ENERGY IN TEXAS VOLUME II: POLICY ALTERNATIVES

Lyndon B. Johnson School of Public Affairs The University of Texas at Austin

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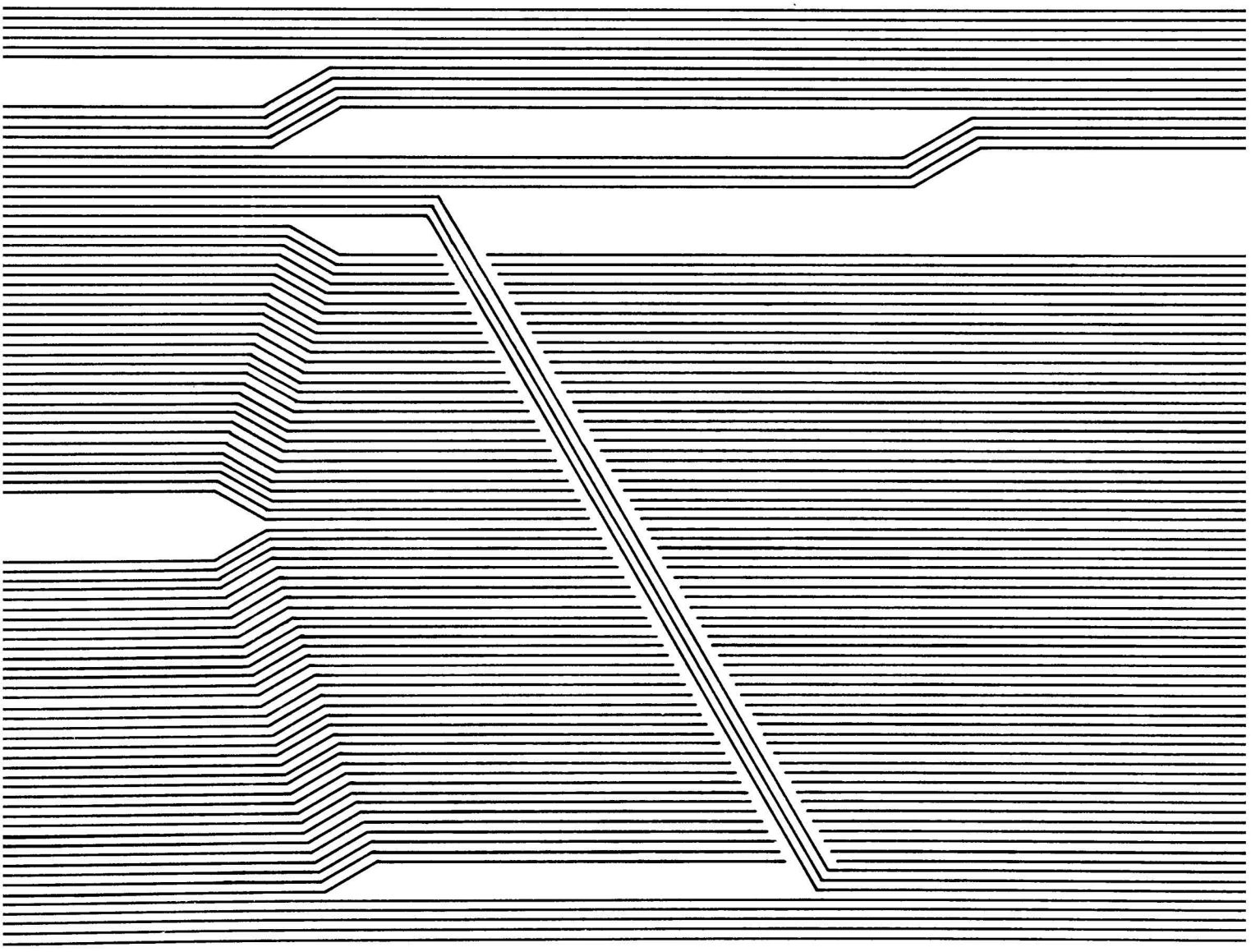
VOLUME II:
POLICY ALTERNATIVES

LYNDON B. JOHNSON SCHOOL OF PUBLIC AFFAIRS POLICY RESEARCH PROJECT REPORT



A Report by The State Energy Policies Policy Research Project
Marlan Blissett, Project Director
Lyndon B. Johnson School of Public Affairs
The University of Texas at Austin 1974

FOREWORD

This report was prepared for the Energy Crisis Committee of the Texas House of Representatives by the Research Project on State Energy Policies of the Lyndon B. Johnson School of Public Affairs. The committee, recognizing that short-term problems must often dominate in the legislature, sought this study in order to provide a perspective on both short- and long-term aspects of the energy crisis. We had hoped that the report would provide a focus for discussion about state energy policy. Judging from the interest in the preliminary report, we are certain that our expectations will be fulfilled. This document will undoubtedly be required reading for anyone concerned with energy policy in Texas.

