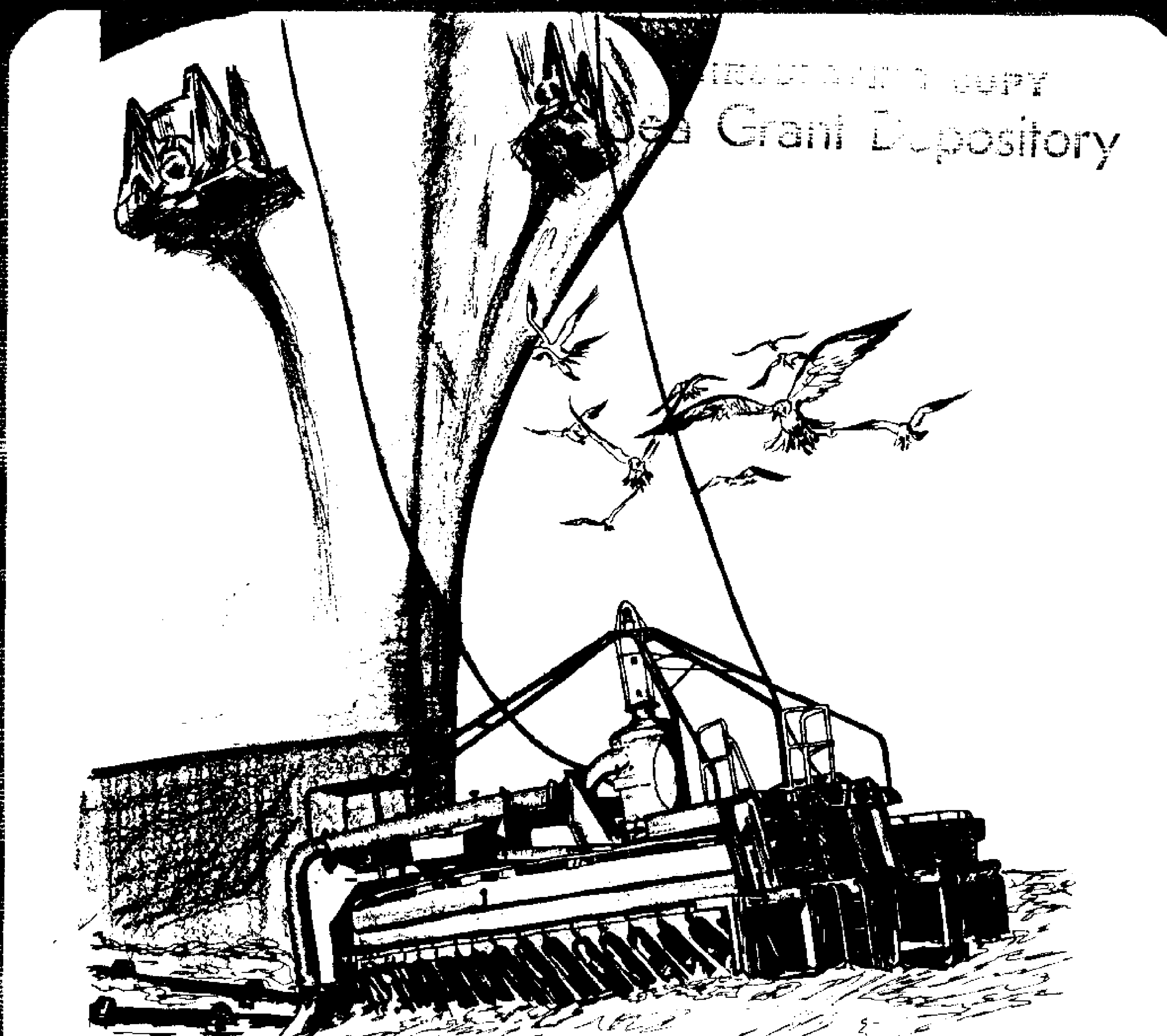
The Economic Impact of a Deepwater Terminal in Texas



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SUMMARY

Determination of the economic impact of a deepwater terminal is an essential prerequisite for building such a facility. Many decisions concerning the terminal will be made on the strength of the anticipated economic gains that such a facility will bring to the region where it is constructed.

The primary impact of a Texas deepwater liquid-bulk terminal will be reflected in growth of the oil refining and related industries in the state. This growth will stimulate a spending and re-spending cycle throughout the economy. The total impact will exceed that of the oil refining industry itself.

It is estimated that the crude oil that will be shipped into Texas in large tankers which can dock only at a deepwater terminal will reach levels of 1.0, 2.1, and 3.5 million barrels per day in 1975, 1980, and 1985 respectively, if national energy needs are met in those years and if Texas retains its historical share of national oil-refining capabilities.

These projected import levels will permit a growth of oil refining runs in Texas from a 1972 level of approximately 3.0 million barrels per day to new highs of 3.94 million in 1975, 5.22 million in 1980 and 6.50 million barrels per day in 1985. These refinery run levels will generate refinery outputs of: in 1975, $6.5 billion; in 1980, $9.7 billion; and in 1985, $13.2 billion.

The economic impact of the increased refinery output forecast for future years in Texas, using multipliers from the Texas Input-Output Model, is estimated to be $16.8 billion, $24.7 billion, and $33.8 billion per year in 1975, 1980, and 1985 respectively. Total impact resulting directly from the deepwater terminal, over and above that resulting from present refinery output, is estimated to be $4.417 billion in 1975, $11.828 billion in 1980, and $21.190 billion in 1985 for a cumulative total from 1975 through 1985 of $119.6 billion. New jobs anticipated in Texas amount to 72,887 in 1975; 193,789 in 1980; and 336,770 in 1985.

Without a deepwater terminal in Texas, the primary impact to the state will be a loss of future job opportunities for workers, reduced amounts of tax monies for public services and reduced levels of activity throughout the economy. It could also place in jeopardy the present levels of employment and sales in the Texas refining industry, estimated at 30,000 jobs and $4.7 billion in 1972, through possible relocation of the existing refining industry nearer sources of crude oil.

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FOREWORD

This report, **The Economic Impact of a Deepwater Terminal in Texas,** is the first known effort to assess the economic multiplier effects of an offshore, bulk-unloading ship terminal in the United States. It has been prepared for several reasons:

- to lay the groundwork for other essential studies of the terminal which have not yet been undertaken
- to act as a stimulus and inspiration to those in both the public and private sectors who will be involved in building the terminal
- to provide data upon which decisions concerning the construction of the terminal will be based.

In addition, some of the conclusions reached should be of help to planners in projecting long-range needs for schools, roads, utilities and other facilities in the Texas coastal region.

An extensive literature review, coupled with a large number of interviews with key individuals in both industry and government, provided the basis for much of this study. The leading published forecasts were used in preparing the forecasts and assumptions found in this report. However, published forecast data were modified where changed conditions or later developments indicated that such modifications were necessary.

This report is not the final answer. It represents only a single picture of the subject area — a situation involving a number of dynamic factors which have complex interrelationships. Therefore, it must be recognized that this report is only one of many possible answers to the question of economic impact of a deepwater terminal. However, it does provide a starting point for the development of better insight by others.

The Industrial Economics Research Division is grateful to the many individuals and organizations whose responses to frequent requests for help were always prompt and cordial. Most outstanding in this respect was Dr. Herb Grubb, Manager of Information Services in the Office of the Governor of Texas, whose help and advice concerning the Texas Input-Output Model was invaluable.

Special appreciation is expressed for support given by the officers and trustees of Texas Superport Study Corporation: Ray R. Brimble, Vernon L. Engberg, Rex W. Grabill, J. W. Hershey, William F. North, Eber H. Peters and John R. Suman, Jr.

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From the staff of the Industrial Economics Research Division, valuable assistance was received from Linda Greer and Bob Richards.

Particular thanks are due to Kathi Jensen of the Center for Marine Resources' staff for her editorial assistance.

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November, 1972

INTRODUCTION

Determination of the economic impact of a deepwater terminal in Texas is a critical element in the total effort leading to establishment of such a facility. Other studies — environmental, engineering, legal, site location and management — all play key roles in determining the eventual outcome of the total study recommendations since physical configuration of the terminal, its location, its legal and jurisdictional status, and type of organizational structure created to operate the facility are all pertinent to the whole fabric of the terminal's construction and operation. However, if the project does not get off to a rolling start in the early stages, its chances for fruition may be markedly decreased, no matter how the other studies come out.

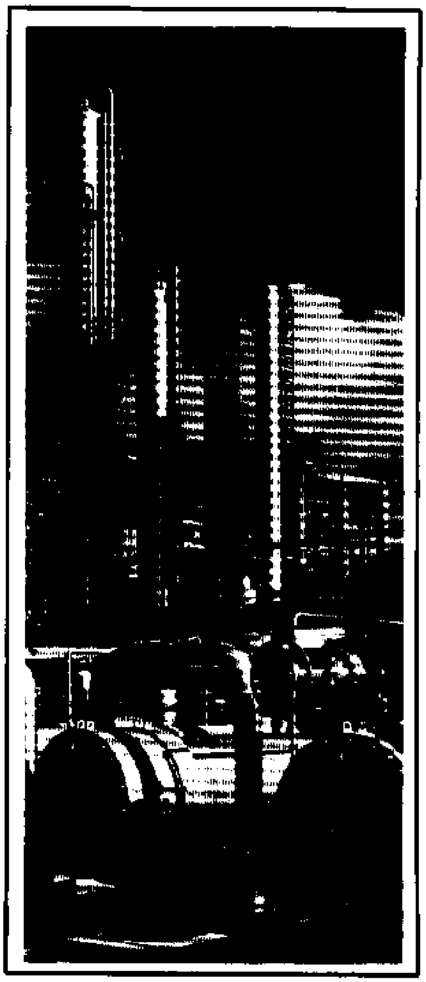
The role played by the economic impact study is to ensure that the project gets off to a good start because:

> Whether or not the terminal gets built, assuming that it is economically feasible, depends upon whether or not permits are issued by the appropriate regulatory agencies. Whether or not permits are issued will depend to a great degree upon public opinion, environmental considerations notwithstanding. And, the nature of public opinion — as to whether or not a deepwater terminal in Texas is needed and desired — will be greatly influenced by the potential economic benefits and environmental effects expected from the terminal and how well these potential impacts are communicated to the public.

The purpose of this study is to assess the potential economic impact of such a terminal. The discussion will consider not only what effects are expected to result from construction and operation of the facility, but also what may happen to the state's economy if the terminal is not built. In arriving at answers to these two theses, several steps are taken: a study area is defined, a methodology for economic impact determination is established, and the nature of the inputs into the model are described. The final result is a quantified statement giving the most likely economic impacts to be generated by a Texas deepwater terminal.

Since the need for a deepwater terminal was first realized, proponents of the project have discussed at great length the many economic advantages of having such a facility in Texas. Even detractors of the project have agreed that the economic impact could be significant. Attempts at quantification of such statements, however, lead the inquirer into a number of questions which, up to now, have remained unanswered. For example, what is the economic significance of a deepwater terminal in Texas? How can its contributions be measured? What sectors of the economy will it impact the most? What best describes its operation? And so on. To accurately determine the potential economic effects of the proposed terminal, answers to these and many other unresolved questions must be found.

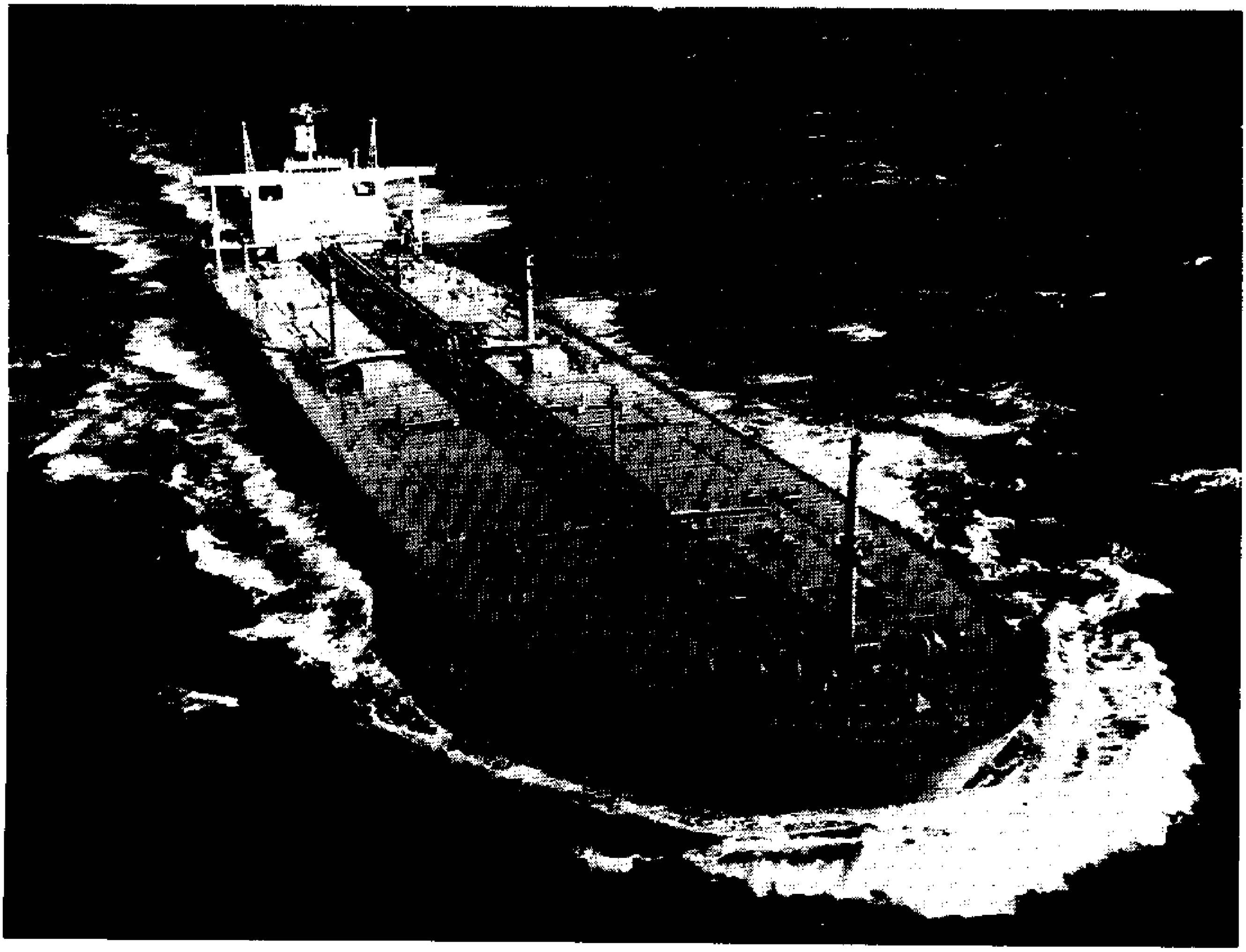
The impact upon Texas of an offshore deepwater terminal will be significant. Construction of a deepwater facility will present a clear opportunity for growth to the industrial community in Texas. Expansion will occur in operations such as oil refining and petrochemicals manufacturing, which utilize oil and gas to produce finished products for export and domestic consumption. Also enjoying growth will be a host of other firms engaged in activities related to the



construction and operation of pipelines, to the provision of transportation services such as ship repair, and to the support and service of the many petroleum-related industries.

Conversely, if no deepwater terminal is built, the trade losses to the state are likely to be considerable. According to Bragg and Bradley,[1] "failure to build a deepwater port may be looked upon by future economists as the 'turning point' marking the beginning of the decline of the Texas Gulf Coast as a dominant figure in the world economic picture."

[1]Bragg, Dan M. and James R. Bradley, "Work Plan for a Study of the Feasibility of an Offshore Terminal in the Texas Gulf Coast Region," Sea Grant Report TAMU-SG-71-212, Texas A&M University, College Station, Texas, June, 1971.



The KINKO MARU, a supertanker operated by the NKK Lines.

TEXAS AND THE NATIONAL ENERGY CRISIS

Energy consumption in the United States is an integral part of economic activity and is essential to the nation's welfare. Practically all human activity depends upon energy. Energy is used not only in virtually every manufacturing operation but also in transportation, lighting, heating, cooling, and in the conversion of energy sources into chemicals, textiles, plastics, pharmaceuticals, and many other products.

Anyone who doubts the importance of energy should try to imagine what conditions would be like without it. Without energy, the nation's economy would come to a standstill. There would be no production of raw materials, no industrial activity, no manufacturing, and no commercial enterprise. If none of the primary energy sources were available, it would be impossible to generate electricity, and the countless needs for electricity everywhere could not be accommodated.[1]

Although a total lack of energy is not in prospect for the United States, the potential for severe shortages is a reality which must be faced. A lasting energy shortage could have drastic effects upon the nation's ability to cope with internal and external problems. Without enough energy, people cannot be adequately fed, waste cannot be disposed of, water cannot be treated and housing shortages would develop. Our vast defense systems would be useless, making the nation helpless against the attack of an aggressor.

In Texas, as in the rest of the nation, the mounting energy crisis is a matter of serious concern. However, because Texas urban and industrial development is somewhat below levels existing in other areas, the state is not beset with the severe environmental problems facing other parts of the nation. Texas historically has enjoyed adequate supplies of energy from intrastate sources and has not had to subsist at the end of a long transportation network. Additionally, the state's weather is relatively mild and there are fewer problems in supplies of heating fuels.

On a long-term basis, however, it now appears that Texas will encounter energy problems similar to those throughout the nation. The stakes in Texas, however, are much higher than elsewhere because of the key role that hydrocarbon processing plays in the state's economy. Without adequate supplies of oil and gas, this industry cannot remain viable.

THE ENERGY PROBLEM

The United States historically has enjoyed a relative abundance of fuels from domestic sources. Our increasing demands for energy have always been met, usually with low-to medium-priced energy forms. An important factor in the nation's unparalleled growth has been the vast reserves of low-priced energy which were always available when we needed them.

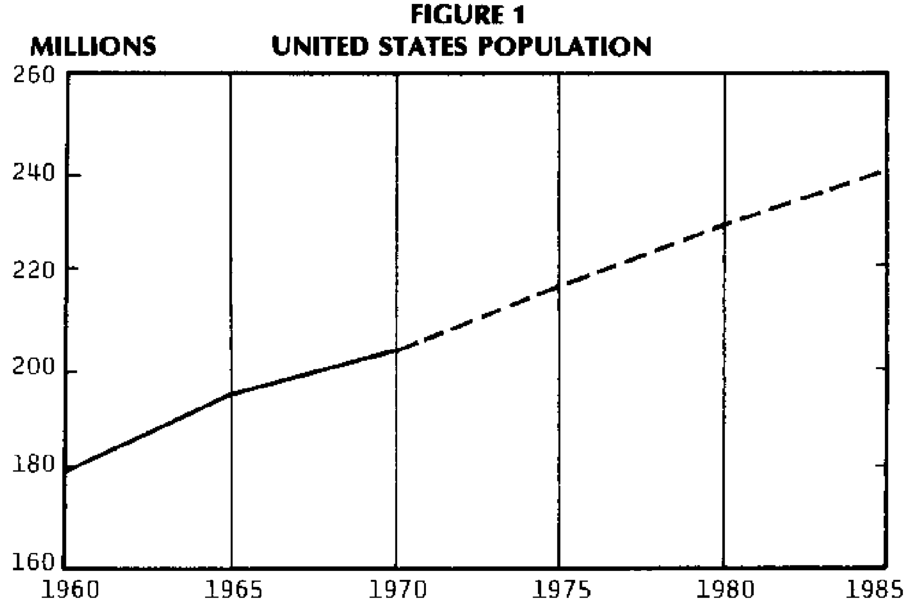
In the next few years, however, the United States will find that it is no longer in the enviable position it once was in regard to energy supplies. Even with full allowables in domestic oil fields and higher prices for natural gas, the nation is no longer capable of being self-sufficient in meeting energy demands and must look increasingly to foreign sources.

What brought on the energy crisis? To find the answer to this, three major factors must be examined — people, our standards of living, and oil production.

Satisfying the needs of people for goods and services is the basic driving force that keeps the economy going. Therefore, a larger number of people means higher levels of energy consumption.

Population growth has continued steadily throughout United States history. Figure 1 shows growth from 1960 to 1970 and projections to 1985.

FIGURE 1
UNITED STATES POPULATION



SOURCE: United States Bureau of Census, Washington, D. C.

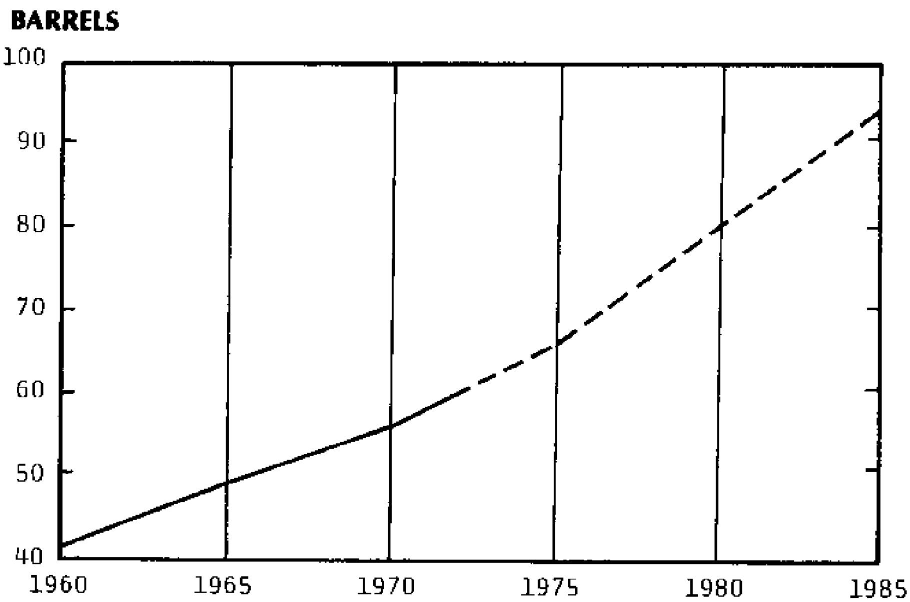
[1]The Chase Manhattan Bank, "Outlook for Energy in the United States to 1985," New York, New York, June, 1972, p. 3.

The Bureau of the Census has predicted a United States population of 241 million by 1985. This is 37 million more than in 1970, but the critical element of concern is the age grouping of the 1985 population. During the years between 1970 and 1985, the 20 to 35 age group will increase by 19 million, nearly twice as much as it increased during the previous 15 years. What makes this so important in terms of energy is that the 20 to 35 age span is the period of most intensive economic activity. Within this age span most marriages occur, most new households are established and most babies are born. During this same period, households are equipped with appliances and second autos are acquired.

In addition to population growth, another major drain on energy reserves is our steadily rising standard of living. The per capita use of energy has doubled in the last 30 years. From 1960 to 1970, although population grew at a rate of 13 percent (180 to 205 million), per capita consumption of energy grew 31 percent (42 to 55 barrels of crude oil equivalent) as Figure 2 shows. With less than six percent of the world's population, the United States accounts for about one-third of world energy use. Our energy use per capita is about seven times that of the rest of the world, reflecting the difference in average living standards.

FIGURE 2

UNITED STATES PER CAPITA CONSUMPTION OF ENERGY PER YEAR (BARRELS OF CRUDE OIL EQUIVALENT)



SOURCE: Shell Oil Company, Houston, Texas.

If current attitudes concerning environmental quality continue to prevail, large amounts of energy will be required to achieve desired environmental conditions. And, if efforts are continued to improve the economic and social well-being of the underprivileged, this will provide additional stimulus to the use of energy.

The third significant factor in the energy crisis is oil production. Since 1956 the number of exploratory and development wells drilled for oil and gas in the United States has decreased more than 50 percent, reaching the lowest level of the postwar period. Domestic operators completed only 27,835 wells in 1971, compared with a record of 58,160 in 1956. However, current trends indicate 1972 operations will show some improvement over the 1971 level, running to as high as 17 percent over last year.

As a result of the slump in drilling, the number of producing oil wells in the United States continues to show a steady decline. The nation had only 512,471 producing wells at the end of 1971, compared to 556,869 in 1966 and the all time high of 617,057 at the end of 1961. Meanwhile, between 1956 and 1971, production of crude oil increased about one-third. As a result, known recoverable reserves of oil available through existing facilities declined to 27.9 billion barrels, excluding Alaska, by the end of 1971. Withdrawal rates from these reserves in 1970 exceeded 10 percent, which is close to the limit of efficient productive capacity. Oil consumption in the United States is rising so rapidly that we are expected to use as much in the next 15 years as has been consumed since the first domestic oil well was tapped in Pennsylvania in 1859. At present rates of consumption, the known recoverable reserves of oil in the United States, not including Alaska, are sufficient for only about 12 more years of use.

