer, environmental and health costs, additional manpower investment, capital investment for new energy sources, domestic and foreign source availability, and the stability of existing and new energy sources.

Natural gas will continue to be a primary U.S. energy source for the next 15 years or more and will provide much of our energy needs. The Nation depends daily on natural gas to heat homes, schools, and apartments and to satisfy various commercial and industrial requirements.

Because this energy resource is vital to the U.S. economy, steps must now be taken to cope with the worsening shortage of natural gas. A number of approaches to the problem exist, but each has limitations.

The extent to which deregulation of natural gas prices will stimulate exploration for and development of new domestic gas fields or encourage increased production to meet demand is uncertain. However, recent studies indicate that deregulation, at least in the short term, will not result in any substantial increase in domestic gas supplies.

The effect of conservation measures on future gas consumption, whether the result of voluntary effort or regulatory measures, is likewise uncertain. But it seems unlikely that any overall savings would appreciably affect natural gas demand as long as gas conserved by one segment of the natural gas market becomes available for use by other segments. This is not to suggest that conservation by individuals and industry is not necessary. Conservation is, of course, vital to meeting future natural gas demand, but it should not be viewed as a panacea.

Experts generally agree that new energy sources will not greatly affect the demand for natural gas in the United States until 1990 or later because of technological and environmental problems.

Another alternative would be to require certain large natural gas users, mostly industrial and electrical generating plants, to shift to other sources of fuel, principally coal or oil. Switching to coal would require increased production with accompanying manpower, health, and safety problems. Increased strip mining would also probably be required. Switching to oil would aggravate the current domestic crude oil shortage or require increased oil imports with attendant political, economic, and national security risks. Additional pipeline distribution, refineries, and storage capacity would be required in the United States. Greater use of coal and oil would also require a major capital investment for expanding facilities as well as for machinery and equipment to comply with increasingly restrictive U.S. environmental standards.

The remaining alternative is to import LNG to supplement domestic gas supplies. As with the other alternatives, there are drawbacks. LNG imports are expected to only minimally alleviate the natural gas shortage in the short term. If LNG is imported on a large scale, the same economic, political, and national security risks created by oil imports may arise. A major capital investment for building LNG carriers and other facilities would also be required.

Natural gas available to the United States from foreign sources is being reduced by exploitation of resources within those countries, such as by construction of petrochemical and other industrial plants, and also by competition from energy-short countries. The gas available to meet U.S. demand may thus be limited.

The Government's legislative and executive branches are formulating national energy policies that will affect our individual lifestyles and American industry for years to come. The data and observations in this report should help the Congress and the executive branch evaluate (1) the need for and reliance on imports of natural gas, (2) the economic, political, and national security problems and costs associated with such imports, and (3) the available alternatives.

SHORTCOMINGS OF THE MORE COMMON NATURAL

GAS SUBSTITUTES AND ALTERNATIVE ENERGY SOURCES

Following are some problems and limitations associated with the more common substitute and alternative energy sources which could alleviate a natural gas shortage in the United States.

1. U.S. petroleum reserves are declining. Domestic production provides only about two-thirds of U.S. requirements. Heavy and continued reliance upon foreign sources of oil to augment domestic production is not in the best interests of the United States because of national security risks and potential economic threats by foreign countries to achieve their political objectives. Current U.S. efforts to augment domestic supplies, decrease petroleum consumption through conservation, and shift generating plants and other industries to the use of coal are indications of the emerging nature of the domestic petroleum shortage.

2. Coal is plentiful in the United States--amounting to an estimated 1.6 trillion tons of proved resources. Recoverable coal reserves account for about 88 percent of the Nation's proved reserves of all fuels, but coal supplies only 18 percent of the energy used. Of the 600 million tons mined each year, about 45 percent is strip mined.

Electrical generating plants use about one-sixth of the natural gas and two-thirds of the coal consumed annually in the United States. A further shift to coal is possible, but large amounts of capital would be required and major problems can be expected. The problems would involve upgrading mine safety and health standards; recruiting additional miners; and dealing with the environmental consequences of water and air pollution, waste disposal, and strip mining.

3. Substantial quantities of oil shale exist in the United States and shale oil production is feasible but large outlays of capital will be required. An oil shale complex capable of producing 500,000 barrels of oil a day could cost an estimated $6 billion to $8 billion. But shale oil production may be limited due to the large quantities of water required and the environmental impact of strip mining.