The partnership between the committee and the research project has produced benefits for both. We have been presented with much more information than we could have brought together on our own, and the students have gained a unique "real world" experience in government. The committee commends this type of arrangement to other legislative committees and state agencies. The people of Texas stand to profit greatly from such partnerships.

The faculty and students are to be congratulated for synthesizing effectively such a large body of information and presenting it in a manner suitable for legislative consideration and action. The committee and the people of Texas would like to thank Project Director Dr. Marlan Blissett, as well as the faculty and students of the project for their cooperation with the committee and their conscientious efforts in producing this document. They have challenged this committee, the legislature, and all Texans to respond to the energy problem in a rational and systematic manner. This report represents the first step; we invite those responsible for it to continue with us in this effort.

Jon Newton
Chairman, House Energy Crisis Committee

PREFACE

This is the second of a two-volume study dealing with energy problems in Texas. Volume I examines electric power generation in the state, with emphasis on consumption patterns, available fuels, environmental impacts, and procedures for regulating both conventional and nuclear powerplants. This volume surveys a much broader energy spectrum and develops a number of state policy alternatives for coping with immediate and long-range energy demands. Both studies are the product of two separate policy research projects conducted at the Lyndon B. Johnson School of Public Affairs over a two-year period, 1972-1974.

Research for Volume II began in the fall of 1973 at the request of Jon Newton, Chairman of the Energy Crisis Committee of the Texas House of Representatives. The committee's interest in the project and its continuing support were prompted by the lack of usable information on what the state could do to alleviate energy shortages and plan intelligently for the future. On May 13, 1974, a preliminary draft of this report was presented to the committee at a special hearing called for that purpose. During the proceedings committee members examined the findings and probed almost every policy recommendation with a stern and critical eye. The draft report was circulated later for review and comment by individuals and groups expressing an interest in its contents.

In its present form Volume II represents the work of many people, researchers as well as critics. Even so, it is by no means a perfect document, for it embraces a variety of technical areas that cannot be completely understood without extensive training and experience. On the other hand, the research presented here has a policy focus that is frequently absent in technical reports. It is our hope that what may have been sacrificed in the way of technical expertise is counterbalanced by the effort made to discuss the comprehensive nature of energy problems confronting the state.

We are grateful to many individuals whose cooperation and assistance have made this volume possible. In particular we wish to thank: Dan Caldwell, Project Director for the House Energy Crisis Committee; Bill Duncan, Bob Davis, Harriett Hahn, and Denzel Fisher, Energy Resources Section, Division of Planning Coordination, Office of the Governor; John Jacobsen and M.F. Sullivan, Shell Oil Company; G.R. Stanford, Texas Offshore Terminal Commission; Al Askew, State Emergency Fuel Allocation Office; Abe Dukler, Governor's Energy Advisory Council; Myron Dorfman and William Kaiser, Bureau of Economic Geology, The University of Texas at Austin; William Gibson, School of Law, The University of Texas at Austin; Joe Bill Watkins, Attorney General's Office; Robert Lockwood, Bureau of Business Research, The University of Texas at Austin; Tom Hays, John Huggins, and Guy Matthews, Texas Railroad Commission; H.E. White, John Staleski, and George Frank, General Land Office; Harold Tynan, Electric Reliability Council of Texas; and Samuel Ellison, Department of Geology, The University of Texas at Austin.

We are also grateful to the Ford Foundation for funding a portion of the costs of the research effort.

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SUMMARY OF RECOMMENDATIONS

CONSERVATION

1. ***Public education campaign.*** The Office of the Governor should conduct a public education campaign to inform Texas residents of ways to conserve energy in the home.

2. ***Efficiency labels for appliances.*** Legislation should be passed requiring retailers to label all appliances sold in Texas with efficiency labels in comparable energy units.

3. ***Insulation standards.*** Minimum insulation standards for all new buildings should be set by law.

4. ***Limitation of lighting for advertising.*** The legislature should limit commercial lighting for advertising.

5. ***Industrial energy awareness program.*** The state should encourage, coordinate, and assist in the funding of an industry-led "energy awareness" program to distribute information on the technical and economic aspects of energy conservation.

6. ***Industrial life-cycle planning.*** In order to encourage greater industrial life-cycle planning, including recovery and recycling procedures, the legislature should help to initiate and fund related projects by providing subsidies or tax considerations for participating industries.

7. ***Modular Integrated Utility Systems.*** The legislature should pass a resolution encouraging the development of Modular Integrated Utility Systems (MIUS).