A significant point to be made about the drop in producing wells and the rise in consumption rates is that the United States no longer has the spare productive capacity that proved so useful in many emergencies. Even with production at capacity, domestic supplies are falling further behind demands. The deficits are being covered by imports. As Secretary of the Interior Rogers Morton stated at a meeting of the National Petroleum Council in March, 1971, "The nation's entire capacity to act in a crisis may become restricted by its dependence on energy sources over which it has no control."

What is the solution? The immediate solution, most experts agree, is to increase imports of oil to a sufficient level to get the nation through the present crisis until alternate forms of energy can be brought on-stream. Increased imports of oil means the Middle East. Output of oil in the United States cannot be rapidly expanded, even with accelerated leasing of offshore areas. New supplies from Alaska will not soon be forthcoming because of continuing delays in construction of a pipeline. Canada and Latin America are not expected to make much more oil available to the United States because of concern over their own future needs.

ALTERNATE ENERGY FORMS

What about other forms and sources of energy? The major fuels available to meet the energy needs of the United States are coal, nuclear power, natural gas, oil and synthetics. Other forms, such as hydro, geothermal, magnetohydrodynamic and fusion, cannot be depended upon in the foreseeable future.

Coal

It has been estimated that United States domestic coal reserves are sufficient to last from several hundred to as much as 1,000 years.[2] Coal represents the largest, most accessible energy reserve in the United States and its absolute usage is expected to grow about 3.5 percent a year.

[2]"The Energy Dilemma: Part Two," The Houston Post, February 13, 1972.

Electric power plants are the largest consumers of coal, burning 326 million tons in 1971 and expected to use 345 million tons this year. Their use of coal to generate almost half of all United States electric power is expected to increase to 436 million tons by 1976.

Although an adequate supply of coal is available, environmental restrictions on the burning of high-sulphur fossil fuels, along with inadequate production levels resulting from new mine safety laws, will continue to limit the use of coal to meet energy demands.

Nuclear

At present, nuclear energy supplies two percent of our total energy consumption. Its use up to now has been restricted to the generating of electricity. By the end of this decade, however, it is expected that 20 percent of the domestic electric generating capacity will be powered by nuclear energy; by 1985 this should rise to 35 percent. Despite the rapid growth anticipated, however, nuclear energy is not expected to contribute more than 13 percent of total energy supply in 1985.

At present there is much controversy over possible environmental hazards of nuclear plants. As a result, start up of a number of plants has been delayed. However, the use of coal for power generation is also under attack, and with the likelihood that oil and gas cannot meet the demands for power generation, the stage is being set for a direct conflict between consumers and environmentalists when the demands for electricity can no longer be met.

Synthetics

The recovery of energy in synthetic fuel derived from coal, oil shale and tar sands is being actively researched. Oil shale and coal in the United States are among the larger hydrocarbon reserves of the world, but output of recovered synthetic oil and gas is unlikely to reach commercial volume until the 1980's.

By the mid-1980's, oil shale, located mainly in Colorado and Utah, and tar sands, from Canada, may be important fuel sources. By 1985, between 400,000 and 750,000 barrels per day of shale oil could be made available, with tar sand recovery adding another 500,000 to one million barrels daily. Synthetic gas production could reach 10 to 12 billion cubic feet daily.

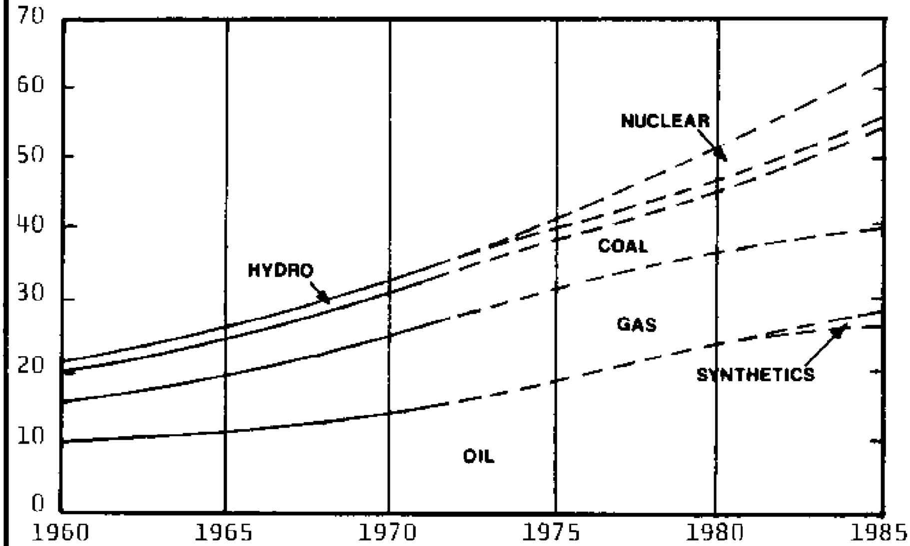
However, when synthetic fuels come into commercial use, they will be expensive. Oil from shale is projected to cost $4.35 to $5.30 a barrel, substantially more than the current average for crude oil of $3.30 per barrel. Synthetic gas is now expected to run $.80 to $1.00 per million B.T.U., which is about the equivalent of a thousand cubic feet of gas in heat value. Price of natural gas currently runs from about $.22 to $.45 for a thousand cubic feet.

ENERGY CONTRIBUTIONS BY FORM

Figures 3 through 7 summarize the demand and supply situation in the United States for the four major energy sources.

FIGURE 3

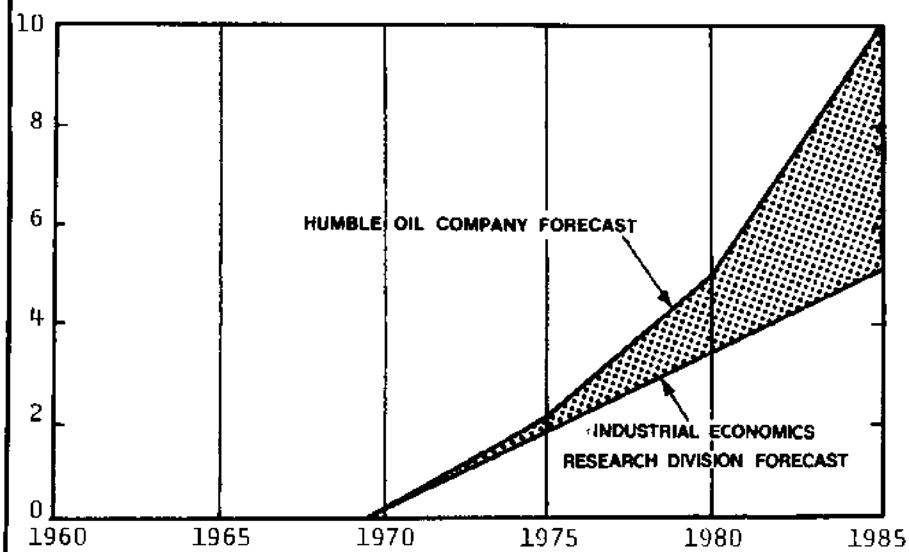
UNITED STATES ENERGY DEMAND BY SOURCE
CRUDE OIL EQUIVALENT
(MILLION BARRELS DAILY)



SOURCE: Humble Oil and Refining Company, Houston, Texas.

FIGURE 4

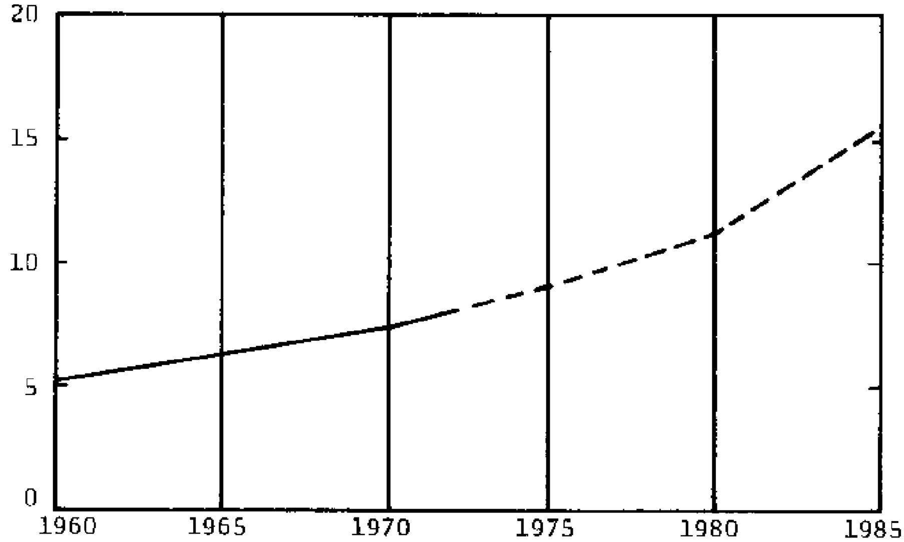
UNITED STATES NUCLEAR POWER SUPPLY
CRUDE OIL EQUIVALENT
(MILLION BARRELS DAILY)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 5

UNITED STATES COAL DEMAND CRUDE OIL EQUIVALENT (MILLION BARRELS DAILY)*

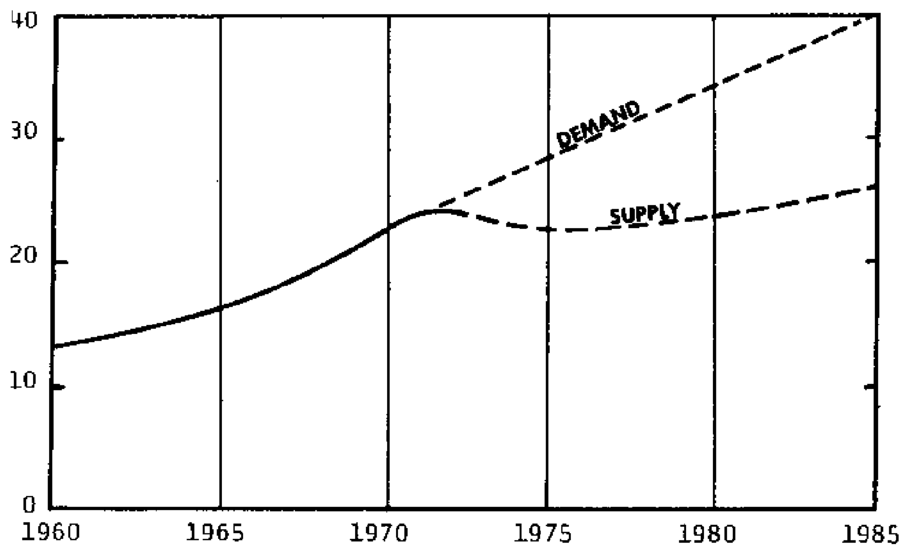


* 1 ton coal = 4.8 barrels of oil

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 6

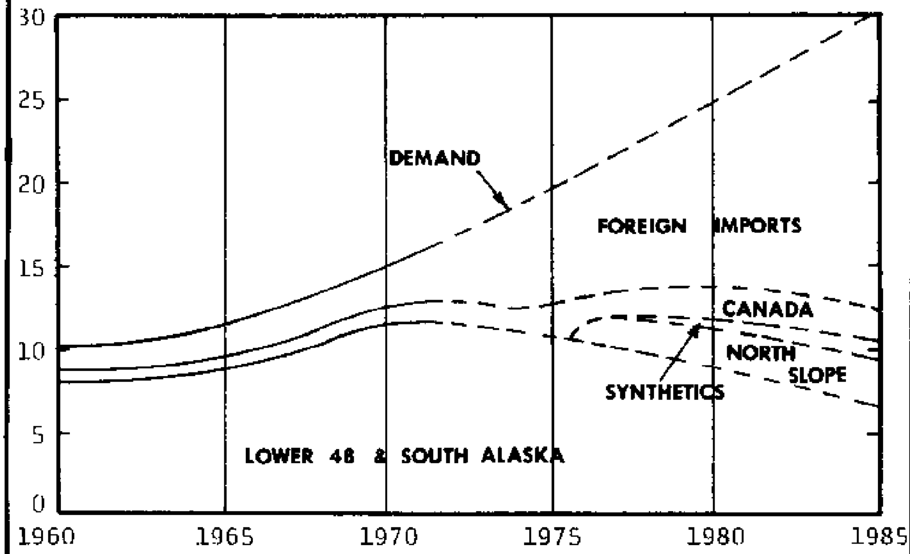
UNITED STATES GAS SUPPLY AND DEMAND (TRILLION CUBIC FEET PER YEAR)



SOURCE: Humble Oil and Refining Company, Houston, Texas.

FIGURE 7

UNITED STATES OIL SUPPLY AND DEMAND (MILLION BARRELS DAILY)



SOURCE: Shell Oil Company, Houston, Texas.

Imported Crude Oil Demand

Future demand for crude oil in Texas primarily will be dependent upon growth in refinery capacities and operating levels. To determine the potential growth of refineries, it is necessary to examine the rational for such growth.

Figure 8 illustrates historical relationships between total United States crude oil production, crude oil demand and crude imports since 1960, and projected to 1985. It should be noted that demand and import levels for petroleum products, although important in the total energy equation for the United States, are not included in this discussion.

As shown in Figure 8, the United States has long been both an importer and major producer of oil. Imports have, however, been relatively insignificant compared to production. A look into the future, on the other hand, shows that rising demand will cause imports to assume a more dominant share of overall oil supply, increasing to as high as 62 percent of total consumption by 1985.

In Texas, history shows that the situation has been entirely different from that of the nation as a whole. Table 1 reveals that past crude receipts by Texas refineries have included some imports, but these shipments

THE NEEDS OF TEXAS

Energy consumption in Texas has been a bellwether indicator of economic growth in the state, probably more strongly than in any other state, because a leading economic activity in Texas for many years has been the production and processing of oil and gas. Oil refining, although it does not consume oil, has a high demand for energy per unit of output when compared to other industry. An oil shortage would not only reduce the energy supply needed to convert raw materials to finished goods, as in the case of a metal working plant for example, but it would also reduce the supply of basic raw material used in the refinery.

Levels of consumption of hydrocarbons in Texas are expected to rise at a greater rate than the nation's average. Texas now consumes 16 percent of the oil used in the United States but, by 1985, present identified growth patterns should drive Texas' energy consumption to much higher levels than indicated by national growth trends.

Population growth in Texas from 1960 to 1970 was 16.9 percent, exceeding that of the United States as a whole (13.3 percent). Also, natural gas demand in the state quadrupled between 1945 and 1970, while — from 1959 to 1971 — electric power consumption almost tripled, from 46 billion to 127 billion kilowatt hours. It is expected, therefore, that by 1985, hydrocarbon consumption in Texas will increase to a new high of 19 percent of total national demand.

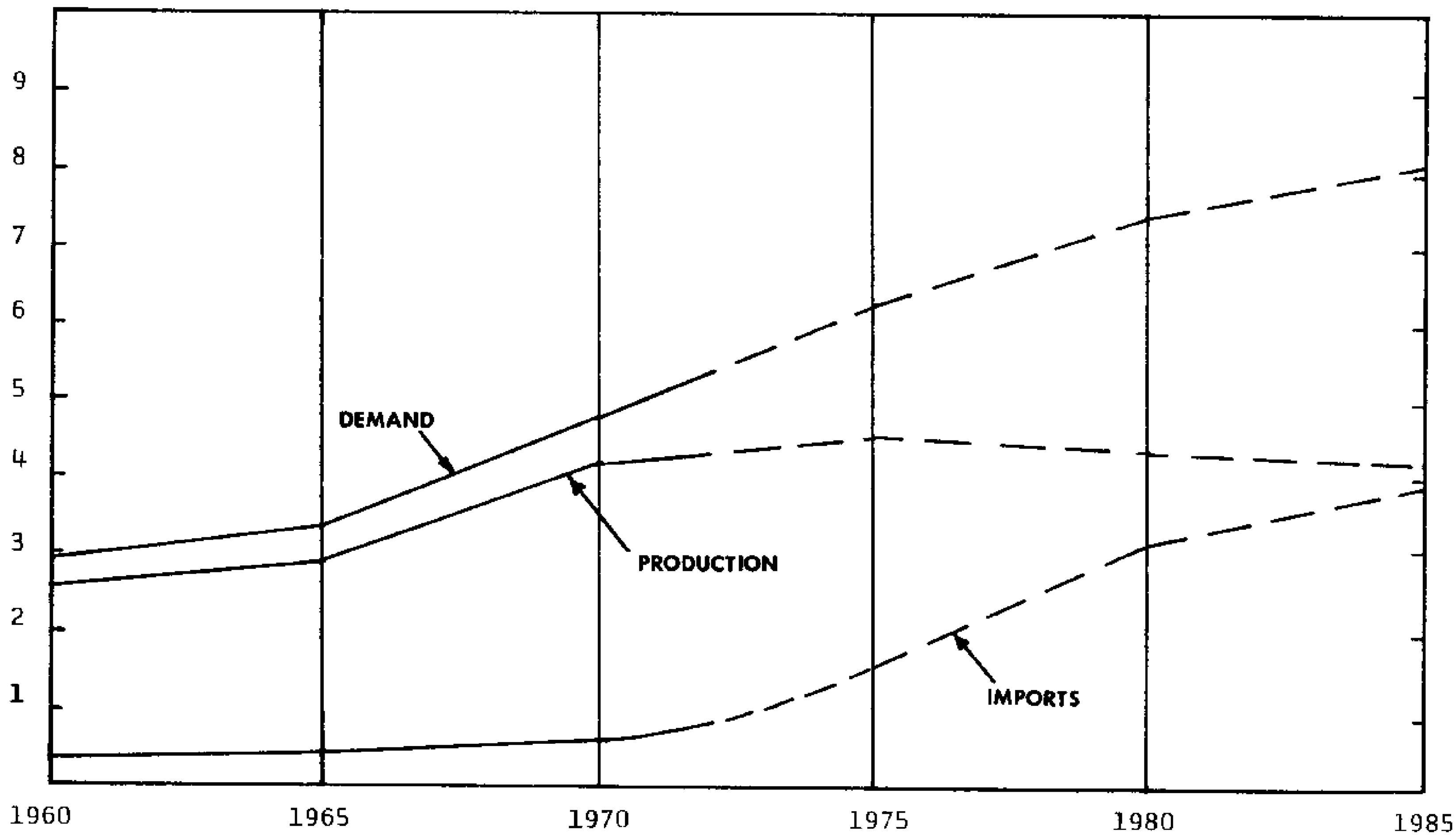
TABLE 1

SOURCES OF CRUDE OIL STATE OF TEXAS (000 Bbls)

YEAR	PRODUCTION	REFINERY RECEIPTS INTRASTATE	REFINERY RECEIPTS INTERSTATE	EXPORTS
1960	927,479	615,312	185,285	338,879
1961	939,191	N. A.	N. A.	N. A.
1962	943,328	626,794	211,463	320,154
1963	977,835	N. A.	N. A.	N. A.
1964	989,525	683,007	215,178	335,900
1965	1,000,749	N. A.	N. A.	N. A.
1966	1,057,706	669,674	253,425	384,523
1967	1,119,962	N. A.	N. A.	N. A.
1968	1,133,380	735,130	264,682	405,935

N.A. — Not Available

SOURCE: American Petroleum Institute, "Petroleum Facts and Figures," Washington, D. C., 1971. *Texas Almanac, 1972-1973.* Bureau of Mines, "Annual Petroleum Statement," *Mineral Industry Survey*, U. S. Department of Interior, Washington, D. C., various years.



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 8

UNITED STATES CRUDE OIL PRODUCTION, DEMAND & IMPORTS
(Billion Barrels Per Year)

have been more than offset by exports and, as a net result, Texas has always been an oil-exporting state. This situation still exists. With the expected rise in demand for refined products on a national basis, however, Texas cannot hope to continue being a net oil-exporter indefinitely.

Refinery Capacity Changes

To consider the possibility and magnitude of future refinery expansions in Texas, it is necessary first to study present levels and future prospects for such expansions on three levels: United States, State of Texas and Texas Gulf Coast. These relationships for the United States are shown in Figure 9. Refinery output in Texas, due to the excess of output over intrastate demand, plays a key role in the national energy picture. And, whatever happens to the demand/supply situation on the national scene will have a direct bearing on what happens in Texas.

To properly evaluate the effect of national developments on oil-refining capacities and operating levels in Texas, and from this, to determine the need for a deepwater terminal in the state, it is necessary to make a basic assumption concerning the national and state interrelationship. Although demand for all forms of energy will continue to display rapid growth nationally, environmental constraints on the use of coal, coupled with growing shortfalls in natural gas supplies, will tend to create unusually strong demands for liquid petroleum in the East Coast area. However, because of several negative factors, expansion of the region's refining capacity will be severely restricted. Based on this, the following assumption has been made:

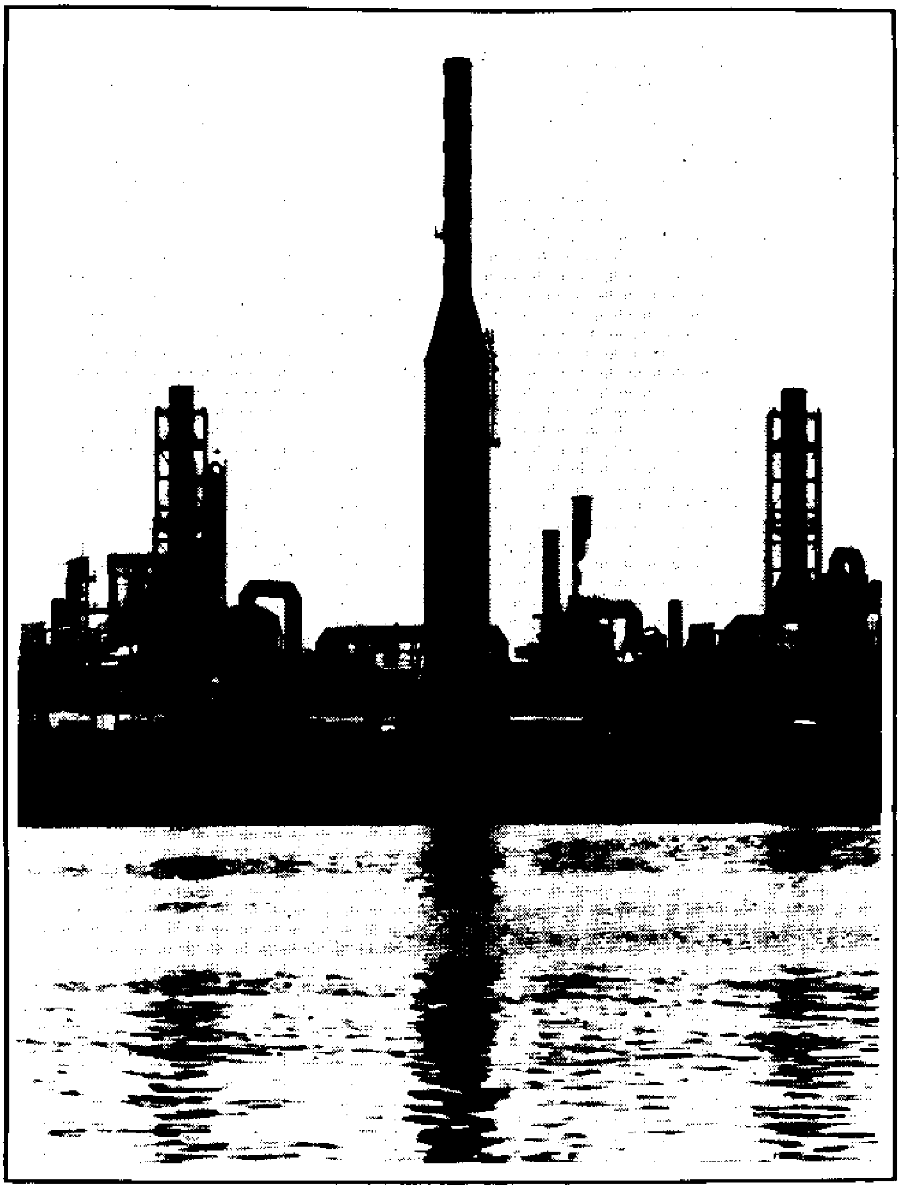
> Because of various factors such as adverse public opinion, restrictive legislation, and a general lack of suitable refinery sites on the East Coast, the present ratios of refinery capacity and petroleum product demand between Gulf Coast and East Coast regions will remain almost constant in the future. That is, the Gulf Coast will continue to have 40 percent of the nation's refining capacity but only about 16 to 19 percent of the total demand for products, while the East Coast will still have only 12 percent of national refining capacity but will have a demand for 40 percent or more of the total petroleum consumed in the United States.