Another method of obtaining shale oil, known as "in situ" retorting, involves extracting oil from shale in a deep mining operation. This method, which will also create environmental problems, is under study but largely untested, and its projected cost and practicality have yet to be determined. However, neither shale oil production method is expected to contribute substantially to an energy solution before 1985.

4. Known tar sands exist in Canada and Venezuela and in small deposits in the United States. Tar sands oil is not widely available today. This alternative will be expensive; the capital investment required to provide only a small percentage of U.S. energy needs will amount to billions of dollars.

5. Coal gasification, burning coal under controlled conditions to produce synthetic natural gas, has proved feasible in Germany and South Africa. Private and governmental research in the United States has reached the point that several companies have announced plans to build coal gasification plants.

The initial cost is high. Applications filed with FPC for two major coal gasification projects, each capable of producing about 275 million cubic feet a day of high-BTU, pipeline quality gas, indicated an average capital cost of about $750 million, excluding the costs of the associated coal mines. Each plant would burn over 6 million tons of coal annually, consume about 1 billion gallons of water daily, and require disposal of over 600,000 tons of ash each year.

AVERAGE ANNUAL NUMBER OF GAS CUSTOMERS AND

ANNUAL CONSUMPTION PER CUSTOMER, 1955-74

	1955	1960	1965	1970	1971	1972	1973	1974
Residential:								
Number of customers (note a)	26.28	30.42	34.34	38.10	38.79	39.43	40.12	40.53
Annual consumption per customer (note b)	85	105	117	129	130	131	125	121
Commercial:								
Number of customers (note a)	2.05	2.46	2.79	3.13	3.20	3.26	3.33	3.36
Annual consumption per customer (note b)	295	374	488	641	675	699	685	690
Industrial (note c):								
Number of customers (note a)	.12	.14	.17	.20	.21	.21	.21	.21
Annual consumption per customer (note b)	29,168	33,495	36,983	42,397	42,122	41,953	40,003	39,285

a/Number of customers in millions.

b/Consumption in millions of BTUs.

c/Includes sales by gas utilities to electrical generating plants but excludes direct sales by producers to these plants.

CURRENT AND PLANNED INVESTMENTS IN WORLDWIDE LNG FACILITIES, 1974, AND GROWTH OF WORLDWIDE PETROCHEMICAL PROJECTS

ABU DHABI

An American engineering firm and Japanese interests have recently combined their skills and invested $300 million in a gas liquefaction plant. The plant, expected to be operational in 1976 or 1977, will provide Japan with about 435 million cubic feet of gas daily.

ALGERIA

One liquefaction plant is in the planning stage, a second under construction, and a third in operation and providing LNG to the United States, France, and the United Kingdom. Due to a disruption of operations caused by technical problems, gas deliveries to the United States in 1973 were considerably less than planned under a contract with the Distrigas Corporation. El Paso Natural Gas company has a contract for 1 billion cubic feet of gas daily with initial deliveries expected in 1977-78. Another company filed applications with FPC for permission to import about 3.3 trillion cubic feet of gas over a 20-year period starting in 1979.

Foreign financing of present and planned Algerian liquefaction plants is substantial. The U.S. Export-Import Bank has provided $157 million in direct loans for an LNG project and a like amount in loan guarantees. This is a portion of a $2 billion investment in plant and facilities to provide LNG for export to the United States. In connection with this project, the Export-Import Bank recently approved a direct credit of $47.7 million for the sale of $119.2 million of U.S. equipment and services to the Algerian oil and gas firm for a natural gas processing facility. Great Britain has also loaned about $92 million for expanding the existing plant. Under a tentative agreement, Algeria has agreed in principle to supply Spain with about 438 million cubic feet of pipeline gas daily for 20 years in exchange for a $340 million loan for an additional liquefaction plant. In September 1974, it was reported that the state-owned oil and gas firm had let an $850 million contract to a consortium of European interests for constructing an LNG complex. In addition, Algeria has arranged loans to build the first 3 of a proposed 13-ship LNG tanker fleet that it will own.