8. ***Energy Conservation Council.*** The legislature should create an Energy Conservation Council to study and recommend energy conservation measures, including demonstration projects; the council would coordinate energy efforts of citizens, businesses, and public institutions.

9. ***Energy budgets for state facilities.*** The State Building Commission should establish energy budgets for all existing state-owned or state-operated structures. The commission should also require that energy budgets be included as an integral part of all design plans and contracts for future state facilities.

10. ***Equipment purchasing policies.*** Where applicable, the State Board of Control should require energy efficiency labels for equipment, and this information should be considered in making purchasing decisions. The Board of Control should also formulate guidelines for energy savings in the purchase of state vehicles.

11. ***State Department of Transportation.*** A Texas State Department of Transportation should be established with responsibilities for the planning, design, construction, operation, and maintenance of all transportation and related facilities of the state.

12. ***State transportation funds.*** Legislation should be passed which would permit transportation funds, regardless of their source, to be expended for the mode of transportation recommended by the State Department of Transportation.

13. ***Local transportation authorities.*** The legislature should pass a law permitting the 24 counties in the state with populations of 50,000 or more to institute county-wide mass transportation authorities. In addition, two or more counties should be permitted to form regional or metropolitan transportation authorities to plan and operate urban transportation systems.

14. ***Park and ride services and contra-flow traffic lanes.*** The legislature should pass a resolution encouraging the cities of Texas to study the feasibility of park and ride services and/or contra-flow lanes on main traffic arteries.

15. ***Freeway lanes reserved for mass transit vehicles.*** The legislature should enact a law giving the cities of Texas the option of reserving freeway lanes during the morning and afternoon rush hours for the exclusive use of public transit and/or multiple-occupant motor vehicles.

16. ***Tax exemption for urban mass transit companies.*** The state should exempt urban mass transit companies from paying the following taxes and fees, whether state or local: property tax, gross receipts tax, franchise tax, motor fuel tax, and motor bus registration fees. The exemptions should be granted only if all revenue realized is invested in maintenance, planning, purchase of rolling stock, operation, and service of the urban mass transit systems.

17. ***Task force to investigate assistance for urban mass transit systems.*** The legislature should create a special task force to investigate the various means by which the state could financially assist urban mass transit systems.

ALLOCATION OF ENERGY RESOURCES

1. ***An allocation plan for intrastate natural gas.*** The Texas Railroad Commission should be directed by law to develop an end-use allocation plan for all intrastate natural gas. The commission should also be given clear statutory authority to implement the plan when the governor declares an emergency caused by shortages of natural gas.

2. ***State Allocation Office.*** A State Allocation Office should be legislatively eneacted with a budget and given statutory authority and guidelines within which to carry out the allocation of petroleum products.

INCREASING OIL AND GAS SUPPLIES

1. ***In-kind Relinquishment Act Land royalties.*** The legislature should authorize the state to take Relinquishment Act Land royalties in-kind.

2. ***State oil and gas lease option.*** In future state leases, the legislature should require an option for the state to take all or part of the oil and gas produced from state wells by paying the prevailing market price.

3. ***Variable royalty bidding.*** The boards for lease of state lands should be required to conduct the sale of leases for oil and/or gas production according to the variable royalty bidding method.

4. ***Majority-consent unitization.*** A majority-consent unitization law should be enacted. An oil field should be operated as a unit if 75 percent of the field operators and 75 percent of the royalty owners agree to the unitization of that field. Payments to royalty owners should be made according to a formula which insures to every owner the amount which could be expected without unitization, plus a fair share of the revenues from the overall production increase.

5. ***Unitization of state lands.*** State lands should be included in the scope of any majority-consent unitization law passed by the legislature.

6. ***Construction of an offshore terminal.*** The legislature should approve the construction, with proper environmental safeguards, of an offshore terminal.

7. ***Public ownership of the offshore terminal.*** The offshore terminal should be publicly owned and regulated.

POWERPLANTS: THE USE OF LAND AND WATER

1. ***Powerplant Siting Agency.*** The legislature should create a Powerplant Siting Agency to develop a comprehensive state powerplant siting policy. The agency should encourage the use of marine water where feasible and should evaluate proposed cooling systems on the basis of their effect on water supply.

2. ***State Utility Commission.*** The legislature should establish a State Utility Commission to set electrical utility rates.

3. ***Allocation of water.*** The state should modify the present practice of allocating water on a perpetual basis so that high-priority users may have access to a sufficient water supply.

FUTURE ENERGY SOURCES

1. ***Classification and regulation of geothermal energy.*** The legislature should classify geothermal energy as a mineral and should empower the General Land Office to regulate geothermal energy production.