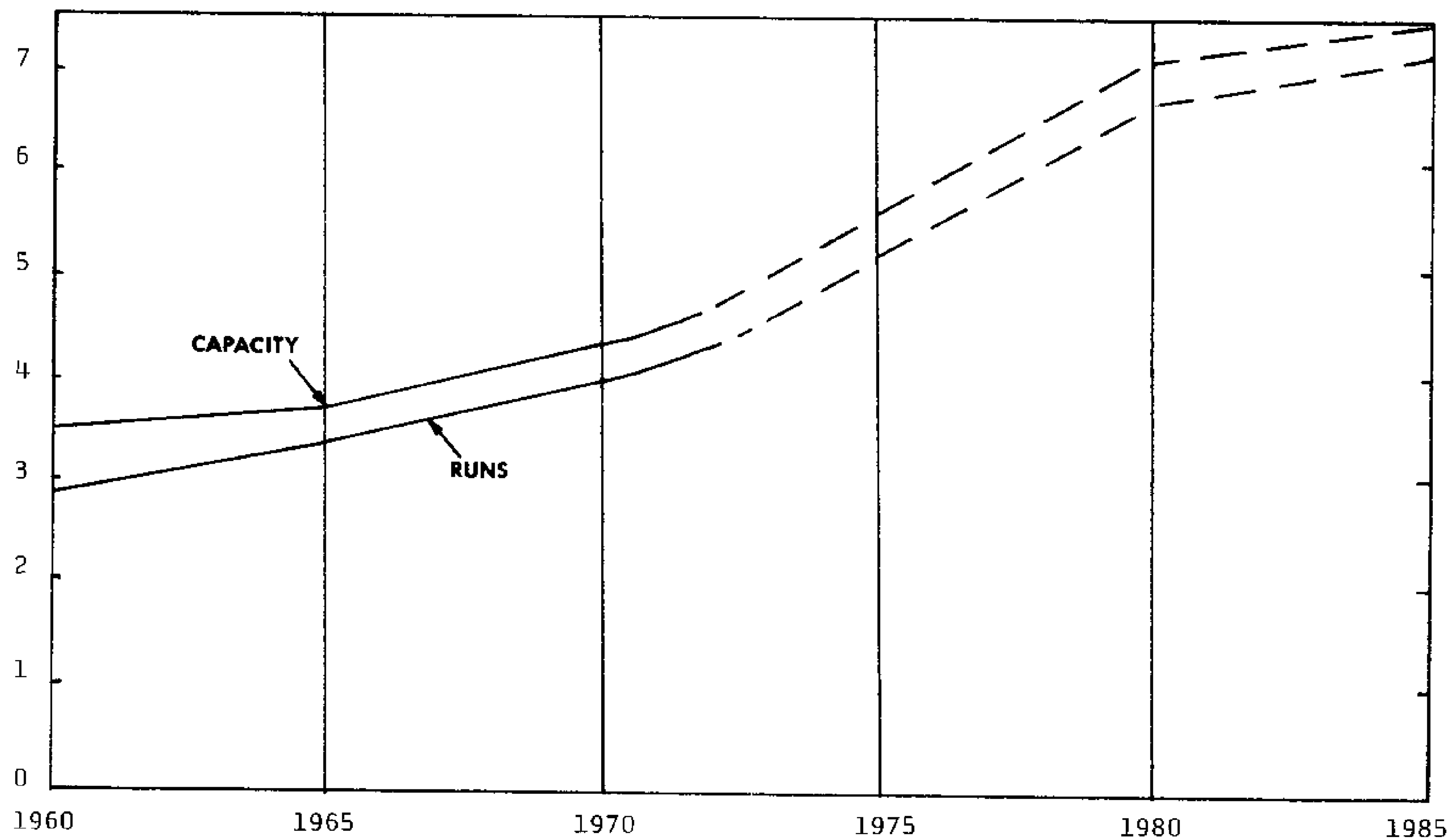
Under this assumption, Texas is expected to retain or even increase its historical share of national refining activity. As Table 2 shows, Texas refinery capacity has averaged 26 percent of national capacity in recent years, while crude runs to stills in the state have averaged 27 percent of total United States runs.

Figure 10 shows the Texas refinery capacity and average refinery runs from 1960 to 1985. Texas crude oil production for the same time frame is also shown to illustrate how demand compares to supply. Using the ratios between United States and Texas refinery runs, shown in Table 2, and considering the assumption made above, Texas refinery capacities and refinery runs in Figure 10 have been extrapolated along the same slope as that shown by United States crude oil demand in Figure 8, in order to show Texas crude demand to 1985. Future refinery capacity in the state, for 1975, 1980, and 1985 is projected to be 4.50, 5.97 and 7.43 million barrels per day respectively. Projected imports are also shown.

Refinery capacities and average crude runs for the United States, and the same data for the Texas Gulf Coast, along with figures showing the percent share that the Texas Gulf Coast, activity represents of total national levels, are shown in Table 3. As the illustration indicates, Texas Gulf Coast refinery capacity has averaged 23 percent of national capacity during the last decade, while crude runs to stills in the region have also averaged 23 percent of total United States run.

Figure 11 shows Texas Gulf Coast region refinery capacities and average refinery runs from 1960. By using the ratios of United States and Texas Gulf Coast refining activities shown in Table 3, and considering the basic assumption made earlier regarding the future ratios of United States and Texas refining activities, Texas Gulf Coast refinery levels have been extrapolated to 1985. Refinery operating capacities in 1975, 1980, and 1985, compared to the current level, are estimated to be 3.94, 5.22 and 6.50 million barrels per day, respectively.

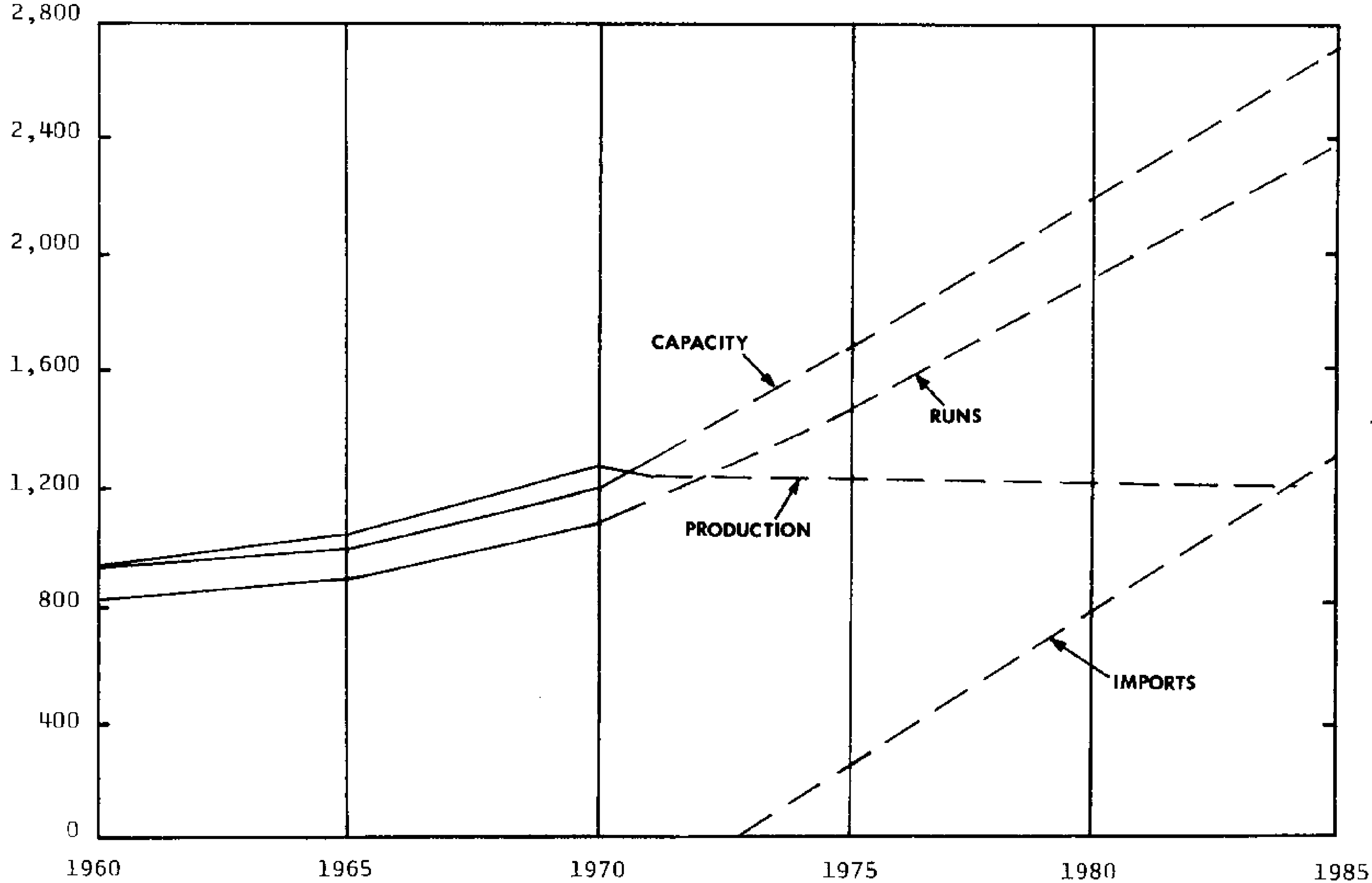




SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 9

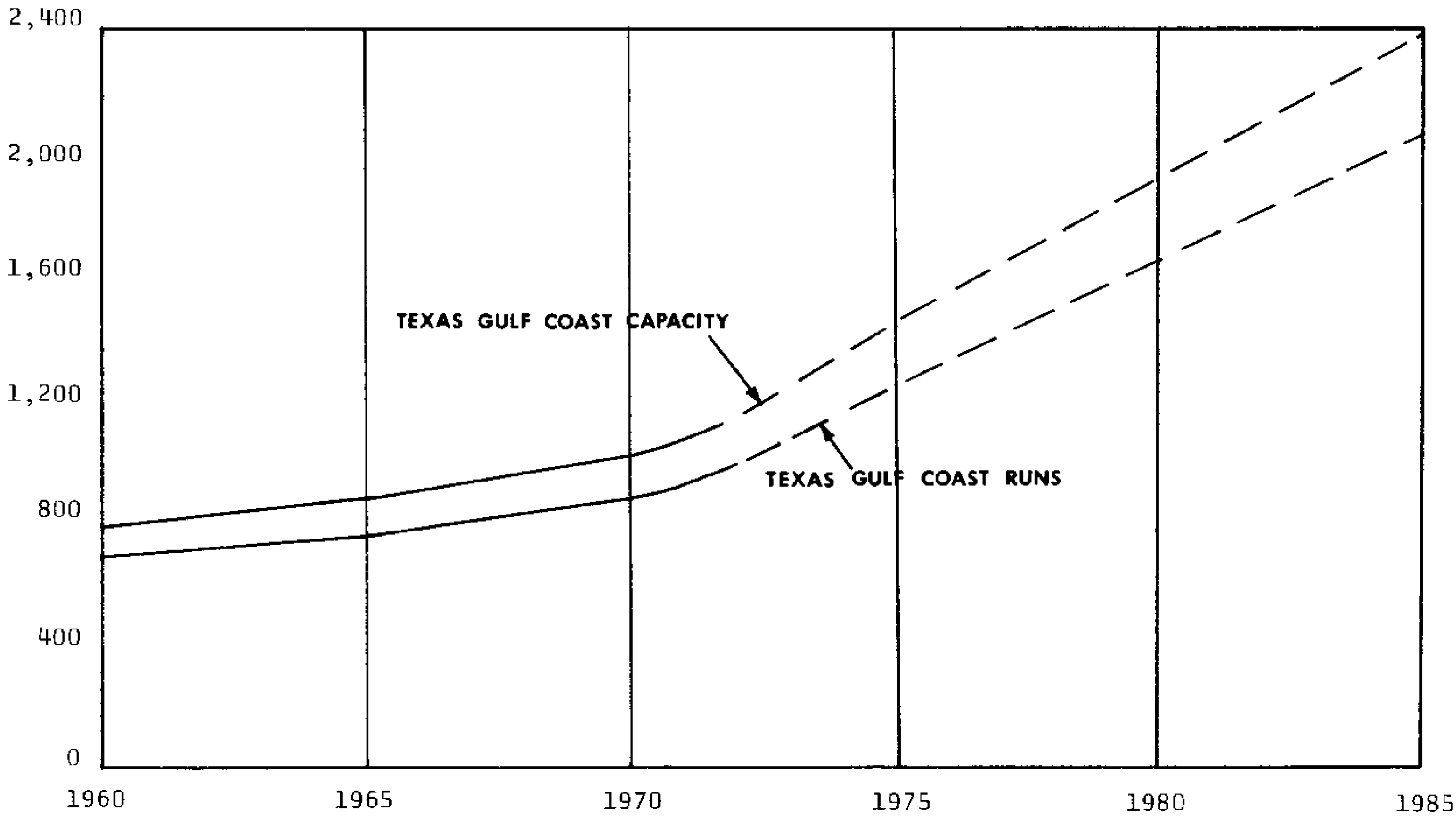
UNITED STATES REFINERY CAPACITY AND RUNS
(Billion Barrels Per Year)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 10

TEXAS REFINERY CAPACITIES AND RUNS, CRUDE PRODUCTION AND CRUDE IMPORTS (Million Barrels Per Year)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 11

TEXAS GULF COAST
REFINERY CAPACITIES AND RUNS
(Million Barrels Per Year)

TABLE 2

REFINING CAPACITIES AND RUNS TEXAS AND UNITED STATES

YEAR	REFINING CAPACITY (BBL/DAY) U. S.	TEXAS	% U. S.	REFINERY RUNS (BBLS/DAY) U. S.	TEXAS	% U. S.
1960	9,543,329	2,545,620	26.7	8,067,032	2,197,000	27.2
1961	9,629,685	2,521,590	26.2	8,183,994	2,189,000	26.8
1962	9,812,248	2,612,500	26.6	8,409,947	2,295,000	27.3
1963	9,814,791	2,605,950	26.6	8,686,718	2,401,000	27.6
1964	10,063,164	2,664,750	26.5	8,806,910	2,410,000	27.4
1965	10,161,311	2,732,015	26.9	9,043,403	2,437,000	27.0
1966	10,171,159	2,729,102	26.8	9,444,364	2,525,000	26.7
1967	10,412,447	2,769,732	26.6	9,815,000	2,633,000	26.8
1968	11,172,694	3,075,464	27.5	10,312,000	2,773,000	26.9
1969	11,575,829	3,126,679	27.0	10,630,000	N.A.	-
1970	11,882,393	3,235,342	27.2	N.A.	N.A.	-
1971	12,299,922	3,320,979	27.0	N.A.	N.A.	-
1972	13,087,223	3,469,605	26.5	N.A.	N.A.	-

N.A. — Not Available

SOURCE: American Petroleum Institute, "Petroleum Facts and Figures, 1971" API, Washington, D. C., 1971.

TABLE 3

REFINING CAPACITIES AND RUNS TEXAS GULF COAST AND THE UNITED STATES

YEAR	REFINING CAPACITY (BBL/DAY) U. S.	TEXAS GULF COAST	% U. S.	REFINERY RUNS (BBLS/DAY) U. S.	TEXAS GULF COAST	% U. S.
1960	9,543,329	2,186,220	22.9	8,067,032	1,904,000	23.6
1961	9,629,685	2,156,340	22.4	8,183,994	1,885,000	23.0
1962	9,812,248	2,241,000	22.8	8,409,947	1,986,000	23.6
1963	9,814,791	2,235,850	22.8	8,686,718	2,092,000	24.1
1964	10,063,164	2,321,050	23.1	8,806,910	2,093,000	23.8
1965	10,161,311	2,355,850	23.2	9,043,403	2,117,000	23.4
1966	10,171,159	2,358,350	23.2	9,444,364	2,185,000	23.1
1967	10,412,447	2,396,500	23.0	9,815,000	2,283,000	23.3
1968	11,172,694	2,687,700	24.1	10,312,000	2,362,000	22.9
1969	11,575,829	2,734,700	23.6	10,630,000	N.A.	-
1970	11,882,393	N.A.	-	N.A.	N.A.	-

N.A. — Not Available

SOURCE: American Petroleum Institute, "Petroleum Facts and Figures, 1971" API, Washington, D. C., 1971.

A bay near Houston is dotted with platforms for drilling operations or producing wells.

ECONOMIC EVALUATION CRITERIA

To evaluate the economic impact of a deepwater terminal in Texas, it is essential to establish representative criteria for study to ensure that the results obtained are relevant and meaningful. Two major requirements for achieving relevance are, first, choice of a factor or factors which are most susceptible to being impacted by the facility and, second, designating the most likely geographic area or areas of impact.

In this section, decisions are formulated and justified for the economic evaluation criteria used.

DELINEATION OF STUDY AREAS

To assess the effect of a deepwater terminal in the Texas economy, regions of impact must be established. Since economic spinoffs of a major industry operation such as this are varied and occur in a complex and overlapping pattern of interrelationships, it is impossible to trace each thread of impact to its ending point in the economic structure. Researchers, therefore, frequently use geopolitical boundaries to delineate a study area. As with other methods, the accuracy of results is a function of how carefully those boundaries are selected.

To answer questions about the multiplier effects of changes in the base economy, the investigator must have some knowledge of current conditions. This description of current changes must be formulated so that both the immediate and indirect impact of any expected changes can be determined. These information requirements at the national level have been reasonably well met by the federal government. A voluminous amount of data is compiled and published on a quarterly or annual basis by the Department of Commerce and the Department of Labor. In addition, detailed information is available from the Census of Population taken every ten years and from the Census of Manufactures, Agriculture, Business and Mining every five years.

Information about subnational areas within the United States, however, is inadequate. Although many attempts have been made by government agencies and private organizations to provide this information, searches for various data describing conditions in a state, city, or county are frequently unsuccessful.

This lack of available useful information on characteristics of local areas has a twofold implication to investigators and planners. First, it means that many decisions must be made without complete knowledge of existing conditions in a given area and existing interrelationships among economic sectors. Second, the ability to use available information is limited because such data do not easily lend themselves to analysis of the effects of significant changes in the community economy. A study area must, therefore, be configured to provide the greatest accuracy possible with available information.

In many economic investigations, study areas are those that follow boundary lines of existing political subdivisions, encompassing a region believed to represent the area of primary economic impact. The most commonly-available statistical economic data appear in these subdivision units. Examples of such data units are cities, counties, school districts, councils of government (COG) and standard metropolitan statistical areas (SMSA).

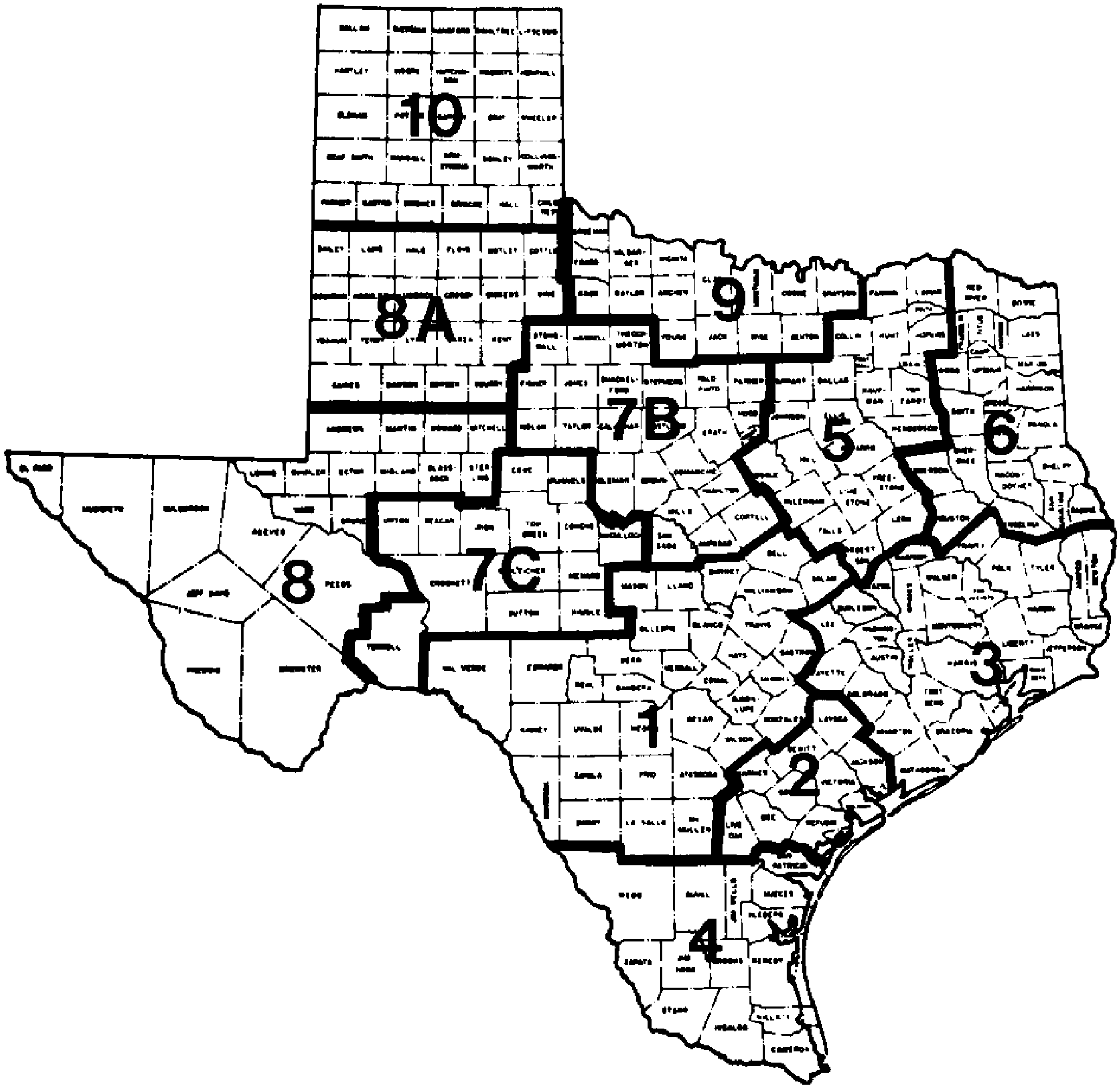
The Primary Area

One recent designation established in Texas and in several other states is that of Coastal Zone. During preliminary studies leading to this economic impact analysis, the Texas Coastal Zone was considered a representative area in which to examine the economic effects of the deepwater terminal. However, Miloy and Copp[1] define the coastal zone as "that geographical area having a boundary with the sea or ocean which is affected by its proximity to the sea and also that part of the ocean which is affected by its proximity to the land. It includes the inshore part of the continental shelf, the ocean shoreline and the estuaries with their marginal shores." This coastal zone definition is adequate for analysis of offshore mineral resources, fisheries, oceanographic-related research, pollution, air sea interaction, aquaculture and marine recreation. If this definition is used, however, it restricts the analysis to the contiguous coastal area. Since the economic effects of a deepwater terminal, the principal function of which will be the unloading of crude oil, will extend further inland than just the land-sea interface, then the coastal zone is probably not the best-defined area to use in this study.

Examination of statistical information sources concerning two primary factors in the deepwater terminal study — crude oil supplies and oil refining activities — suggests that some existing geographic delineations lend themselves for study as primary economic impact areas. For example, crude oil production in Texas is reported to the Texas Railroad Commission and other regulatory agencies by Oil Conservation Districts. Figure 12 shows the boundaries of these districts. Note that the boundaries of Districts 2, 3, and 4 include the coastal area.

Another geographic designation commonly used as the basis for reporting large amounts of oil industry data is the refinery district. These areas, designated by the Bureau of Mines of the Department of Interior, are used as reporting units for data on numerous facets of the oil refining industry, ranging from crude runs to operating capacities to product outputs. Figure 13 shows Bureau of Mines refinery districts for the southern

[1]Miloy, John and E. A. Copp, "Economic Impact Analysis of Texas Marine Resources and Industries," Sea Grant Report TAMU-SG-70-217, Texas A&M University, College Station, Texas, 1970.



SOURCE: Texas Railroad Commission, Austin, Texas.

FIGURE 12

TEXAS OIL CONSERVATION DISTRICTS

SOURCE: American Petroleum Institute, Washington, D. C.

FIGURE 13

REFINERY DISTRICTS IN PAD* III

*Petroleum Administration for Defense District

United States. Note the boundary of the Texas Gulf Coast District and its close similarity to the combined outer perimeter of Texas Railroad Commission Oil Conservation Districts 2, 3 and 4.