BRUNEI

A liquefaction plant with a processing capacity of 450 million cubic feet of gas daily is in operation and supplying gas to Japan. The plant, a result of a joint venture involving two foreign companies and the Brunei Government, will ultimately be capable of processing about 650 million cubic feet of gas daily. An initial investment of $170 million was provided by the firms involved.

CHILE

A liquefaction plant, with a designed capacity of 290 million cubic feet of gas daily, is now being planned. The plant, scheduled for completion in 1977, will cost an estimated $130 million.

INDONESIA

A liquefaction plant will be constructed to provide LNG for export under contracts negotiated with American and Japanese utility companies. In one agreement with an American utility firm, the state-owned Indonesia oil company will provide 550 million cubic feet of gas daily to the United States over a 20-year period. This gas will be provided from a liquefaction plant yet to be built. Details of financing for the plant are not yet available. Under another contract signed with a consortium of Japanese companies, about 1.1 billion cubic feet a day of gas will be exported to Japan for 20 years. The Japanese Government is investing $700 million in the LNG project; the first shipments to Japan are scheduled for 1977.

IRAN

American, Japanese, and Norwegian interests and the National Iranian Gas Company have signed a $700 million contract for constructing LNG facilities to provide 1.2 billion cubic feet of gas daily to Japan.

IRAQ

Japan is providing a $1 billion loan to finance an LNG plant, a cement plant, an aluminum plant, and a petrochemical complex. No details as to the size or exact cost of the plant were available in the January 1974 announcement concerning the tentative project.

KUWAIT

An American engineering firm has been asked to perform the basic feasibility study for a possible liquid petroleum gas complex. The complex, the initial stage of which is expected to cost $100 million, is expected to eventually produce about 65 million cubic feet of LNG daily as well as other liquid petroleum gases.

LIBYA

A liquefaction plant costing $168 million is in operation and producing 345 million cubic feet of gas daily for export to Italy and Spain. The contract with Italy calls for shipping 235 million cubic feet of LNG daily for 20 years; the agreement with Spain calls for supplying 110 million cubic feet daily for 15 years.

MALAYSIA

A Dutch company plans to build a liquefaction plant capable of processing about 750 million cubic feet of gas daily for export to Japan under a 20-year contract. The plant is expected to become operational in 1978. Negotiations are underway to determine the size of each participant's share in the project.

NETHERLANDS

A 13-billion-cubic-feet-a-day LNG plant is in the engineering stage. However, no LNG is presently expected to be exported.

NIGERIA

Negotiations are underway between the Nigerian Government and two groups of companies concerning tentative LNG projects, but no contract has been signed.

RUSSIA

Russia has about one-third of the world's proved natural gas reserves. During the last 3 years the Soviet Government has held a number of discussions with Japanese and U.S. firms desiring to buy the natural gas.

U.S. firms have so far shown the most interest in a partially developed gas field in western Siberia. The cost of developing this field, along with a 1,500-mile pipeline, a gas liquefaction plant, and LNG tankers, has been estimated at from $5 billion to $7 billion. In early 1974, a Soviet delegation to the United States indicated that they desired two things--(1) major U.S. investment and (2) $500 million in trade goods, which when sold in Soviet markets would provide the Soviet portion of financing. In early 1973, the Soviets were considering selling the United States about 2 billion cubic feet of gas a day at a cost of 60 cents per MCF at the port of embarkation. Since then they have indicated that the cost could be as high as $1.50 per MCF at the port of embarkation.

Large natural gas and petroleum deposits also exist in eastern Siberia. The Japanese, and to a lesser degree U.S. firms, are interested in developing this area. A major problem appears to be the high cost, estimated at $10 billion to $12 billion. Russia has indicated that oil and gas lines or a railroad line probably should be built for the exports. Both methods pose problems in supply interruption because the supply line would stretch over 2,000 miles. According to a Department of State official, weather conditions are the major problem in the construction, drilling, and operation of oil and gas fields. The long border between Russia and China could also be a problem, depending upon the political climate between the two nations.

Funding for the two projects is still tenuous. Russia has requested, but not received, an initial Export-Import Bank loan of $49.5 million and is seeking an additional loan of $400 million from both the Japanese and U.S. Export-Import Banks. This is only a minor portion of the estimated $15 billion to $19 billion needed to complete the two projects. Negotiations on the Soviet gas deals are presently at a standstill.