2. ***Geothermal energy production on state lands.*** The state should direct the General Land Office to lease public lands for the production of geothermal energy. In order to encourage development, state leasing should be conducted by the variable royalty bidding method.

3. ***Organic wastes as a fuel for powerplants.*** Power-generating facilities should be approved by the state, contingent upon plans for use of organic wastes as a fuel source or upon a statement of reasons why such plans are not feasible.

4. ***Regulation of surface mining.*** The General Land Office should regulate surface mining for coal and tar sands and should establish requirements for land reclamation.

5. ***Solar and wind energy demonstration projects.*** The legislature should encourage demonstration projects using wind and solar energy. Specifically, certain state buildings might be experimentally heated and cooled by solar and/or wind energy.

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CHAPTER ONE

INTRODUCTION

The United States has entered a period in which traditional assumptions and practices in the field of energy are being questioned. Not only are there uncertainties about the adequacy of energy supply, but widespread disagreement exists over price relationships, rates of usage, distributional equities, and the role of energy in sustaining economic growth. The Arab oil embargo illustrated dramatically the effect of temporary energy shortages; yet the underlying causes are rooted in past policies, and prospects for lasting solutions lie well into the future.

Because of the national and international nature of fuel supply markets, the federal government has assumed a major responsibility in dealing with energy problems. This does not mean, however, that the role of the states has been preempted or that effective state action must await implementing legislation in Congress. Indeed, a number of policy alternatives are available to the states, depending upon the character of their resource base, their industrial structure, and their energy-consumption requirements. Major energy-producing states such as Texas and Louisiana have different options from "market-demand" states such as Florida and Oregon, but all states have powers that are sufficient to cope with a large number of energy and energy-related problems. In many cases, the failure of a state to formulate a meaningful response to the energy crisis is not due to lack of power but to lack of initiative and determination.

PURPOSE AND SCOPE OF REPORT

The purpose of this report is to explore energy policy alternatives for Texas. Altogether, seven substantive policy areas are examined:

- energy requirements and reserves in Texas
- conservation of energy
- allocation of energy resources
- increasing oil and gas supplies
- land and water resource management
- future energy sources
- the need for a coordinated state energy policy

Chapter II, "Energy Requirements and Resources in Texas," develops a profile of present energy supply and demand conditions in the state. The information gathered clearly shows production and consumption patterns in Texas that are quite different from those of the United States as a whole.

Chapter III, "State Conservation of Energy," discusses energy-saving methods that decrease demand, thereby increasing some energy supplies for allocation elsewhere. It also analyzes present conservation practices in the residential, commercial, industrial, transportation, and public sectors, and proposes new policies.

The Arab oil embargo accelerated the problem of energy shortages to such a point that the federal government was forced to institute petroleum-product allocation policies. Even before the embargo, both the Federal Power Commission (FPC) and the Texas Railroad Commission had instituted natural gas policies to allocate natural gas supplies among a distributor's customers when the distributor experienced shortages. Chapter IV, "Allocation of Energy Resources," describes the types of governmental allocation programs and the reasons for them. It examines current federal and state allocation policies and proposes additional state policies.

Energy supply and demand factors, the need for conservation, and the state of current allocation policies all lead to a requirement for "Increasing Oil and Gas Supplies," discussed in Chapter V. Within this broad policy area, the report examines the possibilities for limiting energy exports from Texas and increasing production through secondary and tertiary recovery methods. It considers the policy of leasing state land for exploration and development and the concept of majority-consent unitization. The final part of the chapter is concerned with increasing imports and refining capacity through the use of an offshore terminal facility.

Policy options for meeting the energy crisis must be broader than alternatives considered from the perspective of fuel resources alone, as dealt with in the first four chapters. They must encompass certain ancillary resources, particularly land and water, used in producing energy. Chapter VI, "Powerplants: the Use of Land and Water,"

stresses the importance of managing land and water resources so that the development of needed energy supplies is not impeded and provisions are made for alternative land and water uses. Within this context the chapter argues the need for powerplant siting legislation and a comprehensive policy for managing Texas land and water resources.

Chapter VII, "Future Energy Sources," examines the forms of energy production that may be used to provide energy as the finite reserves of oil and gas are exhausted. Nuclear, geothermal, and solar energy, as well as coal, wastes, tar sands, and wind are explored as future energy sources. Insofar as possible, each is presented in terms of its costs/benefits, feasibility, and potential. Because these sources are not fully developed at this time, Texas' policy toward them has not been explicitly formulated. This chapter proposes policies to aid the future development of these forms of energy for Texas.

The concluding chapter, "Toward a Coordinated Energy Policy," summarizes the preceding chapters, showing the interrelationships among different energy policy areas. These interrelationships point out unequivocally the need for a coordinated state energy policy to replace the fragmented policy that exists at present.