An examination of the study regions used in development of the Texas Input-Output Model, a recently-released economic study tool, shows that three of the regions are concentrated along the Gulf Coast of Texas. Further examination of these subdivisions, Regions 7, 8, and 9, shows that their combined periphery is quite close to the boundary of the Texas Gulf refining district, established by the Bureau of Mines, and also quite close to the joint outline of Oil Conservation Districts 2, 3, and 4, established by the Texas Railroad Commission. Geographical similarity of these three sets of subdivisions is illustrated in Figure 14.

For this study, resource data from the oil conservation districts and the Texas Gulf Coast refining district are used. Application of these data in the determination of economic impact is, however, through the use of multipliers from the Texas Input-Output Model (based on study regions 7, 8, and 9). Accuracy of results using this combination of study areas should be more than adequate due to the similar geographic areas encompassed by each set of subdivisions.

The Secondary Area

Impact of a deepwater terminal in Texas will occur more directly and to a higher degree in the Texas coastal region than it will throughout the rest of the state and the Southwest. Obviously, proximity to such an activity is important; the diseconomies of distance tend to cause expenditures by a facility to cluster in the region around the facility. Overcoming distance involves both material and time costs and, all other things being equal, economic units attempt to minimize these costs.

In the case of the deepwater terminal, other reasons besides proximity will cause the greater part of the economic impact to be felt in the coastal region. As established in discussion appearing later in this chapter, the primary impact of a Texas deepwater terminal will be transmitted to the economy through growth in refinery output. The Texas coastal region — the primary area defined earlier — contains almost 90 percent of total refining capacity in Texas. Thus, it is expected that a high percentage of impact will occur in areas most proximate to the Gulf Coast refineries. However, a portion of the money generated by output of these refineries "leaks" out of the regional economy and tends to reduce the

A deepwater terminal's main impact will be on refinery growth.

overall multiplicative effect in the region. These leakages normally occur in the areas of capital consumption allowances, corporate overhead, profits, purchases from outside the region, and expenses of sales outside the region.

In addition to the effects of economic leakage, the proposed terminal will also impact the economy outside the primary region through facilitating refinery growth in other regions. For the purposes of this study, the secondary area of impact includes and is limited to the rest of the State of Texas outside the primary region. Computation of impact in the secondary area includes the direct, indirect and induced effects of refinery growth in the secondary area only, plus the secondary direct, indirect and induced effects of "leakage" from the primary area.

PRIMARY IMPACT FACTORS

To evaluate the economic impact of a change in the economic base of a region, those sectors of the economy most likely to be directly affected by the change must be identified. In the case of the Texas deepwater terminal, these sectors, which are considered as "primary factors of impact," are identified by studying the main functions of the terminal and deciding how the terminal stimulates these primary factors as it fulfills its functions.

Functions of a Deepwater Terminal

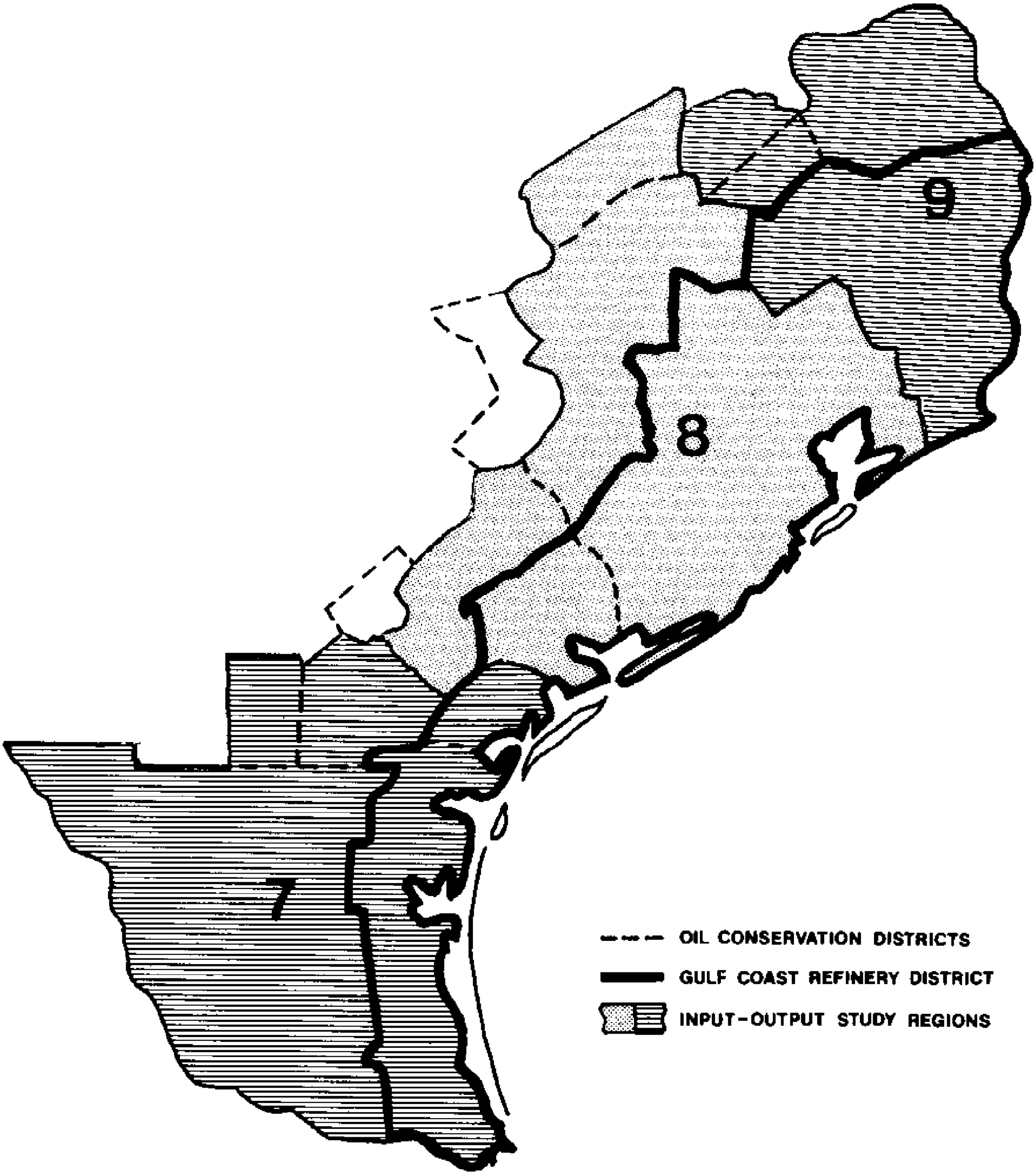
The principal purpose of a deepwater terminal is to serve as a berth for the docking, and loading or unloading, of ocean-going ships that require water depths, for hull clearance, greater than those depths available in existing conventional ports and harbors. The reason deepwater terminals are being considered for Texas was developed in the section entitled "Texas and the National Energy Crisis." Briefly, the growing demand for energy in the United States has created a need for petroleum that can be met, on a short-range basis, only with imported oil. Even oil-rich areas like Texas will soon require large amounts of imported petroleum and petroleum products to satisfy the combined demands of refiners and consumers in the state.

As concluded in a later section of this report entitled Commodities and Volumes, the movement of bulk commodities other than crude petroleum and its products is not expected to be a significant factor in the operation of a deepwater terminal in Texas, for at least the next several decades. Consequently, the Texas terminal will be designed initially for the handling of liquids only. Bulk solids, except for those capable of being slurried into liquid form, will not be moved through this terminal in the immediate future and are not, therefore, considered in the calculation of economic impact.

The economics of mammoth seagoing bulk ships are most favorable on very long voyages. On shorter trips, the costs of loading and unloading, including entry into and exit from mooring areas, along with other associated activities, become a significant factor in the overall economic equation, and increase the ton-mile cost of transportation in these vessels to unattractive levels. For this reason, the use of mammoth ships to move crude oil and products in United States coastwise trade will likely not prove economically feasible under routine business conditions. The use of pipelines and smaller "coaster" vessels is expected to continue and to expand as demand for products increases.

Thus, for all practical purposes, the primary effects of a Texas deepwater terminal on the economy of the state will be a direct result of the movement of foreign crude oil through the facility. Economic impact will be limited to those sectors of the economy in which imported crude oil will play a leading role.

In Texas, the only sector that will be directly affected by import of foreign crude will be the oil refining industry. Texas refinery demands, up to 1972, have been met almost entirely with domestic crude oil; however, crude production appears to have reached a peak level in the state this year and future refinery capacity expansions will depend almost wholly upon the availability of imported crude oil. Therefore, economic impact of the deepwater terminal will be a direct function of Texas refinery growth, plus the additional, relatively small amounts of growth in port-related activities.



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 14

STUDY REGIONS

Transit sheds for general cargo handling at the Port of Port Arthur, Texas.

COMMODITIES AND VOLUMES

Deepwater port facilities have become a major concern throughout the world because the oceanborne movement of bulk commodities is quite large and growing at a fast rate. In 1971, for example, world oceanborne shipments of six major bulk commodities — oil, iron ore, coal, coarse grains, phosphate rock and bauxite — amounted to over 1.9 billion short tons. Of these six commodities, crude oil and petroleum products accounted for over 72 percent of the trade, iron ore was 14 percent, and the remainder was coal, grains, phosphate rock and bauxite.

United States oceanborne bulk shipping comprised about 15 percent of the 1971 movements, while Japan's exceeded 20 percent of the world total. Although the United States historically has not been greatly dependent upon trade because of our wealth of domestic resources, this picture is changing. The nation increasingly imports raw materials like petroleum and bauxite, and exports coal and grains. Because oceanborne trade is becoming so important, our capability to handle goods through our ports becomes more and more critical.

According to Litton,[1] United States oceanborne imports will reach 1.9 billion long tons per year by 2043 and, during the same period, exports will be 2.2 billion long tons per year. This is a total oceanborne trade for the United States of 4.1 billion long tons annually, more than double the 1971 world total. In comparison, world ocean trade will total 35 billion long tons in 2043.

FORECASTING RATIONALE

In forecasting trade projections for bulk commodities, it is not enough to merely extrapolate past trends in a straight-line manner; rather, it is essential to determine individually for each commodity the factors underlying the trade pattern. Such things as unique, nonrecurring factors that have affected previous trends should be examined. For example, the European Common Market imposed quotas on coal imports in the late 1950's and this action depressed United States coal exports to Europe for several years during the early 1960's. However, these movements are now back to normal.

Other very positive indicators which must be evaluated are future developments like the exhausting of reserves, such as iron ore. The initial iron ore source developed in the Mesabi Range of the United States was found over 100 years ago. Ores first produced there had an iron content greater than 70 percent. Over the years, however, United States steelmaking has depleted the higher-quality ore bodies to the extent that the richest ore left at Mesabi contains only 50 percent iron. Partly as a consequence of this, imports of iron ore to the United States have climbed from five million tons in 1949 to 36 million tons in 1969.

GULF COAST BULK TRAFFIC

The basic forecasting method used for Gulf Coast bulk traffic projections consisted of three steps:

1. Study of past trends
2. Projection of these trends into the future
3. Adjustment of these projections based upon expected developments such as exhaustion of raw materials, shift in trade patterns and changes in demand.

In addition, published forecasts by such agencies as the Bureau of Mines and the Foreign Agriculture Service were used.

Forecasts of bulk traffic for the Texas Gulf Coast have been separated for this study into three categories: grains, non-fuel minerals and fuels. Commodities to be considered include: wheat; rice and grain sorghum; sulphur; iron ore; aluminum ore; ammonium sulfate and aluminum compounds; crude petroleum and its products. The commodities used were selected on three primary criteria: past tonnage shipped, suitability for bulk shipping and known future demands.

Many variables, such as politics and vagaries of nature, which might impact oceanborne trade have no rational basis and they cannot be considered in projecting import and export data. Therefore, the forecasts can be considered valid if:

1. No political disruptions occur;
2. No major depressions or natural disasters occur;
3. No unforeseen technological changes occur.

EXPORTS

The major determinants in the United States export forecasts are future world demand and world production. Whether the Gulf Coast is a major exporter of any commodity is determined largely by which countries import them. Western Europe, Latin America and some Asian countries are the major destinations of Gulf Coast exports.

Grains

Three major assumptions are considered in forecasting foreign demand for grain products. The first assumption is that existing trends and government policies will continue and that a "green revolution" brought about by higher yielding grains and improved agricultural practices will continue in the lesser developed countries (LDC's). The second and third assumptions consider an acceleration or deceleration of a "green revolution." Generally, an accelerated "green revolution" in the LDC's would result in a decreasing dependence on grain imports, while a decelerated "green revolution" would have the opposite effect.

The forecasts which follow reflect these three assumptions by showing a range of values for future grain shipments.

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[1]Litton Systems, Inc., "Oceanborne Shipping: Demand and Technology Forecast," Culver City, California, June, 1968.

Insofar as non-recurring factors are concerned, no attempt is made to incorporate into the forecasts the effect of the 1972 grain sale to Russia because this event was the result of a crop failure and cannot be considered as a factor affecting future export levels.

Grain exports through Texas Gulf ports consist primarily of wheat, rice and grain sorghum.[2]

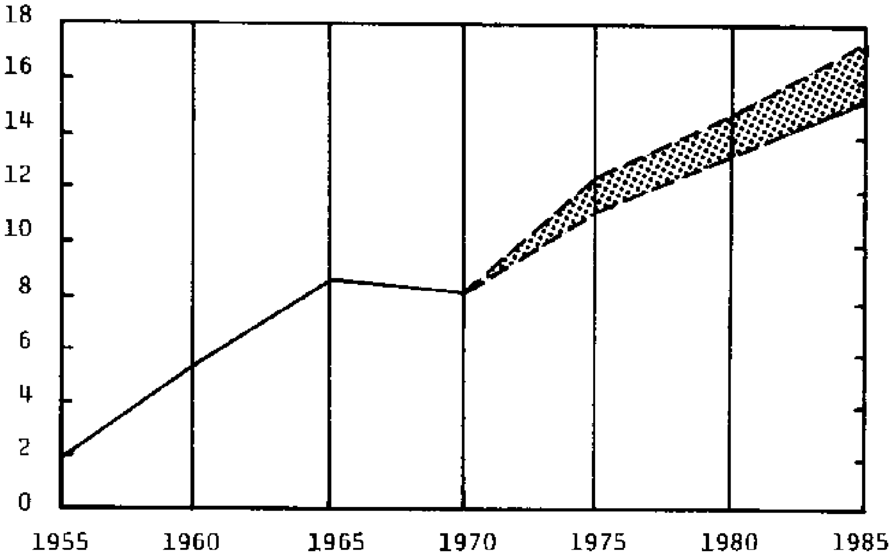
Wheat. Major importers of wheat in the future are expected to be the LDC's. Projections indicate that developed countries will import a total of 7.1 million metric tons in 1980, over one million less than the 1964-1966 average of 8.4 million metric tons. The LDC's are expected to import nearly ten million metric tons more in 1980 than the 1964-1966 average of 23.3 million metric tons. Imports by the Communist Bloc countries are quite variable, but a tentative projection of 3.4 million metric tons has been set for 1980. The large import projection for the LDC's stems mainly from an assumption of substantially improved living conditions in areas not ideally suited for greatly increased wheat production.

If no new major producers enter the market and if foreign policy remains the same, the United States should be the largest net exporter. The percentage of wheat shipped from the Gulf Coast has risen in recent years as wheat producers have begun to utilize low cost barge traffic in shipping. The North Atlantic ports are becoming less important as wheat exporters because rail shipping has become relatively more expensive than barge movement, and this trend is expected to continue. Figure 15 shows wheat exports from 1960, forecast to 1985.

Rice. Although rice is a major Texas export, the forecast for future exports is poor. This stems primarily from an assumption of a continued "green revolution" among the LDC's, which includes the Asian nations, traditionally the largest consumers of rice. The forecast is for a total of 4.8 million metric tons in imports by the LDC's by 1980, an increase of .5 million metric tons over the 1964-1966 average of 4.3 million metric tons. The developed nations are expected to import .4 million metric tons less than the 1964-1966 average of 13.3 million metric tons, thus creating a net increase in world rice imports of .1 million tons. The United States was the second largest exporter of rice in 1964-1966 with 1.5 million metric tons of export product.[3] The Texas Gulf Coast is a major exporter of rice, handling about 40 percent of all exports. Figure 16 shows historical and forecast rice exports.

FIGURE 15

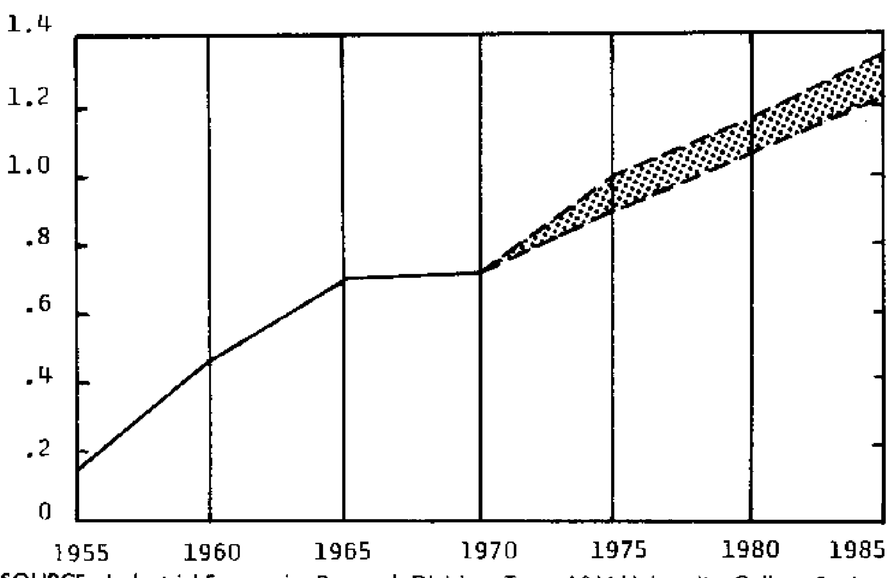
WHEAT EXPORTS — TEXAS GULF COAST
(Million Tons)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 16

RICE EXPORTS — TEXAS GULF COAST
(Million Tons)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

[2]**World Demand Prospects for Grain in 1980**, Foreign Agricultural Report No. 75, U. S. Department of Agriculture, Economic Research Service, 1971, Washington, D. C., p. 64.

[3]*Ibid.*, pp. 64-69.

Rice is often classified as an "inferior" product in that as incomes rise, other foods are substituted for it. Therefore, as incomes in other nations rise, wheat should increase by replacing rice as a major food grain. The median projection for exports of rice from the Texas Gulf Coast is based on the last 15-year trend, and indicates steadily increasing exports. The estimate of 1.3 million export tons by 1985 could conceivably be slightly high due to the potential decrease in world demand for rice.

Grain Sorghum. The principal use of grain sorghum is the feeding of animals raised for meat production. Therefore, it is an essential commodity in countries where meat is considered important in the diets of the people.

The United States is the world's largest exporter of grain sorghum, but in recent years Argentina has become a major competitor for the European and Japanese markets. Primary United States production areas are the Midwest Belt and Texas. As a result, the Gulf Coast area handles the vast majority of all grain sorghum exported.

As Figure 17 shows, the forecast is for approximately eight million long tons to be exported from the United States by 1985, with as much as 75 percent being exported from the Texas Gulf Coast.[4] Generally, the predicted demand for United States grain sorghum is good, as per capita meat consumption is expected to increase as a function of income. The production of feed grain in importing nations is expected to increase only marginally, thereby causing the demand for imports to increase proportionally as their per capita income rises.

Non-Fuel Minerals

Gulf Coast export of mineral commodities is projected to increase from 22.9 million tons in 1968 to 40.0 million tons in 1980. Larger tonnages are forecast mainly for phosphate rock with lesser gains for fertilizers, sulphur, and petroleum coke.[5] Of the total value of exports of $827 million in 1968, about 50 percent went to developed countries and 50 percent to lesser developed countries (LDC's). The largest market areas were as follows: developed countries, western Europe (31 percent); LDC's, Latin America (31 percent) and Asia other than Japan (24 percent).

From the Texas Gulf Coast, principal exports in bulk were ammonium sulfate, sulphur, and aluminum compounds. Other Gulf Coast mineral exports were either not moved in bulk or were not moved through Texas ports.

Ammonium Sulfate. Ammonium sulfate is used almost exclusively as a fertilizer. Although relatively low in nitrogen (21 percent), ammonium sulfate contains 22 to 24 percent sulphur, which makes it useful on land that requires sulphur fertilization. Prime export markets for ammonium sulfate in 1968 were Brazil and India, which together accounted for 89 percent of Gulf Coast exports of this commodity. Texas exports in 1968 were 340,190 short tons, or 70 percent of the Gulf Coast total of 487,869 short tons.[6]

The most important factor affecting future exports of ammonium sulfate will be continuation of the Agency for International Development (AID) or similar programs, and the composition of fertilizer orders associated with these programs. The AID program consumed more than one-third of United States ammonium sulfate production in 1968. Exports of this commodity reached a high mark in 1966 and then declined as a result of reduction in AID-financed shipments.

Sulphur. Value of crude sulphur exports from the total Gulf Coast in 1968 was $65.7 million. Louisiana and Texas produced 40 percent of the world's supply of elemental sulphur in 1968 and together the two states shipped 99 percent of total United States sulphur exports.

In 1968, Texas Gulf ports handled 660,000 tons or 38 percent of total Gulf Coast sulphur exports of 1,735,000 short tons. The balance, 1,075,000 tons, or 62 percent, was shipped out of Port Sulphur, Louisiana. This compares with the 1964-66 period when the percentage share between Texas and Louisiana was exactly reversed. Of the total exported from Texas ports in 1968, 65 percent (435,000 tons) was in dry form.

Annual shipments of sulphur in the period from 1955 to the present have shown severe fluctuations in tonnage

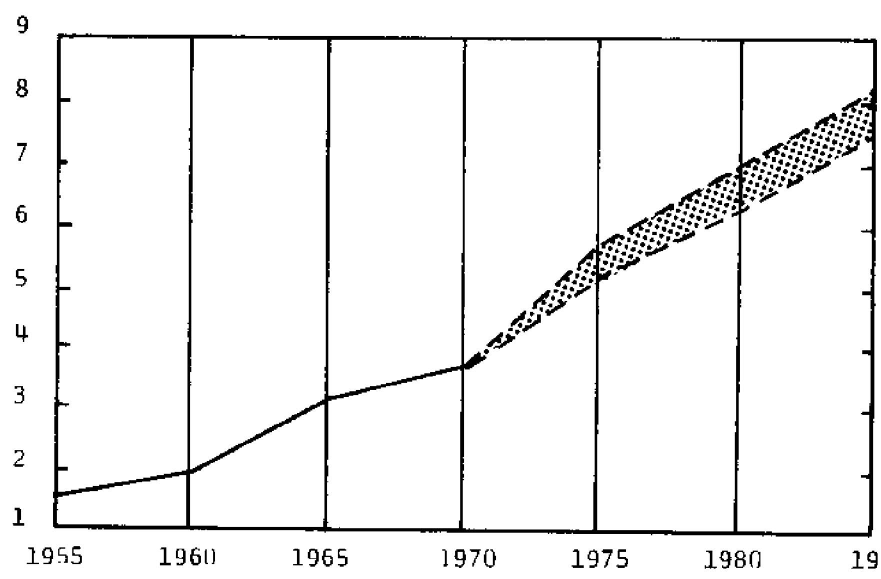
[4] *Forecast of U. S. Oceanborne Foreign Trade in Bulk Dry Commodities*, Booz-Allen Applied Research, Inc., 1969, pp. 53-54.

[5] Fulkerson, Frank B., "Gulf Coast Export-Import of Mineral Commodities," United States Department of the Interior, Bureau of Mines, Washington, D. C., 1971.