The question of continued availability of gas has been raised. Russia's internal gas demands are rising at about 7 percent a year. By 1985, at the present rate of growth, Russia will double its internal demand. With the long lead time, until 1985 or later, to place these two projects in full operation, the United States and Japan may find they have financed domestic Soviet gas development, thus limiting the amount available for export.

UNITED STATES

The United States has a number of LNG plants and associated storage facilities in operation. The American Gas Association reported that in 1973 36 plants were in operation with a total liquefaction capacity of about

204 million cubic feet a day. An additional 16 plants with a liquefaction capacity of 77 million cubic feet a day had been proposed or were under consideration. The plants are small, averaging less than 6 million cubic feet each of capacity daily. The output of these small LNG plants is stored near consumer markets, where natural geological underground storage structures for natural gas in its gaseous state are not available.

In addition, a number of LNG projects are either planned or operational in Alaska. An American utility firm has proposed a project in the Cook Inlet area of southwestern Alaska which will initially deliver up to 200 million cubic feet of gas daily to southern California users. The capacity is expected to double at a later date.

The estimated total cost (in 1974 dollars) of the liquefaction plant and marine terminal facilities is about $500 million. Total capital expenditures for the project through its completion are estimated to be $924 million. The LNG plant is expected to become operational in 1979.

An LNG project planned for the Prudhoe Bay area of Alaska, as an alternative to a proposed Alaskan-Canadian pipeline system, would deliver approximately 2.8 billion cubic feet of gas per day to Point Conception, California, for distribution to market areas in the continental United States. Gas deliveries will begin around 1980. The proposed LNG plant, expected to have a processing capacity of about 3 billion cubic feet a day of LNG equivalent loaded aboard LNG carriers, will require an investment of about $1.2 billion (in 1974 dollars). Other capital costs, including pipeline and marine terminal facilities, 11 LNG carriers, and administrative costs, will amount to about $4.4 billion.

Another liquefaction plant in Kenai, Alaska, owned by two oil companies, is presently in operation and providing 140 million cubic feet of gas daily to Japan. This plant has been selling LNG to Japan since November 1969.

A problem may arise concerning the shipment of LNG from the Alaskan facilities to other U.S. destinations. The Merchant Marine Act of 1920 (also known as the Jones Act) provides that only U.S. built and owned vessels are to be used to transport water freight between points in the United States, including districts, territories, and possessions. (46 U.S.C. 883 (Supp. III, 1973)). There are as yet no domestically built and owned U.S.

LNG ships. Thus, under the existing statutes, LNG from the proposed and operational liquefaction plants in Alaska could not be shipped to other U.S. ports for domestic use. However, the Act of December 27, 1950, ch. 1155, sections 1, 2, 64 Stat. 1120, has been interpreted as allowing an exception to the rule when the secretaries of cognizant agencies and departments deem waiver to be in the best interests of national defense.

WORLDWIDE PETROCHEMICAL PROJECTS

Many countries are investing in petrochemical projects throughout the world. Stimulated by a year of high demand with improved profit margins, petrochemical projects have been increasing at a rapid pace. As shown in the following table, the worldwide total of projects proposed, planned, or under construction reached a record high of 1,262 in 1975, an increase of about 80 percent over 1974.

Petrochemical Units Worldwide (note a)

	1974	1975
North America	89	163
Latin America	117	315
Asia/Pacific	164	294
Western Europe	164	263
Eastern Europe	110	135
Middle East and Africa	59	92
Total	703	1,262

a/For projects, all units are counted separately--either proposed, planned, or underway at a given location. Some projects involve several units.

Such a building surge could lead to petrochemical surpluses, but this projection may shrink as capital requirements, engineering manpower shortages, and the economic slump take their toll.

Of the 1,262 projects, about 50 were scheduled to be completed in late 1974 or early 1975. Several have completion dates in 1976 or early 1977. The United States has a total of 125 listed projects, more than any other country.

Although petrochemical complexes may represen.. in part a means by which certain producing countries plan to enhance the value of oil and natural gas in world markets, the profit motive is not the only reason for the recent acceleration in petrochemical development. The surge also reflects the drive of countries to reduce imports or to become completely self-sufficient in various petrochemical products.

In terms of number of projects, ethylene and polyethylene complexes lead with 99 and 96 projects, respectively. Growth in petrochemical industries may affect the availability of LNG for export.