We recognize that this report, although broad, is not comprehensive and that others working toward energy policy recommendations will undoubtedly advocate actions we have not proposed. However, we believe this report provides the framework for an effective discussion of present and future energy policy requirements in Texas.

CHAPTER TWO

ENERGY REQUIREMENTS AND RESOURCES IN TEXAS

INTRODUCTION

Before the state can develop an effective energy policy, the impact of policy alternatives on energy production and consumption must be considered. At present, Texas has numerous policies affecting both the production and consumption of energy; discussion of these policies and possible modifications to them are reserved for later chapters. This chapter gives the factual basis of the state's unique energy position, first presenting data concerning production and reserves of energy in Texas and second, a sector-by-sector analysis of energy consumption.

PRODUCTION AND RESERVES

Production

Texas is the country's leading producer of crude oil, natural gas liquids, and natural gas. Statistics from the U.S. Department of the Interior show that Texas produced 1,222,926,000 barrels of crude oil in 1971. This amount represents 35.4 percent of total U.S. crude oil production. However, the total production of presently developed fields is declining and continued decline can be expected unless new fields and policies are brought into operation. Texas production of natural gas liquids amounts to 49.6 percent of the national total, or 306,721,000 barrels. Texas natural gas production of 8,550,705,000,000 cubic feet accounts for 38 percent of natural gas production in the United States. Of the total production of oil and natural gas in Texas, 61 percent is exported to meet the energy needs of the rest of the nation, making Texas a major contributor to the national fuel supply market.

Although Texas does produce some bituminous coal and lignite, the quantity has been negligible when compared with national coal production. Moreover, production of coal in the state pales in comparison with production of petroleum and natural gas. The Bureau of Mines does not release data concerning the production of uranium ore in Texas.

Table 2-1 indicates U.S. and Texas production of primary energy resources. Production is shown in conventional units (barrels for oil, short tons for coal, cubic feet for natural gas), in British thermal units (B.t.u.), and as a percentage of total energy production in both the United States and Texas. This information is presented graphically in Figure 2-1.

Reserves

Unlike production, reserves cannot be readily measured. A quantity of produced resources can be physically counted, but the quantity of resources *in situ* can only be estimated because of the imprecise nature of present technologies. In this section, reserves will be considered to be stocks of minerals *in situ* as viewed by the operators producing them. Reserves are explicitly defined in terms of short-run economic feasibility of extraction, a definition consistent with that of the coal, petroleum, and gas industries.

According to the Department of the Interior, Texas has 13,023,529,000 barrels of crude oil reserves, or 34.2 percent of the national reserves. In addition, the state has 42.4 percent of the nation's natural gas liquids reserves and 36.4 percent of the natural gas reserves. Texas reserves of bituminous coal and lignite (see Map 2-1) constitute 1.6 percent and its uranium reserves 5.3 percent of the U.S. figure.

Table 2-2 indicates U.S. and Texas reserves of primary energy resources. Reserves are shown in their common unit of measure, B.t.u., and as a percentage of total energy reserves in the United States and Texas. These data are displayed graphically in Figure 2-2.

CONSUMPTION

An analysis of present energy consumption in Texas is a prerequisite for any consideration of state energy policies. A determination of the effects of any policy depends on knowledge of the present situation. This section contains a statement of present energy consumption in Texas and highlights consumption according to energy sources and economic sectors based on data for 1972. The Bureau of Mines of the U.S. Department of the Interior is the primary source for all statistics.