[6] *Ibid.*

FIGURE 17

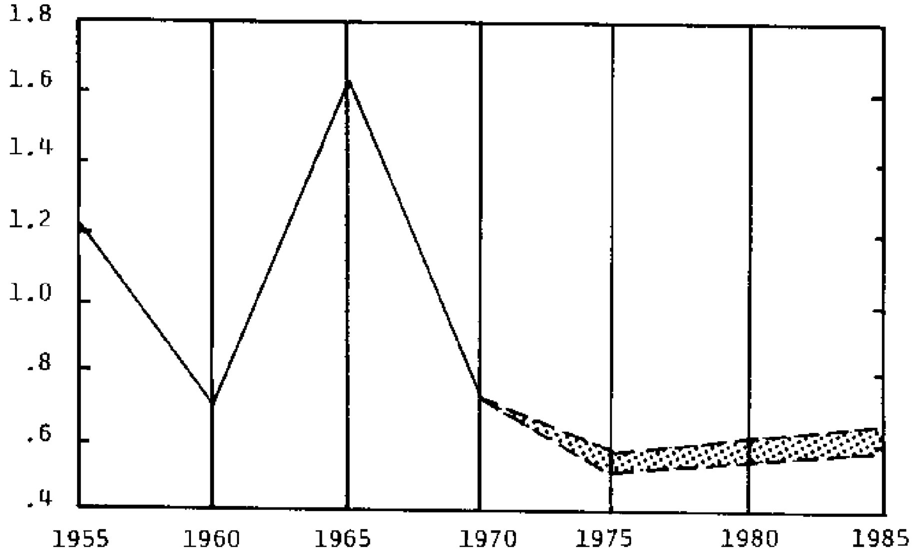
GRAIN SORGHUM EXPORTS — TEXAS GULF COAST (Million Tons)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 18

DRY SULPHUR EXPORTS-TEXAS GULF COAST
(Million Tons)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

levels. As shown in Figure 18, exports peaked in 1965 and, since then, have dropped considerably. However, an upturn is forecast to start in 1975.

The outlook for sulphur exports shows a projected growth of five to eight percent per year. However, expanding supplies of sulphur recovered from fossil fuels, as a result of desulphurization processing, have created a temporary condition of oversupply in world sulphur markets. Whether or not this condition persists will have a significant bearing on sulphur exports. Since sulphur is a basic ingredient in so many industrial processes, consumption should continue to climb and, in the near future, there should again be a demand for exports of this commodity.

Aluminum Compounds. The Gulf Coast supplied 97 percent of United States export of aluminum compounds in 1968, amounting to 887,000 tons valued at $65.4 million. Over 80 percent of Gulf exports of aluminum compounds went to five countries: Ghana, the U.S.S.R., Canada, Norway and Mexico. The bulk of the export was in the form of alumina for production of primary aluminum.[7]

Forty-two percent of alumina exports from the Gulf Coast in 1968 were handled through Texas ports. These 372,000 tons moved primarily through ports at Corpus Christi, Port Lavaca and Point Comfort.

Gulf Coast export of aluminum compounds increased nearly thirtyfold from 1959 to 1968. However, starting in 1968, alumina production capacity began to increase sharply in such places as Australia, Jamaica and Surinam, as governments of these nations instituted policies to encourage more vertical integration of the aluminum industry inside their borders. These policies, plus the economic realities of shipping costs for bauxite, which contains one-half as much aluminum as does alumina for the same tonnage, should cause a reduction of alumina exports from Texas. However, increasing consumption of aluminum throughout the world will have an offsetting effect, causing Texas alumina exports to remain at a constant level in the near future.

Fuels

The foreign export of mineral fuels from the Gulf Coast is relatively limited, with the exception of liquified petroleum gases (LPG), petroleum coke and lubricating oil. Small amounts of coal have been shipped, also.

LP Gas. The Gulf Coast accounted for 86 percent of the quantity and 84 percent of the value of United States export of LP gases in 1968. The LPG was shipped mainly to Mexico and the United Kingdom. Gulf Coast exports of LPG were 9.1 million barrels. Texas ports shipped 71 percent of that total, while most of the balance went to Mexico overland through the El Paso customs district.

United States export of LPG recorded a fivefold increase from 1959 to 1968; however, in view of the increasing shortage of clean fuels in the United States, further growth in export of LPG is not anticipated.[8]

Petroleum Coke. Petroleum coke is used raw as a utility fuel and, calcined, as a material for anodes used in aluminum production. Coke is produced when thermal cracking is employed to upgrade residual oil into more desirable light products. There is usually an oversupply of petroleum coke and, although the export market absorbs most of the surplus at reduced prices, some is stockpiled at refineries.[9]

Gulf Coast export of petroleum coke in 1968 amounted to 1,252,000 short tons. This amount compares to 476,000 tons shipped in 1959. Of the 1968 total, Texas ports handled 77 percent or 975,000 short tons.

As the volume of oil processing rises along the Texas Gulf Coast in the future, so will the amount of coke produced. Domestic production of primary aluminum, which absorbs one-half pound of coke for each pound of aluminum produced, will rise also and, therefore, the Gulf export of petroleum coke is projected to increase to only 2.5 million tons by 1980. Texas' share of Gulf exports should remain at 77 percent or two million tons.

Lubricating Oils. Gulf Coast exports of lube oils and greases in 1968 amounted to 1.7 million short tons valued at $110 million. Exports through the ports of Texas constituted 71 percent of the Gulf total, or 1.2 million tons.

About 45 percent of the lube oils and greases were shipped to Asia, with Japan and India receiving the largest shares. Of the remaining exports, Europe received 27 percent and Latin America, the balance.[10]

Gulf shipments of lube oils and greases remained at about the same levels from 1959 through 1968, rising from 1,413,000 short tons at the start of the period to 1,719,000 tons in 1968.

Most lube oil shipments are in bulk, in vessels of 15,000 to 25,000 tons;

[7] *Ibid.*

[8] *Ibid.*

[9] *Ibid.*

[10] *Ibid.*

some packaged goods are also handled. The ships often call at more than one port to complete loading.

Export of lube oils and greases is expected to decline as a result of expansion in foreign lubricant manufacturing capacity. Whereas Gulf exports rose from 1.4 million tons in 1959 to 1.7 million tons in 1968, they are expected to remain at the 1.7 million ton level or to decline by 1980.

Coal. The United States is the world's largest exporter of coal. In 1970, total exports were 71.7 million tons. This included 52.2 million tons to overseas points, the highest level since 1957, the year of the Suez Canal crisis. The value of United States exports in 1970 exceeded $1 billion, including rail shipment charges to the ports of exit.[11]

Export of coal from the Gulf Coast is insignificant compared to total United States quantities and values. In 1970, the Gulf shipped a total of 1,343,000 tons of coal and coke, with Mobile, Alabama, the leader at 780,000 tons. Texas ports in 1970 shipped just 72,000 tons with Galveston taking the lead at 47,000 tons.

Prospects for increased coal exports from Texas are encouraging as a result of construction of a modern coal-loading facility at Port Arthur by Texas-Oklahoma Port Company, a coal exporter. This new installation has stacker-reclaimers and ship-loaders with a total capacity of 3,000 tons per hour, along with ship unloaders which operate at 1,500 tons per hour.

The export market for coal is forecast to have a long-term economic growth. Although overseas coal exports dropped from 52.2 million tons in 1970 to 39.0 million in 1971, because of a six-week United States strike, exports are expected to reach 44 million tons in 1972 and 52 million in 1976.[12]

IMPORTS

Several factors govern the United States import market. The major determinants of the quantity of any goods imported are demand, import restrictions, relative foreign and domestic reserves and prices, and changes in technology.

According to a 1971 publication by the Bureau of Mines,[13] tonnage of Gulf Coast imports of mineral commodities is projected to increase from 26.6 million in 1968 to 33.7 million in 1980. The average annual increase is forecast to be 600,000 tons, as compared with an average annual increase of 963,000 tons from 1959 to 1968. However, based upon developments of the past 18-24 months, this total import tonnage forecast is significantly understated. A rapidly-mushrooming shortage of energy supplies in the United States has drastically increased the need for imported petroleum, both crude and products, and large volumes of oil will be moving into the United States by 1980, thereby greatly increasing total bulk imports.

For bulk commodities other than petroleum, recent forecasts of future imports are still valid.

Iron Ore. In 1968 about 5.4 million long tons of iron ore valued at $49 million were imported into the Gulf Coast. Texas ports received 14.4 percent, or 775,000 tons of the total handled.

Sources of Gulf iron ore imports in 1968 were: Venezuela (48 percent), Canada (23 percent), and the balance from Brazil and Peru.[14]

Iron ore imports into the Texas Gulf Coast are expected to reach approximately 2.8 million tons annually by 1995. Figure 19 shows historical and projected imports of iron ore through Texas ports. United States demand for primary iron should reach 150 million tons per year by 2000, nearly twice the 1968 demand of 84 million tons. At the present time, approximately 40 percent of iron ore used domestically is imported, primarily from Canada, South America and Liberia. The Gulf Coast area receives approximately three percent of all iron ore imports. For several years, United States pellet producing capability prevented foreign competitors from gaining a larger share of the market, but this advantage is becoming less important as foreign technology in this area advances. At the present time there are no trade restrictions on imports of foreign iron ore, and this situation is not expected to change in the foreseeable future. Foreign ores averaged $2 per ton cheaper than domestically produced ores in 1968, and foreign prices should be further reduced by the use of larger bulk transport methods.

Bulk carriers handled 85 percent of all world international oceanborne shipments of iron ore in 1967, and over a period of three years, vessels over 40,000 dwt increased their share from 21 to 42 percent. Use of large, deep-draft vessels, however, is limited to ports with adequate water depth.

Overall, it is likely that the United States will continue to import large quantities of iron ore, and it can be further assumed that much of this ore will be shipped to the Gulf Coast and then barged to steel producing regions.[15] The possibility of primary steel plants locating on the Gulf Coast would also have a positive impact on imports into that area. One factor that could have a negative impact on imports is the increased use of substitute materials for steel. Aluminum and plastics have in recent years become major competitors in the automobile accessory and container

[11] *"World Coal Trade, 1971 Edition,"* National Coal Association, Washington, D. C., 1971.

[12] National Coal Association, "Coal News," No. 4093, January 21, 1972, p. 2.

[13] Fulkerson, Frank B., *op. cit.*

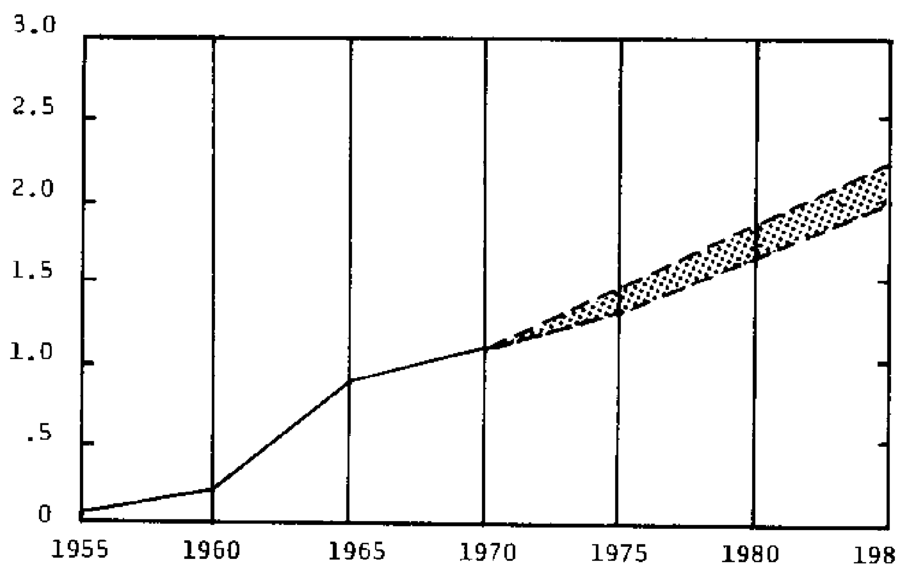
[14] *Ibid.*

[15] Horace T. Reno and Frances E. Brantley, "Iron," *Mineral Facts and Problems –1970,* U.S. Department of Interior, Bureau of Mines, pp. 297-315.

FIGURE 19

IRON ORE IMPORTS-TEXAS GULF COAST

(Million Tons)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

markets. However, there is no suitable replacement for high quality structural steel. Another factor which may reduce the quantity of domestic steel demanded is its steadily rising price in relation to the price of substitute goods.

Aluminum Ores. United States demand for aluminum metal should increase from 4.31 million tons in 1968 to between 21.2 and 42 million tons in the year 2000, an annual growth of 5.1 to 7.4 percent. The principal source of aluminum metal is bauxite, which is found primarily in tropical regions in the lesser developed countries. Approximately one-half of all bauxite is mined in the Western Hemisphere, with Jamaica, Surinam and Guyana accounting for 40 percent of the world trade. As there are few discovered bauxite deposits in the United States, nearly 90 percent of our requirement for aluminum ore is obtained through imports, with approximately 25 percent of the bauxite imported into the Gulf Coast region.

Bauxite and alumina are among the leading Gulf mineral industry imports. Total value for these two commodities in 1968 was $147.8 million, of which bauxite represented $138.0 million and alumina $9.8 million. Jamaica supplied 59 percent of the Gulf bauxite import while the balance came from Surinam (26 percent), Dominican Republic (7 percent), and other countries (8 percent).

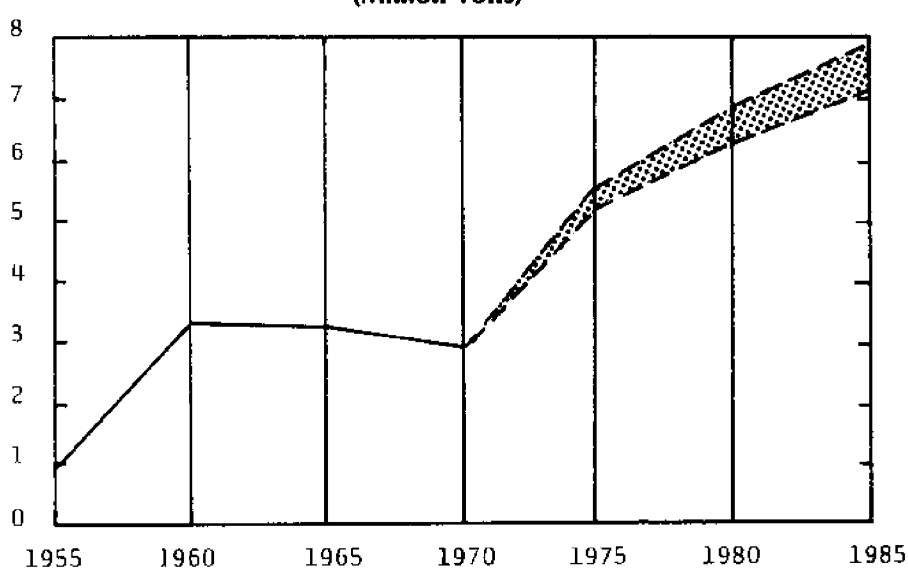
Thirty-nine percent of 1968 Gulf bauxite imports, or 3.5 million long tons, was handled through ports in Texas.

Most of the alumina received in 1968 was from Surinam and was unloaded in the New Orleans customs district.[16]

A 1968 United Nations study revealed that the United States has 45 million long tons of the world reserve of 5,842 million long tons of aluminum. Because of the rapidly growing demand for aluminum and the scarcity of bauxite ore in the United States, it is doubtful that United States producers can supply as much as 10 percent of the domestic requirements, and five percent has been suggested as a more reasonable long-term figure in view of present technology and prices. The maximum quantity that domestic bauxite producers will be able to supply in the year 2000 should be approximately four million long tons. Our dependence on foreign bauxite is shown by the fact that duties on imported bauxite are scheduled to be either reduced or eliminated in 1972. With present aluminum prices, there is no economical method of using sub-marginal deposits in the United States. Improved technology or a changing price structure in the aluminum market could make such methods as the production of alumina from low grade aluminum bearing deposits or the electrodeposition of aluminum chloride economically feasible. However, this is not considered probable and it is likely that the United States will continue to import large amounts of bauxite and alumina.[17] Figure 20 gives history and projections of Texas Gulf Coast aluminum ore imports.

FIGURE 20

ALUMINUM ORE IMPORTS-TEXAS GULF COAST
(Million Tons)



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

Petroleum. A major determining factor for the importation of petroleum is consumption of petroleum derived fuels, which account for nearly 90 percent of all petroleum consumed in the United States. Proven reserves of petroleum in the United States amount to 29.55 billion barrels, over six percent of the world's total. Texas is a major oil producing region with 35 percent of the domestic reserves. However, the United States is in a decreasing reserve position, and reserves are being depleted faster than they are being discovered. United States imports in 1968 totaled slightly over one billion barrels, with about 325 million barrels coming from Venezuela. In comparison, the petroleum industry in the United States produced over 3.3 billion barrels.[18]

Import of oil is controlled through quotas set under the Mandatory Oil Import Program established in 1959. Under this program, oil imports are restricted to 12.2 percent of United States domestic production to assure maintenance of domestic production at a level deemed essential for national security. However, it has become a fairly common practice to issue waivers for such products as home heating oil, and these actions, along with the granting of extra "tickets" to refiners with special problems, effectively raise import levels far above the nominal 12.2 percent allowed by law. During 1972, for example, nearly one out of every three barrels of petroleum consumed will have been imported.

Petroleum demand has been projected to grow at a rate of five percent a year through 1985.[19] Growth in 1970 was 4.2 percent; in 1973 it is predicted to go to 6.1 percent.[20] With domestic production peaking this year, import levels can be expected to rise directly in response to growth in demand.

[16]Fulkerson, Frank B., *op. cit.*

[17]John W. Stamper, "Aluminum," *Mineral Facts and Problems – 1970*, U.S. Department of Interior, Bureau of Mines, pp. 297-315.

[18]Paul Meadows, "Petroleum," *Mineral Facts and Problems – 1970*, U.S. Department of Interior, Bureau of Mines, pp. 156-175.

[19]Chase Manhattan Bank, "Outlook for Energy in the United States to 1985,"New York, June, 1972, p. 30.

[20]"Oilmen Acknowledge Import Necessity — With Restrictions," **The Houston Post,** October 18, 1972.

OCEAN VESSEL TRAFFIC

The problem of ocean vessels too large for existing ports was not widespread until just the last five years or so. Ships did not begin mushrooming in size in great numbers until after the latest closing of the Suez Canal (1967). However, the larger-sized vessels are seeing wider use throughout the world today, not only because of the shipping cost economies they offer but also because of a general growth in world oceanborne bulk trade.

WORLD OCEANBORNE TRADE

From 1960 through 1970, world oceanborne trade in five dry bulk commodities — iron ore, grain, coal, aluminum ores, and phosphates — increased from 228 to 488 million metric tons.[1] During the same period, world oil tanker trade grew from 530 million metric tons to 1.3 billion metric tons.[2] These growth performances are shown in Table 4.

Many commodities are moved in bulk form due to their low value or the volume in which they are consumed. Among these are mineral fuels, such as petroleum and coal, and mineral non-fuels, such as iron ore and sulphur. Besides minerals, other commodities like grain and raw sugar are also handled in bulk. Traditionally, bulk commodities move relatively short distances from source of supply to destination of consumer. However, when unusual circumstances prevail, such as a high level of demand in a region of short or non-existent supply, bulk commodities may move fairly significant distances. Examples of the latter include metallurgical coal from the United States to Japan, and petroleum from the Middle East to Europe. However, even when circumstances warrant long-range movement of low-value bulk commodities, shipping costs remain a problem.

Some bulk commodities are now being moved in the new mammoth

[1]Fearnley & Egers Chartering Company, Ltd., "Trades of World Bulk Carriers 1970,"Oslo, Norway, November, 1971, p.6.

[2]Litton Systems, Inc., "Oceanborne Shipping: Demand and Technology Forecast," Culver City, California, June, 1968, p. 2-18.

TABLE 4

WORLD OCEANBORNE BULK TRADE OF SIX MAJOR COMMODITIES (Million Metric Tons)

COMMODITIES	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Petroleum	523	562	630	688	766	844	920	1,005	1,100	1,200	1,310
Iron Ore	101	98	102	107	134	152	153	164	188	214	247
Grain	46	57	53	59	71	70	76	68	65	60	73
Coal	46	48	53	64	60	59	61	67	73	83	101
Aluminum Ore	17	17	18	17	19	21	23	25	26	30	34
Phosphates	18	19	20	22	24	25	27	28	32	32	33
Total	751	801	876	957	1,074	1,171	1,260	1,357	1,484	1,619	1,798

SOURCE: "Oceanborne Shipping: Demand and Technology Forecast," Litton Systems, Inc., June, 1968, and "Trades of World Bulk Carriers in 1970," Fearnley & Egers Chartering Co., Ltd., November 1971, and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 5

TANKER TRANSPORTATION COST INDEX

ITEM	1945	1950	1955	1960	1965	1970
Tanker Size-1,000 dwt	21	30	47	104	130	326
Freight Cost Index	100	85	72	54	52	44

SOURCE: "Foreign Deep Water Port Developments," Institute for Water Resources, Army Corps of Engineers, Alexandria, Virginia, December, 1971.

bulk carriers if docking requirements of the giant ships can be met with existing facilities at each end of the voyage. Widespread use of the ships, however, and the cost economies they offer, cannot be realized where facilities are non-existent.

The export of metallurgical coal from the United States to Japan may soon be in jeopardy because of the lack of deepwater facilities in this country. Price increases in all components of steelmaking — labor, materials and overhead — are forcing Japanese steelmakers to closely scrutinize each factor in an attempt to reduce costs. As a result, the continuing high cost of transporting coal to the mills cannot be tolerated much longer and, unless giant ships can be used to haul coal from the United States, Japanese purchasers will go to other sources where deepwater facilities are available.

WORLD BULK CARRIER FLEETS

Several leading factors have influenced the growth in world oceanborne bulk trades. Depletion of domestic reserves in developed nations, increasing affluence accompanied by an increased demand for goods in lesser-developed nations, and improved transportation technology that has permitted tapping of hitherto inaccessible raw materials reserves have all played significant roles in the growth of bulk commodity movements worldwide.

In response to the growing worldwide demand for goods that are transported in bulk, shipbuilders have turned out larger and larger vessels which provide economical transportation over long distances. As the tonnage of vessels rises, the ton-mile cost of transportation falls. The extent of cost reduction is illustrated in Table 5.

The reduction in ton-mile cost for dry bulk vessels has been equally impressive, but the cuts have not been as extensive because growth of dry bulk vessel sizes has not proceeded as rapidly as the growth in tanker sizes. Dry bulk carriers are more constrained in cargo handling and storage than are tankers and, consequently, these vessel types have historically been about 10 years behind tankers in size development. Consequently, it is not expected that the size of single-purpose dry bulk vessels will exceed 200,000 dwt during the 1970's.

In the 1960's, development of combined carriers came into full swing with such types as ore-oil, coal-oil, and ore-bulk-oil predominating. These vessels, which cost only five to 12 percent more than tankers on a deadweight basis, have greater flexibility for backhaul or trade switch than do tankers or single-purpose bulk ships. Combined carriers could constitute as much as one-third of the dry bulk tonnage by 1975.

The growth of world bulk carrier fleets as shown in Table 6 is compiled from figures published by Fearnley & Egers, and from the Annual Tanker Report by Sun Oil Company.

Tankers for the transport of crude petroleum and petroleum products are expected to continue being built in mammoth sizes far exceeding the upper size ranges of other type vessels. Table 7 shows the existing world tanker fleet at the end of 1970, while Table 8 gives a breakdown of tankers on order and under construction throughout the world for the same date. Table 9 summarizes all tankers either in service or on order in the world by deadweight size categories. Trends in average tanker size are shown in Table 10 and maximum sizes of tankers on order compared to average size of all tankers in the world fleet is shown in Figure 21.

TRADE ON THE TEXAS GULF COAST

Projections of import-export trade on the Texas Gulf Coast have been presented in the section, "Commodities and Volumes." As indicated by these figures, no dry bulk is expected to move in volumes large enough to justify the use of dry bulk carriers larger than about 50,000 deadweight tons before 1985. Total annual volumes of certain commodities will rise to significant levels by then, but constraints such as consumption rates, cost of inventory and availability of storage space should almost completely rule out their being handled in lots as large as those carried in mammoth bulk carriers.

Petroleum, and possibly liquified natural gas (LNG) are the only two bulk commodities whose usage rates in Texas will create a need for massive import movements. In the case of LNG, the present state of technology of ship design does not provide strong prospects for the construction of this type vessel in sizes as large as the very large crude carriers (VLCC). Average sizes of LNG vessels on order and under construction in the world at the end of 1970 were less than 35,000 deadweight tons.[1]

A number of factors influence the use of very large crude carriers (VLCC), ranging from financial to nationalistic. Consequently, vessels of the supertanker class are not used in a random fashion for cargos of opportunity as is the case with most other

[1]The Labor-Management Maritime Committee, "The Growing Energy Crisis and the U. S. Tanker Fleet," Washington, D. C., December, 1971, p. 70.

TABLE 6

GROWTH IN WORLD BULK CARRIER FLEET
(Million Deadweight Tons)

SHIPS	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Tankers	65.8	68.9	72.0	76.2	85.1	93.2	102.9	112.4	128.1	146.0	166.8
Ore Carriers	2.0	2.4	2.8	3.3	3.6	4.1	4.9	5.8	6.2	6.6	7.1
Combined Carriers	1.2	1.3	1.5	1.8	2.4	2.8	3.6	5.7	8.9	10.6	14.2
Other Bulk Carriers	0.9	1.6	3.6	6.0	8.7	11.1	15.6	21.7	38.9	36.1	40.9
Total	69.9	74.2	79.9	87.3	99.8	111.2	127.0	145.6	182.1	199.3	229.0

SOURCE: "Trades of World Bulk Carriers in 1970," Fearnley & Egers Chartering Co., Ltd., 1971 and "Sun Oil Company's Annual Tanker Report," *Maritime Reporter/Engineering News*, Vol. 33, No. 23, December 1, 1971, pp. 14-16.

TABLE 7

WORLD TANKER FLEET[1] BY TYPE
UNITED STATES FLAG AND OTHER
December 31, 1970
(Deadweight Tons in Thousands)

SECTOR	ALL TYPES		OIL		LPG		LNG		OTHER[2]	
	NO.	DWT	NO.	DWT	NO.	DWT	NO.	DWT	NO.	DWT
U. S. Private	262	7,368	241	6,941	1	26	--	--	20	401
U. S. Gov't	32	371	32	371	--	--	--	--	--	--
U. S. Total	294	7,739	273	7,312	1	26	--	--	20	401
All Other	3,938	145,737	3,597	142,299	161	1,321	10	230	170	1,887
TOTAL	4,232	153,476	3,870	149,611	162	1,347	10	230	190	2,288

[1] all vessels 1,000 gross tons and over

[2] includes chemical, asphalt, sulphur, wine and other special types

SOURCE: "The Growing Energy Crisis and the U. S. Tanker Fleet," The Labor-Management Maritime Committee, Washington, D. C., December 1971, pp. 66-67.

TABLE 8

TANKERS ON ORDER AND UNDER CONSTRUCTION IN THE WORLD[1]
December 31, 1970
(Deadweight Tons in Thousands)

SIZE (DWT)	OIL		LPG-LNG		OTHER[2]		TOTAL	
	No.	DWT	No.	DWT	No.	DWT	No.	DWT
2.0- 24.9	163	1,788	30	356	29	295	222	2,439
25.0- 49.9	78	2,324	15	598	9	312	102	3,234
50.0- 99.9	25	2,064	5	282	2	120	32	2,466
100.0-149.9	38	4,677	--	--	--	--	38	4,677
150.0-199.9	9	1,402	--	--	--	--	9	1,402
200.0-249.9	111	24,952	--	--	--	--	111	24,952
250.0-299.9	124	32,745	--	--	--	--	124	32,745
300.0 & over	10	3,586	--	--	--	--	10	3,586
TOTAL	558	73,538	50	1,236	40	727	648	75,501

[1] all vessels 1,000 gross tons and over

[2] includes chemical, asphalt, sulphur, wine and other special types

SOURCE: "The Growing Energy Crisis and the U. S. Tanker Fleet," The Labor Management Maritime Committee, Washington, D. C., December, 1971, pp. 68-69.

TABLE 9

WORLD TANKER SURVEY BY FLAG[1] IN SERVICE AND ON ORDER[2]
December 31, 1970
(Deadweight Tons in Thousands)

SIZE DWT	NO. - U. S. FLAG		NO. - OTHER FLAGS		TOTAL - ALL FLAGS	
	IN SERVICE	ON ORDER	IN SERVICE	ON ORDER	IN SERVICE	ON ORDER
Under 10.0	21	--	1,010	119	1,031	119
10.0 - 24.9	125	--	1,226	103	1,351	103
25.0 - 49.9	130	5	841	97	971	102
50.0 - 99.9	17	9	587	23	604	32
100.0 - 199.9	1	5	143	42	144	47
200.0 - 299.9	--	2	125	233	125	235
300.0 & over	--	--	6	10	6	10
TOTAL	294	21	3,938	627	4,232	648

[1] 1,000 gross tons and over

[2] includes all types

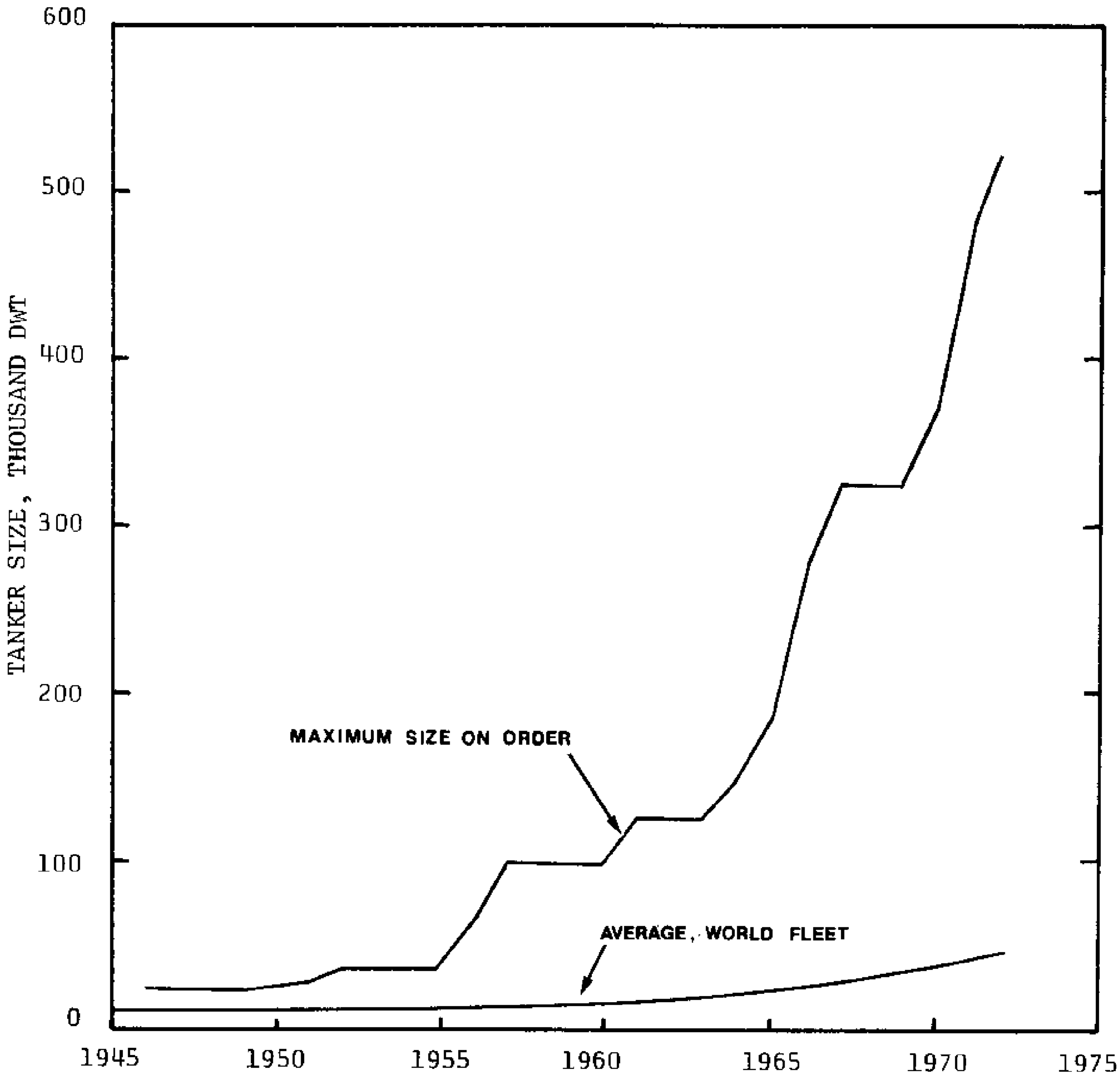
SOURCE: "The Growing Energy Crisis and the U. S. Tanker Fleet," The Labor Management Maritime Committee, Washington, D. C., December, 1971, pp. 71-73.

TABLE 10

TRENDS IN AVERAGE TANKER DEADWEIGHT TONS

YEAR	AVERAGE DWT
1956	16,200
1957	17,100
1958	18,000
1959	19,100
1960	20,200
1961	21,200
1962	22,100
1963	23,200
1964	25,300
1965	27,100
1966	29,200
1967	31,100
1968	33,900
1969	37,500
1970	41,800

SOURCE: Sun Oil Company, "Analysis of World Tank Ship Fleet," December 31, 1966 and December 31, 1970.



SOURCE: Litton Systems, Inc., "Oceanborne Shipping: Demand and Technology Forecast," June, 1966, p. 5-4, and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 21

TRENDS IN TANKER SIZE

ships. Instead, before construction is begun, the VLCC's are designated for a particular route, in the same manner that physical design is frozen before construction in regard to capacity and type of commodity service. Only in the event of drastic changes in world economic conditions will this pre-designation be abandoned in preference to another commodity or another route.

Much of the inflexibility of supertankers in choice of routes is physical; port depth limitations restrict their use to those locations having adequate water depth. Other restrictions are financial; the money for construction is usually advanced on the strength of long-term charters secured in advance of ship construction. To obtain funds to build the ship, the shipowner must commit the vessel to a specific service for a period of time sufficient to ensure payout of the investment.

Nationalistic considerations many times influence the decision concerning routes and commodities for a proposed ship. In return for certain concessions from a national government, such as construction or operating subsidies, preferential cargo opportunities or import duty allowances, a shipowner will commit a new vessel to a long-term charter arrangement that serves the interests of the nation granting the concessions. In the United States, there is a rather strong feeling on the part of the federal government that a portion, if not all, of the huge amounts of oil to be imported into the U.S. during the next several decades should be moved in United States flag vessels. For this to work, however, the existing United States ship subsidy program will have to be vastly expanded.

The U.S. must permit use of foreign flag vessels – at least until our flag fleet is able to do the job.

If the shipbuilding subsidy programs are not expanded and, if it is still required by law that all (or even a large percentage) of our oil imports move in United States vessels, this will create a dilemma for importers:

- not enough U.S. flag tonnage will be available to haul more than a small portion of the amounts of oil required, even if all other service is dropped;
- the U.S. fleet will contain only a few supersized ships and imported oil will cost a premium due to transportation costs;
- the United States will find itself in a perilous position in regard to energy supplies.

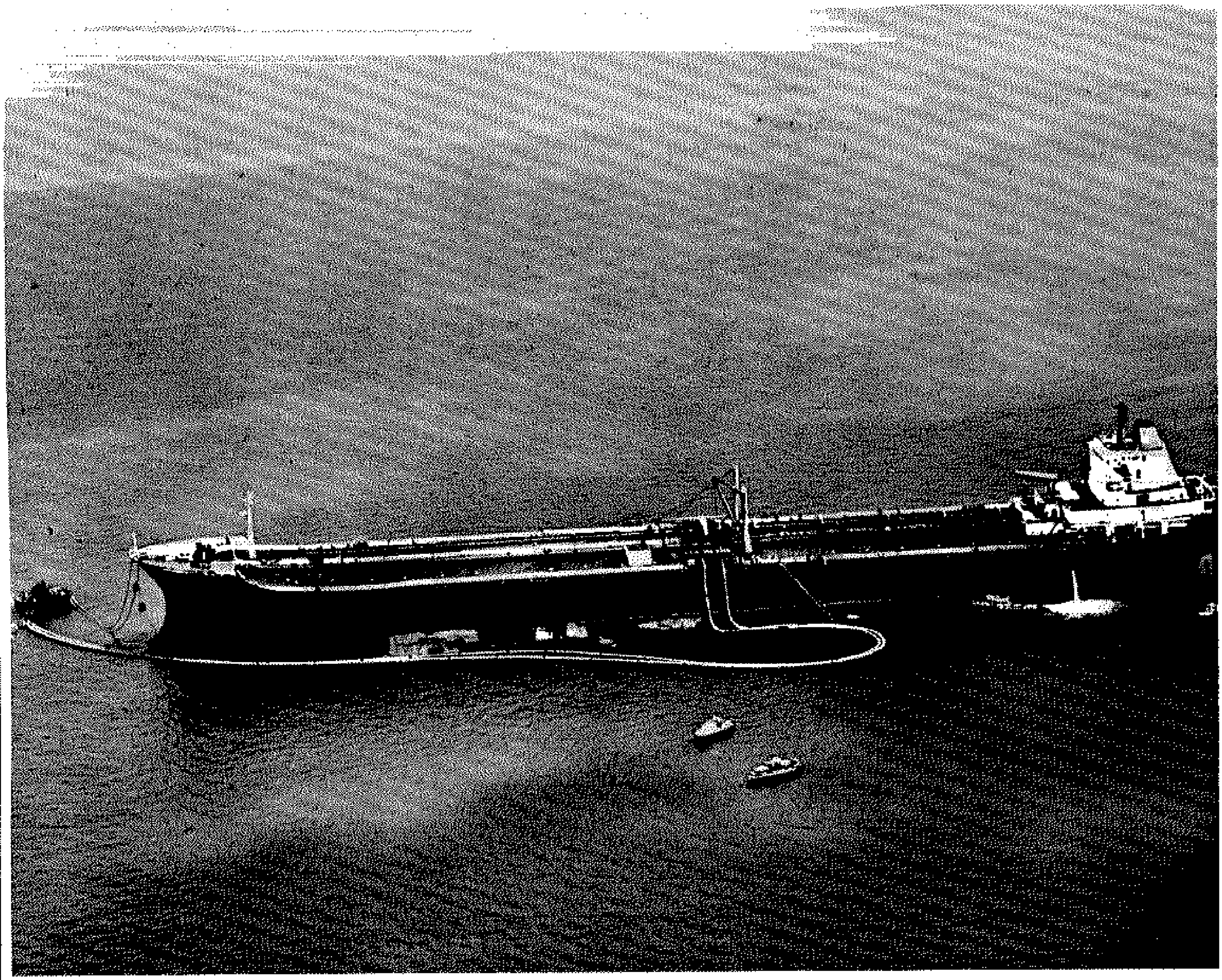
Thus, if only United States flag vessels are permitted to be used in the Persian Gulf-Texas Gulf crude oil service, the number of vessels requiring a deepwater terminal in Texas will be almost nil if current United States fleet characteristics remain the same.

Realistically, then, the United States has little choice but to permit the use of foreign-flag vessels in Middle East - United States oil service, at least until our flag fleet becomes able to do the job. Many foreign-flag vessels used in U.S. trade are owned by American companies. This will continue to be true as oil imports move to new peak levels because the major part of the imports into this country will be shipped and received by and for American energy companies.

Therefore, the family of vessels that will be used to haul crude oil to Texas will in all likelihood consist predominately of VLCC's and other mammoth bulk transporters, mostly foreign flag. This conclusion is drawn from the following assumptions:

- burgeoning energy demands in this country can be met on a short-term basis only with imported oil;
- the tanker capacity required to haul the volumes of oil that will be needed will be equal to the total tanker capacity of the 1970 world fleet;
- the United States cannot supply from American shipyards the tanker tonnage needed in time to meet the need;
- the new tonnage built to meet United States needs will be built primarily under foreign flags and will predominately be vessels of VLCC size or larger;
- the magnitude of oil import levels by 1985 lends strong support to the possibility that the maximum-sized vessels in the world fleet will call at the Texas deepwater terminal(s).

The size range of vessels most likely to see service in the Texas oil import trade is expected to be in direct proportion to the frequency of each size range in the total world VLCC fleet. It now appears that the industry standard VLCC in 1980 and 1985 will be the 250,000-300,000 deadweight tons size. However, some owners will build ships in the 750,000-1,000,000 ton size in order to have the "biggest," even though transportation cost savings do not at present justify this.



This Imodco single buoy mooring system accommodates tankers up to 252,000 deadweight tons.

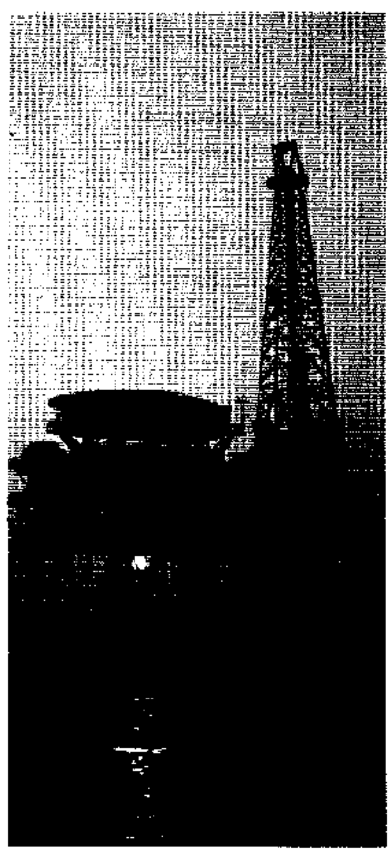
ECONOMIC STUDY METHODOLOGY

Over the years a number of methods have been used to make estimates of the economic effects of industrialization. Most of these acknowledge the fact that the relationship between industrial growth and general community development is a "chicken-and-egg" relationship — you can't have one without the other. While industrial growth stimulates the local economy, the prior existence of the community with its diverse services and facilities makes industrial growth possible. Since the effect of new industrial jobs is not a one way cause-and-effect relationship, the investigator must carefully evaluate the interdependence of the various sectors of the economy.

Economic impact may be measured in many ways. Traditionally it has been measured in terms of employment, sales and investment. However, total sales and total employment generated by industries directly impacted by changes, such as the increase in supply of oil through imports via a deepwater terminal, provide only a partial view of economic impact. Any measurement of effect on the economy resulting from direct stimulation of one or more sectors must also account for the indirect re-spending cycle stimulated by direct sales and the indirect employment generated by the growth stimulus of direct employment. It has been found that in many sectors of the economy, this multiplier effect exceeds 2.0, which means that the indirect impact resulting from direct stimulation of a sector is greater than the direct effect or impact. Therefore, to ensure that quantification of the economic impact of a direct action is totally inclusive, it is important that all of the indirect and induced effects of the action be considered.

In the case of the proposed deepwater terminal, care must also be taken in deciding upon the study method because the whole concept of supertankers, and terminals designed expressly for them, is somewhat overwhelming. The possible location of these facilities far at sea, removed from the protection of the traditional land-locked harbor, is revolutionary and controversial. The public and the regulatory agencies are not confident about what course of action to follow to resolve the problem of supership facilities. Because so much uncertainty and indecision does exist, the situation dictates that the method picked for the economic impact study must be one which ensures results that are relevant and meaningful.

To meet the stringent requirements for an economic impact study of a deepwater terminal, an established and proven method was necessary. After a study of the many methods that have been used in other such projects, it was decided that input-output techniques offered the best answer if the interactive data were available for the selected study area. Discussions with various experts in the field revealed that the Texas Governor's Office had recently completed a Texas Input-Output Model and that this Model was available for application to the study at hand. Therefore, a decision was made to use the Texas Model as the basis for computing the economic impact of a deepwater terminal in Texas. Before discussing how the Model was used and what conclusions were reached, it might be well to briefly describe input-output methodology and to relate how the Texas model came into being.



Expanded offshore oil exploration could help alleviate the energy crisis.

INPUT-OUTPUT MODELING

Professor Wassily Leontief of Harvard University published the first input-output analysis of the U.S. economy in 1936. As opposed to other analytic tools used by economists which emphasize understanding of economic phenomena through economic variables, such as employment, income, the interest rate, the price level, gross product, value added, and investment, Leontief's input-output echniques dealt with the problem of understanding the structure of specialized functioning economies, and the ways in which the individual parts influence each other. The input-output technique permits the analyst to classify and organize transactions data about the economy into mathematical statements that represent the trading among individual sectors of the economy. The models systematically display each sector's sales and purchases and quantitatively measure outputs and inputs of each sector for the time period chosen. A solution of the system of equations provides quantitative estimates of interindustry relationships.

ECONOMIC STUDY METHODOLOGY

Over the years a number of methods have been used to make estimates of the economic effects of industrialization. Most of these acknowledge the fact that the relationship between industrial growth and general community development is a "chicken-and-egg" relationship — you can't have one without the other. While industrial growth stimulates the local economy, the prior existence of the community with its diverse services and facilities makes industrial growth possible. Since the effect of new industrial jobs is not a one way cause-and-effect relationship, the investigator must carefully evaluate the interdependence of the various sectors of the economy.

Economic impact may be measured in many ways. Traditionally it has been measured in terms of employment, sales and investment. However, total sales and total employment generated by industries directly impacted by changes, such as the increase in supply of oil through imports via a deepwater terminal, provide only a partial view of economic impact. Any measurement of effect on the economy resulting from direct stimulation of one or more sectors must also account for the indirect re-spending cycle stimulated by direct sales and the indirect employment generated by the growth stimulus of direct employment. It has been found that in many sectors of the economy, this multiplier effect exceeds 2.0, which means that the indirect impact resulting from direct stimulation of a sector is greater than the direct effect or impact. Therefore, to ensure that quantification of the economic impact of a direct action is totally inclusive, it is important that all of the indirect and induced effects of the action be considered.

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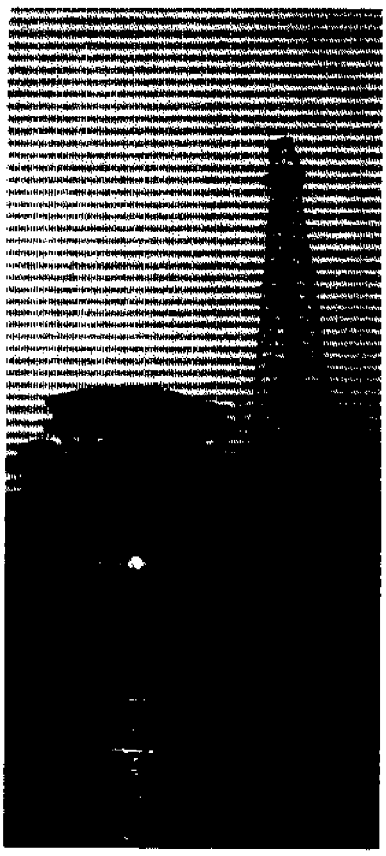

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Since Leontief's first input-output publication in 1936, input-output models of the U.S. economy have been published by the Bureau of Labor Statistics of the Department of Labor (1947) and by the Office of Business Economics of the Department of Commerce (1958, 1963). A number of other national input-output models have been prepared, including models for Japan, The United Kingdom, France, Sweden, The Netherlands, Russia and Israel. In recent years, input-output models of economies of states within the United States have been published. Notable examples are those for West Virginia, Kansas, Washington, Arizona, Nebraska, North Carolina, New Mexico and Mississippi. Other recent studies of regions and parts of states include the Lower Colorado Region, parts of California, Pennsylvania, Oklahoma and Texas.

Governments and industries alike have found the information provided by input-output models useful in planning future activities and assessing the economic impacts of selected investments and policies. Industries such as Western Electric, Celanese Corporation and United States Steel Corporation have used input-output analyses to assist in the planning of procurement of input materials, intra-industry management of diverse but interrelated departments and the estimation of expected direct and indirect consumption of products produced both by direct customers as well as the customers of their respective customers. Notable uses of input-output models by governmental agencies are the evaluations of economic impacts of public facility construction, defense spending and water project construction.

THE TEXAS INPUT-OUTPUT MODEL

During the past three years, the Division of Planning Coordination of the Governor's Office and a group of state agencies of Texas have sponsored an extensive statewide input-output analysis of the structure of the Texas economy and regional economies within Texas. The objectives were to measure the gross output of each sector, to calculate the interdependency among the producing sectors (including each sector's multiplier) and to estimate the structure of the state's economy in quantitative terms. Research teams were organized in early 1969 at each of nine Texas universities and a project administrative and research staff was employed in the Governor's office.

The major purpose of the project was to obtain quantitative information about the Texas economy for use in planning and evaluating industrialization, transportation, education, taxation and public investments in natural resources. The completed input-output models provide much of the information required to calculate the potential indirect benefits of various public investment and service projects available to the state on a region by region basis. In addition, the results of the project serve private industry in a major way in that local in-state, out-of-state and export markets for industrial products and the sources of supply of production inputs are shown for each economic sector of each regional economy.

Construction of the Texas Models. The Texas Input-Output Models were estimated from a combination of survey data from a sample of Texas manufacturing and business establishments, secondary data obtained from agency files and publications of the United States Bureau of the Census and other federal agencies. For readers interested in a more complete description of the Models, additional information may be obtained from the Office of the Governor of Texas.

USE OF INPUT-OUTPUT MODELS

An input-output model does not project economic activity into the future in the sense that a demographer extrapolates population trends. Instead the model represents a static simulation of an economic region. It is based upon the current interdependence of economic activities.