TABLE 2-1

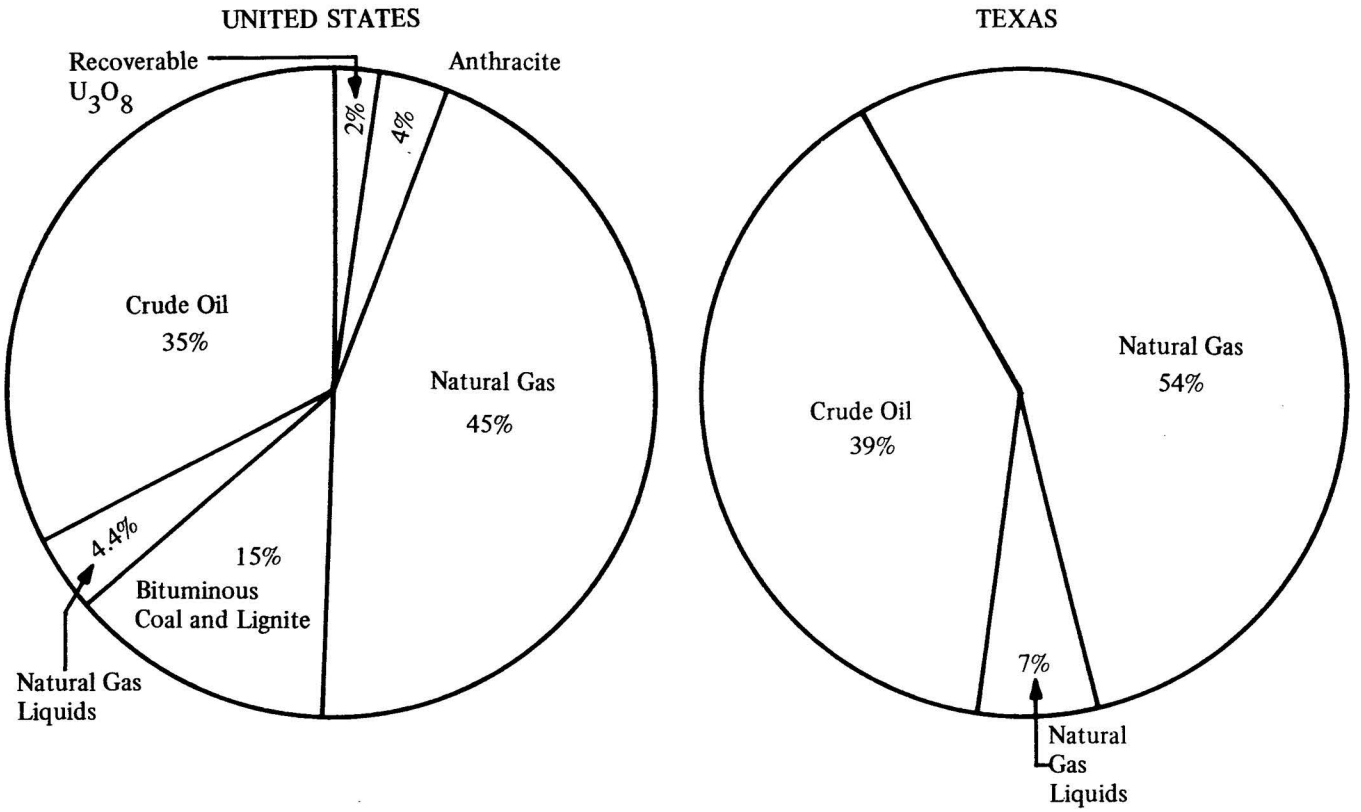
PRODUCTION OF THE PRIMARY SOURCES OF ENERGY IN THE UNITED STATES AND TEXAS (1971)

	Units	B.t.u.	Percent Total United States	Percent Total Texas
CRUDE OIL				
U.S.	34.5×10^8 Bbls.	19.4×10^{15}	35.05	39.22
Texas	12.2×10^8 Bbls.	68.7×10^{14}		
NATURAL GAS LIQUIDS				
U.S.	61.7×10^7 Bbls.	24.7×10^{14}	4.47	7.02
Texas	20.7×10^7 Bbls.	12.3×10^{14}		
NATURAL GAS				
U.S.	22.5×10^{12} cu. ft.	24.8×10^{15}	44.81	53.59
Texas	85.5×10^{11} cu. ft.	94.2×10^{14}		
BITUMINOUS COAL AND LIGNITE				
U.S.	55.2×10^7 short tons	82.8×10^{14}	14.97	---
Texas	withheld	withheld		
ANTHRACITE				
U.S.	87.2×10^5 short tons	24.8×10^{13}	.44	---
Texas	withheld	withheld		
RECOVERABLE U_3O_8				
U.S.	24.5×10^6 lbs.	12.9×10^{13}	.23	---
Texas	withheld	withheld		
TOTAL				
U.S.		55.3×10^{15}	99.97	99.83
Texas		17.5×10^{15}		

Source: U.S. Department of the Interior, *United States Energy Fact Sheets, 1971*.

FIGURE 2-1

PRODUCTION OF THE PRIMARY SOURCES OF ENERGY IN THE UNITED STATES AND TEXAS (1971)



Coal

Texas coal consumption in 1972 amounted to approximately four million short tons, whereas total U.S. consumption for the same year was 519,776,000 short tons. Texas consumption was, thus, about 0.76 percent of total U.S. consumption.

1. Residential and Commercial. The residential and commercial sectors consume no coal in Texas, but national consumption in these sectors amounted to 11,748,000 short tons in 1972, or 2.26 percent of total national coal consumption.

2. Industrial. Texas industrial consumption of coal was approximately 2,000,000 short tons in 1972, or 50 percent of Texas coal consumption. The majority of this total was consumed by an aluminum plant in Milam County. The industrial sector in the United States consumed 159,253,000 short tons or approximately 30.6 percent of the nation's coal consumption.