The use of the terms "input" and "output" emphasizes the importance of the economic interdependence. The output (sales) of any industry, for example petroleum refining, is used as an input (purchase) in a variety of other industries, such as petrochemicals and transportation. Other industries produce inputs for petroleum refining. If petrochemicals and transportation increase significantly, then petroleum refining must also increase if the economy is to avoid a shortage of refined oils. The expansion of oil refining must in turn be supported by inputs of other industries into refining. At the end of all these adjustments there must be one correct level of production for all the industries to allow petrochemical and transportation operations to expand their levels of production.

The input-output model estimates the level of production for each of the industries. Its value to planners interested in promoting growth is obvious. For example, if community groups are considering a promotional campaign to draw industry into a community industrial park, it would be valuable to know that certain types of industries would create more total sales and more employment in the community. Knowledge of the type of industry that would create greater interaction with other business establishments would help determine promotion targets and allow more efficient utilization of promotional funds.

The model can estimate the economic impact of a food stamp program, both by industry and the total economy. It can be used to estimate the impact of the phasing out of an industry or the creation of a new industry. It can estimate the economic impact of a planned government expenditure. If total economic impact is important, the effect of different expenditures can be compared so that the maximum results can be obtained. In short, the input-output model provides a flexible tool that produces estimates of value to both private and public planners.[1]

Limitation of Input-Output Models. Like other analytical models, an input-output model has limitations because of the simplifying assumptions which must be made to make it manageable.

The most serious limitation is imposed by the assumption that the direct requirement coefficients do not change over time. This assumption contradicts other information which is available about the conditions under which production takes place. Specifically, most analysts would agree that over time the direct requirement coefficients will vary because:

- technological innovations take place that modify the optimum input mix for a given production process.

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[1] Murrell, Joe C., Jr., et. al., "An Input-Output Model of the Lower Rio Grande Region of Texas," Office of the Governor, Austin, Texas, April, 1972, pp. 6-7.

- changes in the mix of the size of plants within a sector take place. The best mix of inputs changes with different size plants for many production processes. The measured direct requirement coefficients during a given time period is a weighted average of the mix of plant sizes.
- the management of a plant has the ability, within the technological limitations of the plant, to vary the mix of input factors in response to price changes of various input factors. There will be a tendency to substitute input factors which become cheaper for more costly ones.

A similar set of limitations applies to the trade coefficients that are used in regional input-output models. The requirement coefficients in a regional model are usually not identical to those that would be derived from just the production characteristics of a sector. The regional coefficients also include the influence of imports into the region. For example, if the production coefficient for a given sector indicates that steel plates constitute five percent of the total inputs, the production coefficient would be .05. If one-half of the steel is imported into the region, the regional direct requirement coefficient for the producing sector would be .025 and the import coefficient for steel would be .025.

The import coefficients reflect the distribution of producing activity between the region and other areas of the world. The assumption that the import coefficients are constant implies that the proportional distribution of economic activity between the region and the areas of the world remains constant.

The error that these assumptions build into any projections which are made with the model depends upon the elapsed time period between the estimation of the regional coefficients and the point in time for which the projections are being made. Over short periods of time the changes in both the production and the import coefficients will be small. Both relative factor prices and the rate of technological innovation tend to change slowly over time. Changes in import coefficients can be identified by the location of new establishments within a region. By updating the import coefficients for new establishments, the useful life of a set of estimated coefficients can be prolonged.[2]

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[2]Stern, Louis H., "Houston-Galveston Regional Input-Output Study for 1967," Office of the Governor, Austin, Texas, June, 1972, pp. 66-67.

ECONOMIC IMPACT IN TEXAS

PORT-RELATED ACTIVITIES

In the section dealing with economic evaluation criteria, it was concluded that the primary impact a Texas deepwater terminal will have on the Texas economy will be to facilitate growth in the State's oil refining industry. Other sectors of the economy could also experience direct stimulation. Such activities as ship repair, ship chandlering and bunkering, tug and towboat services, pilotage and longshore labor are all subject to being affected by operation of the terminal. However, no attempt will be made to use them in the model because their total impact is not expected to be as significant as that of oil refining, and other methodology exists to calculate growth in such traditional port-related activities.

The day-to-day operation of a deepwater terminal, possibly with a part of its facilities located in the open sea some distance offshore, has not been experienced before in the United States. Consequently, no historical data exist as to the statistics of such an operation. Local expenditures for services and direct labor, as compared to those of a conventional port, are not known. However, there is a high degree of probability that many expenditures of this type will occur.

Therefore, for the purposes of this study, and in the absence of an established methodology for calculation of the economic effects of a deepwater terminal, the method that is used is the one designed for application to conventional ports. This method was originated by the Port of Philadelphia and is accepted by the American Association of Port Authorities.

Using the Philadelphia method, it is possible to trace the results of the movement of a ton of cargo and to develop the dollars of expenditures it creates in a whole series of activities, such as the following:

Port and Terminal Expenditures
- Pilotage
- Tug Hire
- Line Running
- Dockage and Wharfage

Government Charges
- Entrance and Clearance Fees
- Customs Overtime

Labor
- Stevedoring
- Clerking and Checking

Repairs

Supplies
- Chandler
- Doctor
- Laundry

Bunkers
- Oil and Water

According to Eyre,[1] for petroleum liquids handled in bulk, a port and its local community in 1960 received benefits, in terms of growth of port-related activities, of $4.00 per ton of petroleum handled. If this figure is extrapolated to 1972, with an inflation factor of six percent a year, then a ton of oil handled through a port in 1972 will generate $8.02 in economic benefits to the port community. Table 11 shows the benefits that will accrue to the economy of the region contiguous to the Texas deepwater terminal, assuming six percent per year inflation.

GROWTH OF OIL REFINING

The primary economic impact ot a Texas deepwater terminal will be a

[1]Eyre, John L., et. al., "Measuring Port Sales," The American Association of Port Authorities, Washington, D.C., undated.

TABLE 11

ECONOMIC BENEFITS FROM PORT-RELATED ACTIVITIES

YEAR	TONS OF OIL	BENEFIT PER TON	YEARLY BENEFITS TO REGION
1975	52,000,000	$ 9.55	$ 496,600,000
1980	110,000,000	12.78	1,405,800,000
1985	180,000,000	17.10	3,078,000,000

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

direct result of increased output of the petroleum refining industry in Texas. For this analysis, petroleum refining is defined as all activities and products included under Standard Industrial Classification (SIC) code 2911, as shown in the SIC Manual of 1967.[2] These are:

- Acid oil
- Alkylates
- Aromatic chemicals, made in petroleum refineries
- Asphalt and asphaltic materials: liquid, semi-solid and solid — produced in petroleum refineries
- Benzol, produced in petroleum refineries
- Coke, petroleum: produced in petroleum refineries
- Fractionation products of crude petroleum produced in petroleum refineries
- Gas, refinery or still oil: produced in petroleum refineries
- Gases, liquefied petroleum
- Gasoline blending plants
- Gasoline, except natural gasoline
- Greases: petroleum, mineral jelly, lubricating, etc. — produced in petroleum refineries
- Hydrocarbon fluid, made in petroleum refineries
- Illuminating oil, produced in petroleum refineries
- Jet fuels
- Kerosene
- Mineral oils, natural
- Mineral waxes, natural
- Naphtha, produced in petroleum refineries
- Naphthenic acids
- Oils, partly refined: sold for rerunning — produced in petroleum refineries
- Paraffin wax, produced in petroleum refineries
- Petrolatums, nonmedicinal
- Petroleum refining
- Petroleum re-refining
- Road materials, bituminous: produced in petroleum refineries
- Road oils, produced in petroleum refineries
- Solvents, produced in petroleum refineries
- Tar or residium, produced in petroleum refineries

TABLE 12

PROJECTED TEXAS REFINERY CAPACITY AND RUNS*
(Million Barrels Crude Daily)

SECTOR	1975	1980	1985
State Totals:			
Capacity	4.50	5.97	7.43
Runs	3.94	5.22	6.50
Texas Gulf Coast:			
Capacity	3.94	5.22	6.50
Runs	3.44	4.56	5.69

* runs at 87.5 percent of capacity

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station Texas.

Estimation of the total income and employment impacts of an increased level of oil refining in Texas is made possible through the application of regional and statewide multipliers. The multiplier concept, embodied in input-output models, states that an increase in the output of a sector of the regional economy will lead to an increase in regional employment and therefore to an increase in regional income. This increased income will, in turn, be spent, inducing a second round of increased regional employment and income which will also be spent to induce more income, and so on, to a finite limit. The calculated regional multiplier is an estimate of that finite limit. It is an estimate of the total amount of income generated by the injection of one dollar of new income into the region.[3]

The direct income generated by oil refining in Texas results from expenditures for goods and services used in the refining of a barrel of crude oil into many finished and semi-finished products. Expenditures made during the refining process go for items like: materials, such as feedstocks and intermediate compounds; electricity and fuels; chemicals and catalysts; containers and packaging; labor, both directly employed and contracted; overhead, such as taxes and insurance; capital items such as depreciation and new equipment; and operating margin.

Future oil refining activity in Texas is expected to reach the levels shown in Table 12.

VALUE OF OUTPUT

Value of refinery output is the value of shipments from the refinery. This consists of the cost of materials plus value added and is termed "refining realization." Refinery output can be expressed in terms of total dollars or in dollars per barrel. For this analysis, we began with the average value of output per barrel of crude refined (refining realization) and computed the total dollar output per unit of time, based upon expected run levels for 1975, 1980, and 1985 (Table 12).

Figure 22 is a plot of average refining realizations by year from 1963 and projected to 1985. Average realizations for the United States Gulf Coast and Mid-continent areas are shown separately.

Values of output for the three forecast periods, utilizing run levels from Table 12 and realizations from Figure 22, are shown in Table 13 (in 1972 dollars).

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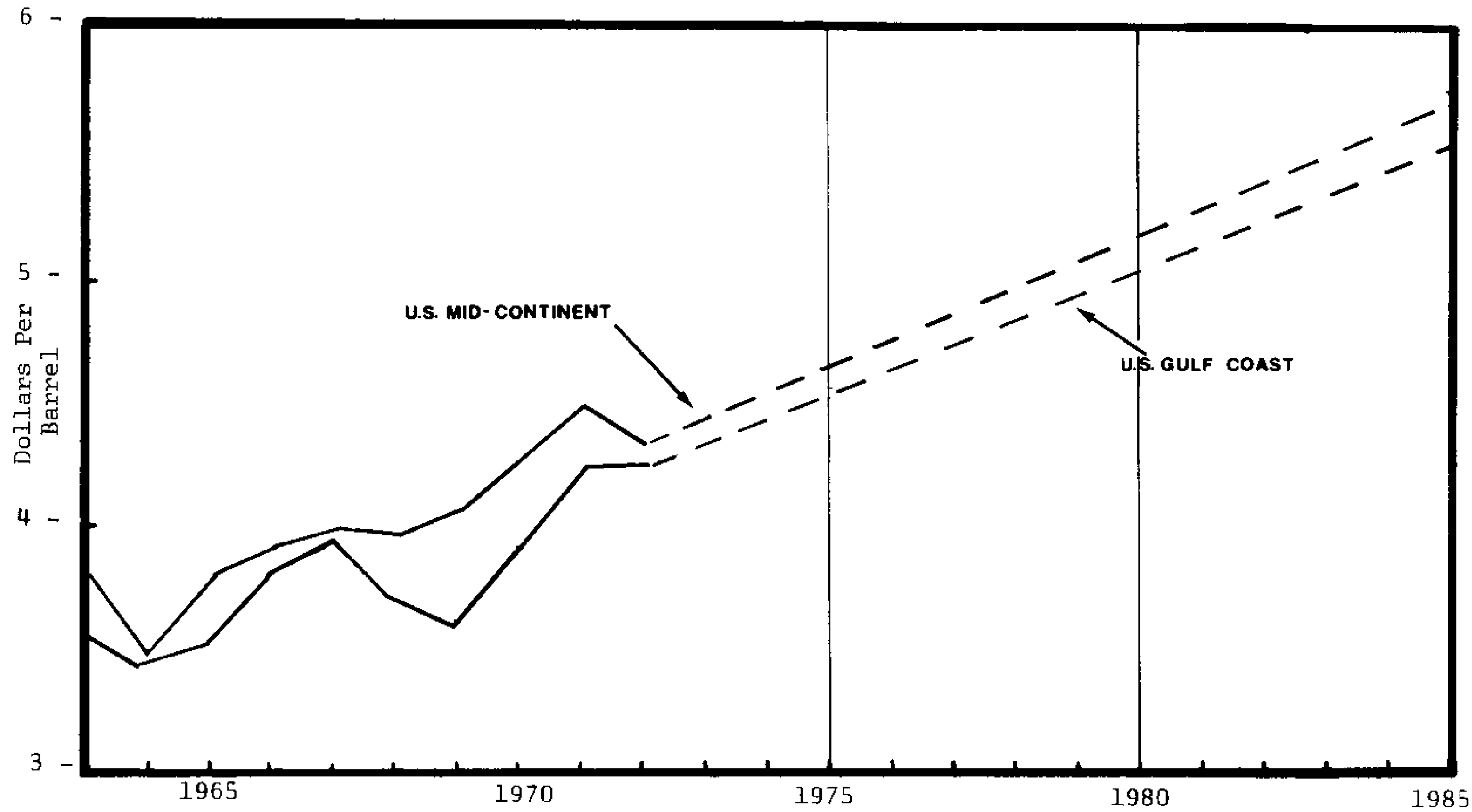
[2] *Standard Industrial Classification Manual*, Executive Office of the President, Washington, D.C., 1967.

[3] Schenker, Eric, "Present and Future Income and Employment Generated by the St. Lawrence Seaway," Center for Great Lakes Studies, the University of Wisconsin-Milwaukee, Milwaukee, Wisonsin, 1971.



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 22

REFINING REALIZATIONS

To obtain the total direct, indirect, and induced effects of the projected refinery outputs shown in Table 13, output multipliers from the Texas Input-Output Model were utilized. The multipliers used were the **closed model output multipliers** for Petroleum Refining from the State table, and the same multiplier from each of the regional tables for Regions 7, 8, and 9. Values for these multipliers are:

State Model 2.55993171

Region 7 ....2.11278513
(Lower Rio Grande)

Region 8 ....1.77905916
(Houston-Galveston)

Region 9 ....1.16810017
(Southeast Texas)

Table 14 summarizes the total dollar impact of refinery output for the state and each region, by forecast period, in 1972 dollars.

TABLE 13

VALUE OF REFINERY OUTPUT
($ Million Per Year)

SECTOR	1975	1980	1985
Texas (Except Gulf Coast)	$ 839.5	$1,252.7	$ 1,685.2
Texas Gulf Coast	5,649.9	8,488.4	11,526.5

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 14

ECONOMIC IMPACT OF OIL REFINING IN TEXAS
($ Billion Per Year)[1]

AREA	MULTIPLIER	1975	1980	1985
State	2.55993171	$16.787	$24.729	$33.829
Region 7	2.11278513	1.118	1.740	2.387
Region 8	1.77905916	4.929	7.252	9.946
Region 9	1.16810017	2.783	4.094	5.615
Texas Gulf Coast (7+8+9)	N.A.	8.830	13.086	17.948

[1] 1972 dollars

N.A. — Not Available

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 15

ECONOMIC IMPACT OF TEXAS DEEPWATER TERMINAL
($ Billion Per Year)[1]

SOURCE	1975	1980	1985
Oil Refining--Net	$3.920	$10.422	$18.112
Port Related	.497	1.406	3.078
TOTAL	$4.417	$11.828	$21.190

[1] 1972 dollars

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 16

NEW JOBS RESULTING FROM TEXAS DEEPWATER TERMINAL

SOURCE	1975	1980	1985
Oil Refining Industry	8,498	22,595	39,266
Total in State (Incl. Refining)	72,887	193,789	336,770

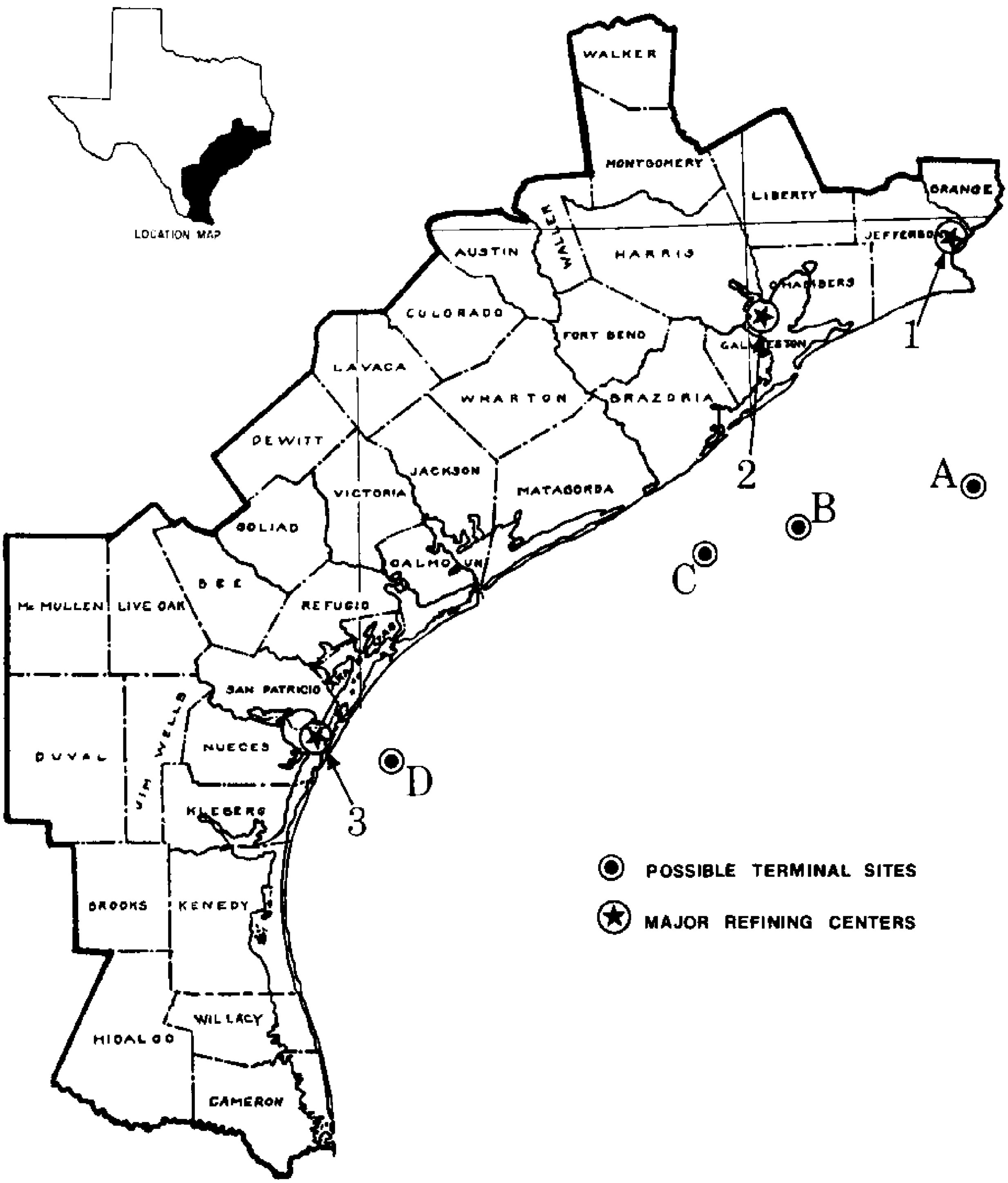
SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

IMPACT OF DEEPWATER TERMINAL

The total impact of the proposed terminal, as defined, is the sum of the impact from port-related activities and the impact from oil refining in the state, less the impact generated by present refining output. Present refining levels are expected to remain as they are, even if the terminal is not built because Texas oil production is forecast to be relatively stable for a number of years. Since no deepwater terminal presently exists, there is no economic effect of a terminal at the present time. Therefore, the net cumulative impact of the deepwater terminal is as shown in Table 15.

Table 16 gives estimates of new job levels anticipated throughout the economy of Texas resulting from growth in the refining industry, considering the number of jobs which presently exist in the industry. The estimates are derived by applying the state labor multiplier from the Texas Input-Output Model to the projected growth in oil refinery output. The state labor multiplier is assumed to be constant through 1985.

New jobs created as a result of the growth in oil refining in Texas represent the major job increase to be experienced. The methodology for determining economic impact from port growth does not provide for a separate calculation of job growth in this area; therefore, the employment increase resulting from growth in port-related areas is not included in this summary.



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 23

POSSIBLE TEXAS DEEPWATER TERMINAL SITES AND EXISTING REFINERY CENTERS

BENEFITS AND COSTS

An important consideration in determining the feasibility and worth of a project is comparison of the cost to the benefits created. Individuals make this sort of comparison by considering the benefits to be gained each time they incur a personal expenditure. Corporations do it when they look at the potential payout of a capital investment. Government agencies perform a cost/benefit analysis of a project to determine if the benefits to the public merit an expenditure of tax dollars.

NATURE OF COSTS

Cost studies of a project traditionally consider only the tangible costs because these are the most obvious and the most easily quantified figures. Other, less tangible costs, such as social costs, are not so easily derived and, even when such factors receive quantification, there is no methodology that ensures the values are absolute.

There are, however, varying degrees of reliability of quantified social costs. For example, industrial development in an area has its costs. Capital outlays and increased community expenditures are often required to provide services for a new firm and its employees. Water supply and sewage disposal systems may require expansion. New streets and highways may be needed, and traffic control expenditures may increase. More police and fire protection may be required. Population increase — a usual result of industrial growth — commonly brings demands for additional educational and medical facilities, and for increased public health and welfare services. And, of more recent interest, costs of environmental involvement must be considered.

Most costs enumerated above should be somewhat quantifiable because the methodology has been proven by use. However, we are all familiar with how many times planners miss the target on estimated costs and needs for public facilities — the highways that are congested as soon as they are put into service, new schools that are soon overcrowded, and inadequate parking space around many newly-constructed public facilities. Thus, the reliability of social cost quantification is somewhat questionable.

Because social cost quantification leaves much to be desired, particularly when any long-range forecast is attempted, this impact analysis does not attempt to include the dollars and cents of social costs in the cost/benefit equation. Instead, the costs used are limited to those of a highly quantifiable nature which, by definition, are the capital costs associated with construction of the deepwater terminal and its supporting facilities.

NATURE OF BENEFITS

For any project, benefits, like costs, range from the material to the intangible. Material benefits are those of an immediate and direct nature, such as cost savings, increased incomes and increased sales. Certain benefits are relatively intangible, such as increased income to a taxing body, higher-value utilization of land, higher degree of job security for individuals through diversification of the economic base and improvement of environment through better treatment of waste.

Some intangibles can be quantified to a degree but, as in the case of costs, the reliability of such quantification is questionable. For this analysis, benefits are used in the cost/benefit equation only to the extent that they are quantifiable to a high degree of accuracy. By definition, this is limited to benefits of an economic nature only; in this case, only the multiplier effects of petroleum refinery growth and savings in transportation of imported crude oil are considered.

COST/BENEFIT OF THE DEEPWATER TERMINAL

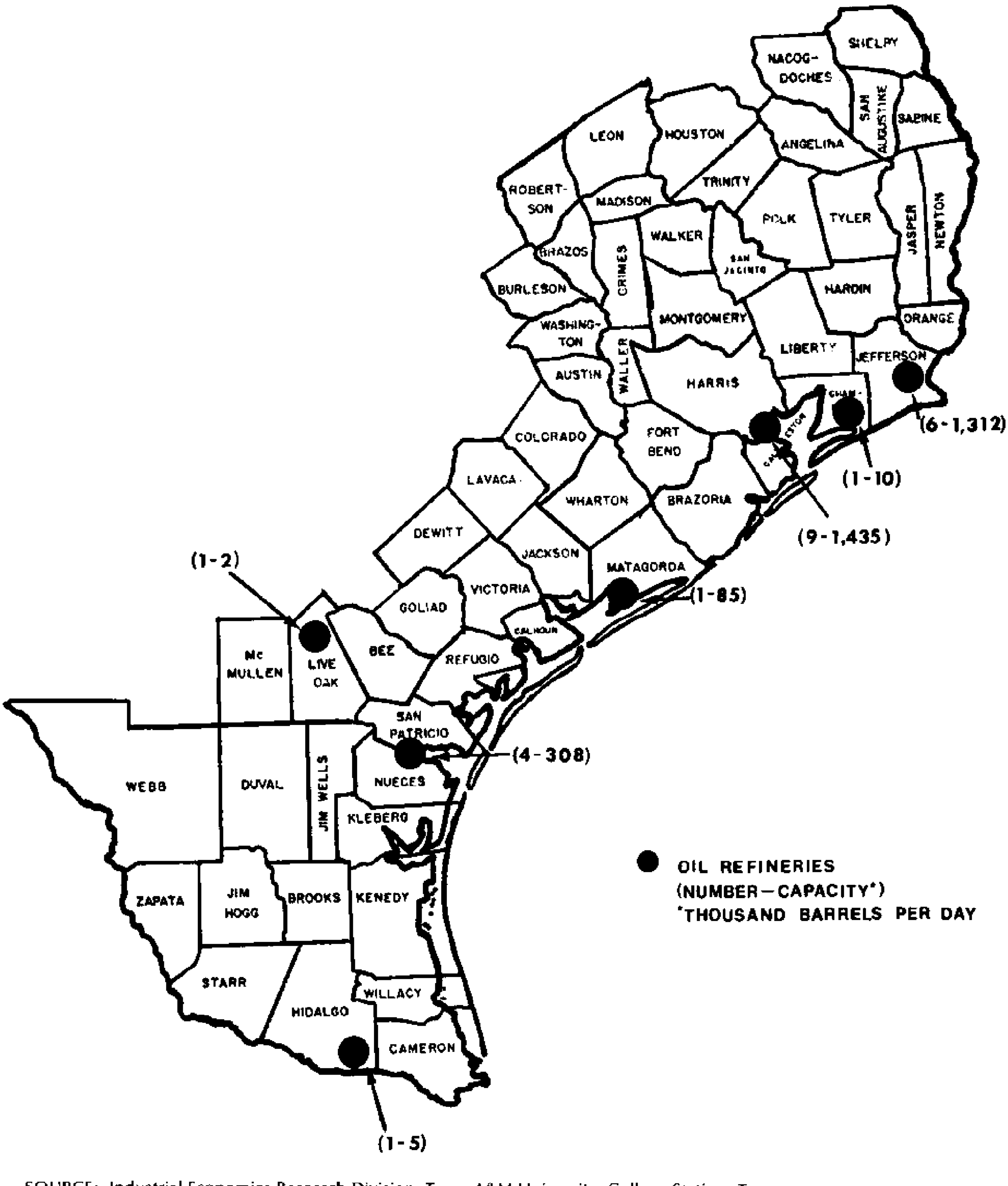
Estimation of the capital costs for a Texas deepwater terminal utilize 1972 base costs obtained from a variety of industry sources. In the absence of detailed engineering design and cost analysis, the costs calculated are of a general nature and not exact; the numbers used are indicative, in terms of 1972 dollars, of what can be expected when the terminal is actually built.

For capital cost estimation purposes, four suggested sites along the Texas coast are used. Location of 100-foot water depth determines the distance offshore for each site. The suggested sites and their locations are shown in Figure 23 and described as follows:

- Site A — approximately 65 nautical miles due south of Sabine Pass, Texas
- Site B — approximately 47 nautical miles due south of Galveston, Texas
- Site C — approximately 29 nautical miles due south of Freeport, Texas harbor entrance
- Site D — approximately 18 nautical miles east-southeast of Aransas Pass, Texas

To determine the other end-point of crude delivery from the deepwater terminal, three main centers of refining capacity have been designated in Figure 23 and are generally situated as follows:

- Center #1 — the general area along the west side of Sabine Lake in the Port Arthur, Beaumont, and Orange, Texas triangle.
- Center #2 — along the Houston Ship Channel, and the west and northwest shores of Galveston Bay.
- Center #3 — the general vicinity of Corpus Christi, primarily Harbor Island.



SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

FIGURE 24

TEXAS GULF COAST REFINERIES AND CAPACITIES

The three refining centers were chosen because they represent the bulk of the Texas coastal refining capacity. In the immediate area of location number one, there is a total of 1.312 million barrels per day of capacity; at location number two, the capacity amounts to 1.435 million barrels a day; at location number three, there is a total of 308 thousand barrels per day for a total at all three locations of 3.055 million barrels per day. In comparison, the entire Texas coastal zone has a total of 3.157 million barrels per day of capacity. Figure 24 shows these refineries.

It is also likely that much of the new capacity added along the coast in the next several years will consist of additions to and expansions of these existing refineries. Calculation of the cost of the Texas deepwater terminal using these centers as receiving points for crude oil is, therefore, a logical course of action.

Calculation of Costs. The deepwater terminal design that appears most feasible for Texas at this time is one with a number of component parts, including: monobuoys, along with platforms containing pumping and service equipment, undersea pipelines connecting each buoy to a platform, undersea pipelines running from each platform to shore, oil storage facilities on shore, and distribution pipelines overland from the storage facilities to crude oil users.

Monobuoys are proposed for the Texas deepwater terminal because they offer the twofold advantage of being usable during relatively rough weather and, as larger vessels create demands for deeper water in which to tie up, the buoys can be relocated to deeper water to meet the need. The buoys proposed are assumed to have a throughput capacity, on a year-round average, of 600,000 barrels per day each. Cost of each buoy, installed in 100-foot water, is estimated to be $2.5 million.

Underwater pipelines, connecting each buoy to a platform and connecting each platform to the onshore storage facility, will probably need to be at least 48 inches in diameter, due to the unloading rates and flow volumes predicted. Forty-eight inch pipelines, buried three feet under the ocean floor, except at ship fairway crossings where they will be buried at least 10 feet beneath the ocean floor, are estimated to cost approximately $1.0 million per mile, in place.

Monobuoys offer two primary advantages: the ability to withstand rough weather and the flexibility to accommodate increased ship sizes.

It is assumed that there will be one pumping platform for each monobuoy. Each platform will contain pumping and metering equipment to move the crude oil to shore as it is unloaded from tankers. A platform, completely equipped, is estimated to cost $5.0 million.

Storage tanks on shore are proposed to be of 500,000-barrel size. This size should hold down the per-barrel cost of storage to a minimum. Each 500,000 barrel tank is estimated to cost $1.5 million and, for optimal operating conditions, enough tanks should be built to provide a minimum of eight days' receipts of crude oil through the offshore facilities. At least 2,000 acres of land should be provided for the storage facility and for possible future expansion. Certain supporting equipment such as valves and meters will also be required.

Offshore pipelines for overland distribution of crude oil from the storage facility to refineries and other crude oil users, can vary greatly in size. Depending upon need, the crude oil pipelines may be six inches to 36 inches in diameter. For this study only two sizes, 16-and 24-inch, are used. A cost of $7,000 per diameter inch, per mile is used to estimate onshore pipeline costs.

A summary of the components of the proposed Texas deepwater terminal is shown in Table 17. All costs are in 1972 dollars.

For each offshore site location studied, the base cost of the off-shore terminal, consisting of monobuoys, platforms, and pipelines connecting them to each other, and the base cost of the onshore terminal, consisting of storage tanks and support equipment, is assumed to be constant. The major cost difference between sites, therefore, is the cost of pipelines — from offshore location to tank farm and from tank farm to each refinery center.

Tables 18-22 show development of the cost for each component of the terminal complex. Table 23 summarizes the various costs to arrive at a total cost for the terminal at each of the four sites, for crude oil volumes to be moved in 1975, 1980 and 1985.

Onshore Pipelines. Volumes of crude distributed to each of the three refinery centers are assumed to be

TABLE 17

COMPONENTS OF A DEEPWATER TERMINAL

ITEM	COST ($ MILLION)
Monobuoy, 600,000 BBL/DAY capacity, installed in 100-foot water, each	$ 2.5
Pipeline, underwater, 48-inch, buried 3 feet (10 feet at fairways), per mile	1.0
Platform, with pumping equipment, (1 per monobuoy) each	5.0
Storage Tanks, onshore, 500,000-BBL. capacity, each	1.5
Pipeline, onshore, per inch-mile	.007
Supporting Equipment for Onshore Tank Farm	6.0-10.0

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 18

FIXED COSTS[1]
($ Million Investment Each Period)

ITEM	1975	1980	1985	TOTAL
Imports (Million bbl/day)	1.0	2.1	3.5	
Offshore Terminal:				
Monobuoys-No./Cost	2/$ 5.0	2/$ 5.0	2/$ 5.0	6/$15.0
Platforms-No./Cost	2/$10.0	2/$10.0	2/$10.0	6/$30.0
Pipelines on Site-Cost	$4.0	$4.0	$4.0	$12.0
TOTAL-Offshore Sites	$19.0	$19.0	$19.0	$57.0
Onshore Terminal:				
Storage Tanks-No./Cost (8 days storage)	16/$29.0[2]	18/$27.0	23/$34.5	$90.5
Support Equipment	$ 6.0	$ 2.0	$ 2.0	$10.0
TOTAL-Onshore Site	$35.0	$29.0	$36.5	$100.5
TOTAL FIXED COSTS	$54.0	$48.0	$55.5	$157.5

[1] 1972 dollars

[2] including land

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 19

UNDERSEA PIPELINES[1]
($ Million Investment Each Period)

SITE	STATUTE MILES	COSTS[2] 1975	1980	1985	TOTAL
Site A	75	$150.0	$150.0	$150.0	$450.0
Site B	54	108.0	108.0	108.0	324.0
Site C	33	66.0	66.0	66.0	198.0
Site D	21	42.0	42.0	42.0	126.0

[1] Two 48-inch pipelines per site per time period

[2] 1972 dollars

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 20

CRUDE OIL DELIVERIES
(Thousands of Barrels Daily)

TO	PERCENT PRESENT REFINING CAPACITY	1975	1980	1985
Center No. 1	37.9	379	795	1,325
Center No. 2	41.4	414	870	1,450
Center No. 3	8.9	89	187	312

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 21

PIPELINE SIZES USED OVERLAND

SIZE-INCHES	CAPACITY-bbl/day	COST PER MILE[1]
16	100,000	$112,000
24	400,000	$168,000

[1] 1972 dollars

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 22

ONSHORE CRUDE PIPELINES REQUIRED[1]

TO	1975	1980	1985
Center #1	1-24 inch	1-24 inch	1-24 inch 1-16 inch
Center #2	1-24 inch 1-16 inch	1-24 inch	1-24 inch 1-16 inch
Center #3	1-16 inch	1-16 inch	1-16 inch

[1] Average size required. Pressure drop and differential sizes for distance not considered.

SOURCE: Industrial Economics Research Divison, Texas A&M University, College Station, Texas.

TABLE 23

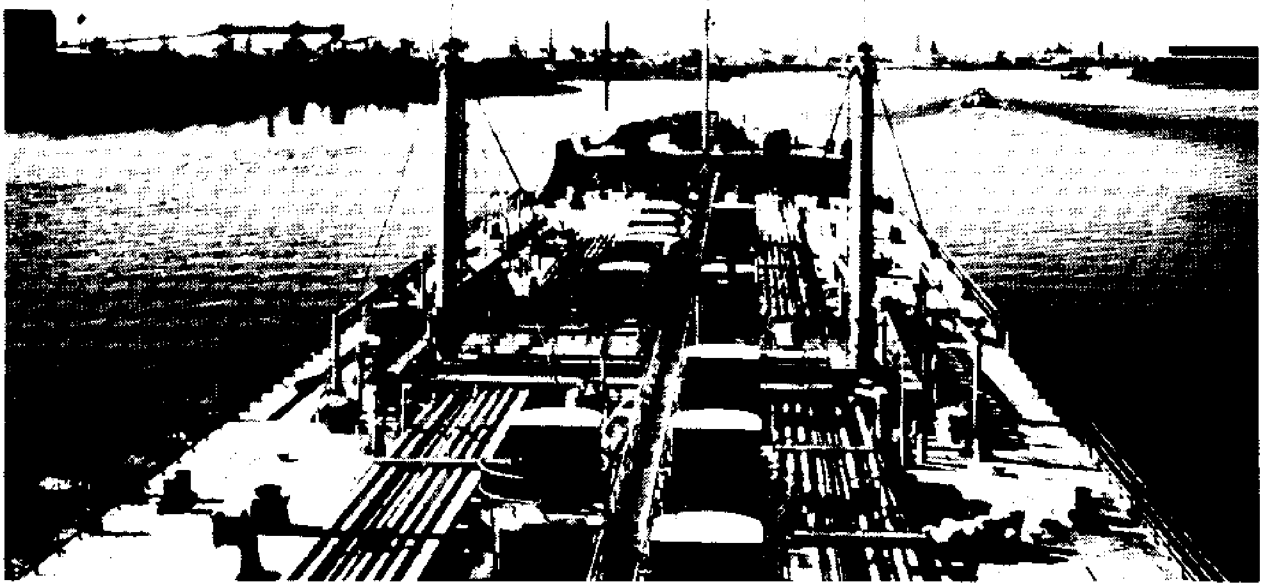
ONSHORE CRUDE PIPELINE COSTS[1]
($ MILLION PER TIME PERIOD)

FROM	TO	STATUTE MILES	1975 COST	1980 COST	1985 COST	TOTAL COST
SITE A	Center #1	22.5	$ 3.78[2]	$ 3.78	$ 6.30	$ 13.86
	Center #2	77.5	21.7	13.0	21.7	56.40
	Center #3	250.0	25.0	25.0	25.0	75.00
TOTAL			$50.48	$41.78	$ 53.00	$145.26
SITE B	Center #1	67.8	$11.4	$11.4	$ 19.0	$ 41.80
	Center #2	35.4	9.9	5.95	9.9	25.75
	Center #3	180.0	20.2	20.2	20.2	60.60
TOTAL			$41.5	$37.55	$ 49.1	$128.15
SITE C	Center #1	119.4	$20.0	$20.0	$ 33.4	$ 73.40
	Center #2	61.3	17.15	10.3	17.15	44.60
	Center #3	135.4	15.18	15.18	15.18	45.54
TOTAL			$52.33	$45.48	$ 65.73	$163.54
SITE D	Center #1	250.0	$42.0	$42.0	$ 75.0	$159.00
	Center #2	183.8	51.5	30.8	51.5	133.80
	Center #3	5.0	0.56	0.56	0.56	1.68
TOTAL			$94.06	$73.36	$127.06	$294.48

[1] Costs assumed: 16-inch, $112,000 per mile; 24-inch, $168,000 per mile.

[2] 1972 dollars

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.



proportional to each refinery center's share of total refining capacity for the state of Texas in 1972. For the rest of the state, it is assumed existing pipelines will be used to deliver imported crude.

By considering the volumes of crude oil to be imported for each time period, along with earlier assumptions regarding proportional distribution of imported crude to each refinery center, it is possible to estimate the pipeline capacity required to serve each refinery center. Table 22 shows the number of pipelines of either 16 or 24-inch size required to be built between a storage facility and each refinery center, by no later than the year shown. Table 23 shows estimated costs for onshore pipelines in 1972 dollars.

SUMMARY OF COSTS

The cost for each of the four suggested sites, based upon assumptions made during this study, is shown in Table 24.

SUMMARY OF BENEFITS

The direct benefit of having a deep water terminal in Texas, aside from the economic impact, will be the savings in transportation costs resulting from use of VLCC's instead of conventionally-sized vessels to transport imported crude oil. Soros Associates, in a report to the United States Maritime Administration,[1] has computed the savings in transportation costs to be gained through use of 250,000 dwt and 326,000 dwt VLCC's as opposed to 65,000 dwt tankers to haul crude oil from the Middle East to the United States. The costs per ton to transport crude oil over the 24,000 mile round trip from the Persian Gulf to U. S. North Atlantic ports are shown in Table 25.

Cost savings for the petroleum-consuming industries of Texas, using 250,000 dwt vessels, starting in 1975 and continuing through 1985, are $3,635,4000,000. This is based on cumulative imports of 1.245 billion tons of crude oil from 1975 through 1985.

In the area of economic impact, the cumulative gains to the state's economy, from 1975 through 1985, amount to $119.6 billion. This is in terms of new jobs, new sales and additional income in many sectors of the economy.

COST-BENEFIT COMPARSION

A comparison of costs to benefits for four possible sites, calculated for the Texas deepwater terminal, is shown in Tables 26 and 27. The reader should understand that these comparisons are based upon numbers that were developed under a set of assumptions that may or may not prove to be valid. All assumptions, however, are the result of a large number of interviews with key persons in government and industry, along with a review of currently-published literature. Consequently, the conclusions drawn in this study should be fully representative of expected conditions.

Table 26 indicates the cost benefit ratios to 1985 for the four suggested terminal sites based on transportation savings. Table 27 is similar, but ratios shown are based upon transportation savings plus the benefits of economic impact.

The benefit-cost potential of one or more deepwater terminals in Texas, ranging from 4.8:1 if only transportation costs savings are considered, to 238:1 when including the economic impact, should leave no doubt as to the desirability of these facilities.

Unfortunately, economic advantages are not the whole story. A great deal of time, care and consideration should, and must, be given to the political, social and environmental implications of deepwater terminals to ensure their acceptability.

Therefore, although an economic impact evaluation is a good beginning, studies in a number of other key areas should be begun as soon as possible so that full knowledge of deepwater terminals can be acquired without undue delay. The need for a decision in Texas is too important for anything less than an urgent, full-scale program of work.

1"Feasibility of a North Atlantic Deepwater Terminal," Soros Associates, New York, New York, July, 1972.

TABLE 24

SUMMARY OF COSTS[1] [2]
($ Million)

LOCATION	1975	1980	1985
Site A			
Offshore Terminal	$ 19.0	$ 19.0	$ 19.0
Onshore Terminal	35.0	29.0	36.5
Pipelines to Shore	150.0	150.0	150.0
Onshore Pipelines	50.5	41.8	53.0
TOTAL-SITE A	$254.5	$239.8	$258.5
Site B			
Offshore Terminal	$ 19.0	$ 19.0	$ 19.0
Onshore Terminal	35.0	29.0	36.5
Pipelines to Shore	108.0	108.0	108.0
Onshore Pipelines	41.5	37.6	49.1
TOTAL-SITE B	$203.5	$193.6	$212.6
Site C			
Offshore Terminal	$ 19.0	$ 19.0	$ 19.0
Onshore Terminal	35.0	29.0	36.5
Pipelines to Shore	66.0	66.0	66.0
Onshore Pipelines	52.3	45.5	65.7
TOTAL-SITE C	$172.3	$159.5	$187.2
Site D			
Offshore Terminal	$ 19.0	$ 19.0	$ 19.0
Onshore Terminal	35.0	29.0	36.5
Pipelines to Shore	42.0	42.0	42.0
Onshore Pipelines	94.1	73.4	127.1
TOTAL-SITE D	$190.1	$163.4	$224.6

[1] Per incremental forecast period

[2] 1972 dollars

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 25

OCEAN FREIGHT COST[1]
CRUDE OIL FROM PERSIAN GULF TO UNITED STATES
(Dollars Per Ton)

VESSEL SIZE	COST	COST SAVINGS
65,000 deadweight tons	$9.63	--
250,000 deadweight tons	6.71	$2.92
326,000 deadweight tons	6.15	3.48

[1] 1972 dollars

SOURCE: Soros Associates, New York, New York.

TABLE 26

TEXAS DEEPWATER TERMINAL
COST-BENEFIT RELATIONSHIPS TO 1985[1]
(Transportation Savings Only)

SITE	COSTS[2] ($ MILLION)	BENEFITS ($ MILLION)	RATIO
Site A	$ 753	$3,635	4.8:1
Site B	610	3,635	5.9:1
Site C	519	3,635	7.0:1
Site D	578	3,635	6.3:1

[1] 1972 dollars

[2] Capital costs only

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 27

TOTAL TEXAS DEEPWATER TERMINAL COST-BENEFIT RELATIONSHIPS TO 1985[1] (Transportation Savings and Economic Impact)

SITE	COSTS[2] ($ MILLION)	BENEFITS ($ MILLION)	RATIO
Site A	$ 753	$ 123,235	164:1
Site B	610	123,235	202:1
Site C	519	123,235	238:1
Site D	578	123,235	214:1

[1] 1972 dollars

[2] Capital costs only

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TEXAS WITHOUT A DEEPWATER TERMINAL

If deepwater terminals are not built in Texas, the state could suffer deep and lasting economic repercussions. Not only would there be a failure to achieve continuing economic gains from growth in oil refining, but also the probability of losses to the economy would increase.

When a refiner plans to increase the operating level of his facility to achieve certain economies of scale that will help lower the per barrel cost of processing crude oil, and he finds inadequate availability of crude oil to support the expansion, there is a good possibility that he will start considering relocation to a source of crude. Although the tax life of an oil refinery is 20 years and the useful life is about 40, the present high cost of money causes many industry executives to plan for a five to seven year payout on new plant investments. Thus, conceivably, shutdown of refineries in Texas and relocation of operations elsewhere could begin at any time.

If such an eventuality ever became reality, the potential for loss could involve an estimated 30,000 refinery jobs and $4.7 billion in refinery output (1972 estimates) in Texas. Of course, there would not be a complete shutdown of the Texas refining industry overnight, but attrition will take its course as soon as crude oil supplies begin to run out. And, the $12 billion of economic activity generated by oil refining in the state in 1972 would eventually be gone.

BIBLIOGRAPHY

"A Deepwater Port Analysis-Delaware River Bay," Delaware River Port Authority, Philadelphia, Pennsylvania, May 30, 1972.

American Petroleum Institute, "Petroleum Facts and Figures, 1971 Edition," API, Washington, D.C., May, 1971.

Arthur D. Little, Inc., "Foreign Deep Water Port Developments," Institute for Water Resources, Army Corps of Engineers, Alexandria, Virginia, December, 1971.

Booz-Allen Applied Research, Inc., "Forecast of U.S. Oceanborne Trade in Dry Bulk Commodities," Maritime Administration, U.S. Department of Commerce, Washington, D.C., March, 1969.

Bragg, Dan M. and James R. Bradley, "Work Plan for a Study of the Feasibility of an Offshore Terminal in the Texas Gulf Coast Region," Sea Grant Report TAMU-SG-71-212, Texas A&M University, College Station, Texas, June, 1971.

Census of Manufactures – 1967, Bureau of the Census, U.S. Department of Commerce, Washington, D.C., September, 1970.

Coffey, Joseph B., "Maine's Deep Water Harbors," Maine Department of Economic Development, Augusta, Maine, March, 1971.

"Energy: A Look Ahead," Humble Oil and Refining Company, Houston, Texas, September, 1971.

"Energy, Economic Growth, and Environment," Resources for the Future, Inc., Washington, D.C., April, 1971.

Eyre, John L., et. al., "Measuring Port Sales," The American Association of Port Authorities, Washington, D.C., undated.

Fulkerson, Frank B., "Gulf Coast Export-Import of Mineral Commodities," Bureau of Mines Circular No. 8508, U.S. Department of the Interior, Washington, D.C., 1971.

Heine, Irwin M., "The Growing Energy Crisis and the U.S. Tanker Fleet," The Labor-Management Maritime Committee, Washington, D.C., December, 1971.

International Petroleum Encyclopedia – 1972, The Petroleum Publishing Company, Tulsa, Oklahoma, 1972.

Litton Systems, Inc., "Oceanborne Shipping: Demand and Technology Forecast," Department of Transportation, Washington, D.C., June, 1968.

Madden, Carl H., "What New Industrial Jobs Mean to a Community," Chamber of Commerce of the United States, Washington, D.C., 1968.

Miloy, John and A. E. Copp, "Economic Impact Analysis of Texas Marine Resources and Industries," Sea Grant Report TAMU-SG-70-217, Texas A&M University, College Station, Texas, June, 1970.

"NCA Forecasts 24% Rise in Coal Use by 1976," *Coal News*, National Coal Association, Washington, D.C., No. 4093, January 21, 1972.

"Outlook for Energy in the United States to 1985," The Chase Manhattan Bank, New York, New York, June, 1972.

Schenker, Eric, "Present and Future Income and Employment Generated by the St. Lawrence Seaway," Center for Great Lakes Studies, Milwaukee, Wisconsin, 1971.

Soros Associates, Inc., "Feasibility of a North Atlantic Deep-Water Oil Terminal," Maritime Administration, U.S. Department of Commerce, Washington, D.C., July, 1972.

Standard Industrial Classification Manual, Executive Office of the President, Washington, D.C., 1967.

"Sun Oil Company's Annual Tanker Report," *Maritime Reporter/Engineering News*, Vol. 33, No. 23, December 1, 1971.

Texas Almanac, 1972-73, A. H. Belo Corporation, Dallas, Texas, 1972.

Texas Input-Output Model, Office of the Governor, Austin, Texas, 1972.

"The National Energy Position," Shell Oil Company, Houston, Texas, April, 1971.

"The National Energy Problem," Shell Oil Company, Houston, Texas, May, 1972.

"The Political Economy of Energy and National Security," Rocky Mountain Petroleum Economics Institute 1969, Golden, Colorado, October, 1969.

"Trades of World Bulk Carriers, 1970," Fearnley and Egers Chartering Company, Ltd., Oslo, Norway, November, 1971.

"World Coal Trade, 1971," National Coal Association, Washington, D.C., October, 1971.

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