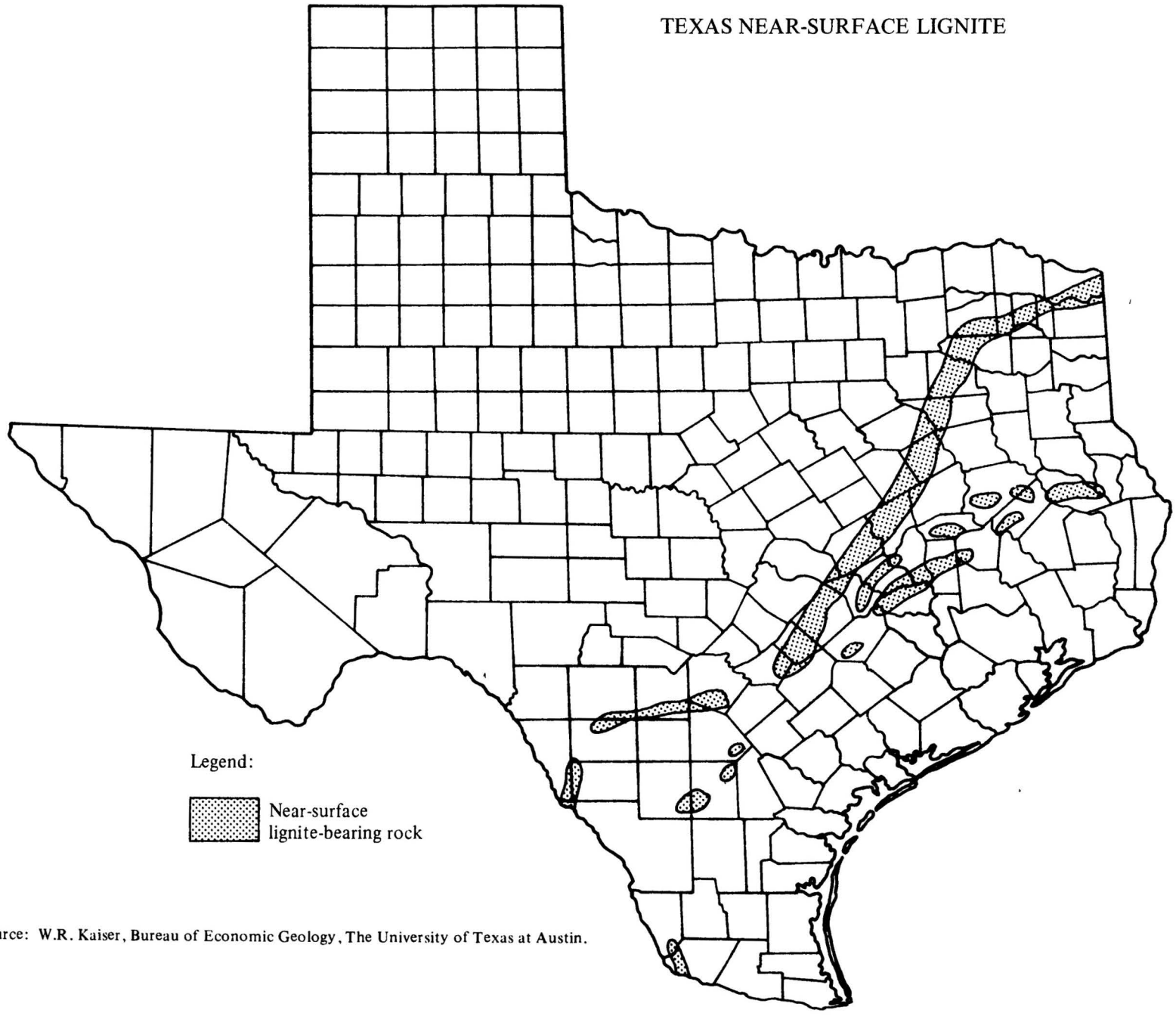
3. Electric Utilities. Because of the historical abundance and low cost of natural gas in the state, electric utilities have only recently turned to coal as a fuel alternative. In 1972, electric utilities in Texas consumed just 2,000,000 short tons of coal. This differs markedly from figures for the United States which indicate a consumption of coal for electric utilities of 348,612,000 short tons or 67.1 percent of total coal use. During the next nine years, however, coal consumption by Texas utilities will increase rapidly. The latest information from the Electric Reliability Council of Texas (ERCOT) shows that by 1983 coal will account for 10,758 megawatts (MW) of electricity or 32 percent of planned generating capacity in the ERCOT area.

4. Transportation. Texas consumes no coal for transportation purposes. This is not surprising in view of the fact that only 163,000 short tons were used for transportation in the nation during 1972, all of which was burned as naval bunker fuel.

In summary, two sectors, industrial and electric utilities, account for the coal consumption in Texas. Oil and natural gas have, in the past, satisfied most of the fuel needs of the state, but the growing shortage of these fuels will encourage the increased use of coal.

MAP 2-1

TEXAS NEAR-SURFACE LIGNITE



Source: W.R. Kaiser, Bureau of Economic Geology, The University of Texas at Austin.

TABLE 2-2

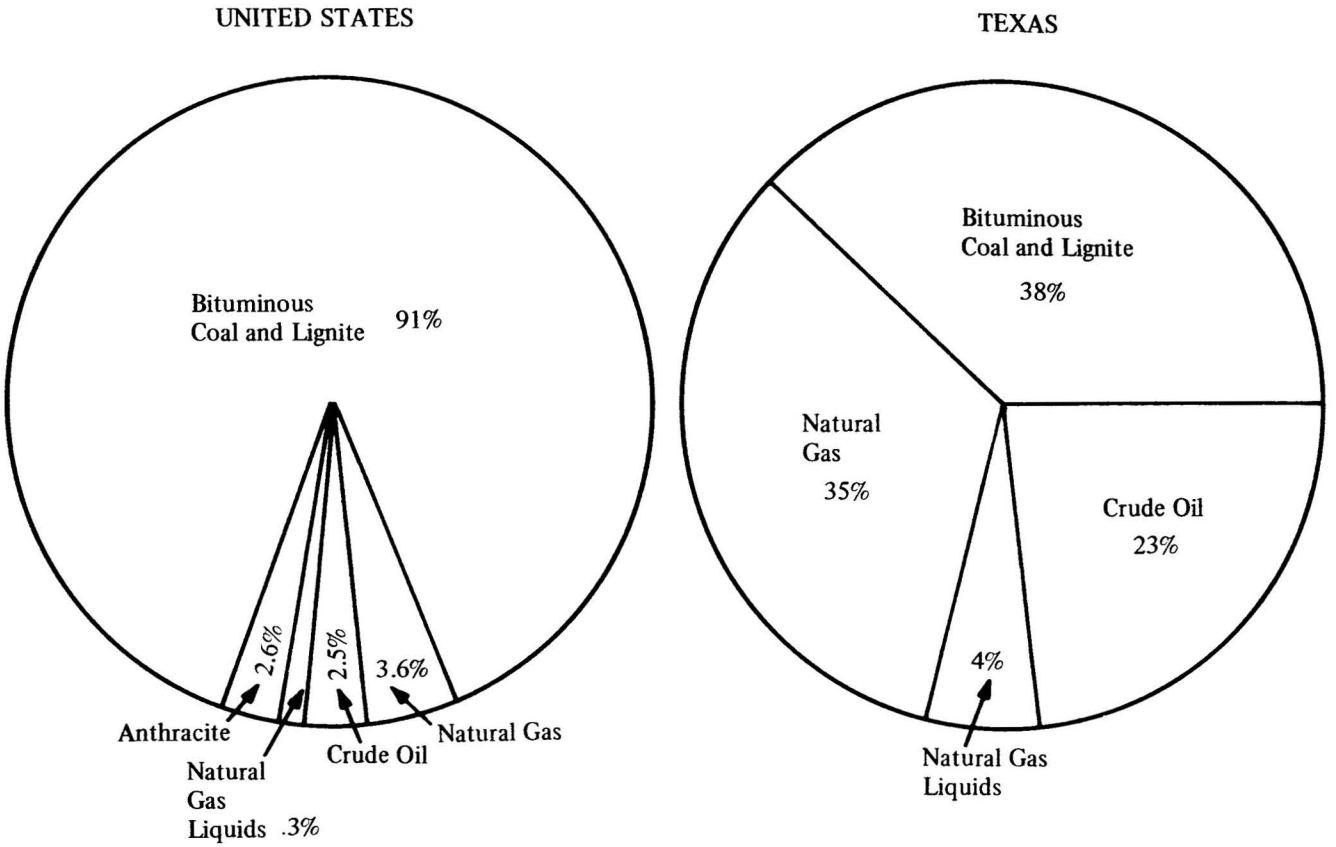
AVAILABLE RESERVES OF THE PRIMARY SOURCES OF ENERGY IN TEXAS AND THE UNITED STATES (1971)

	Units	B.t.u.	Percent Total United States	Percent Total Texas
CRUDE OIL				
U.S.	38.1×10^9 Bbls.	21.7×10^{16}	2.53	23.2
Texas	13.0×10^9 Bbls.	74.2×10^{15}		
NATURAL GAS LIQUIDS				
U.S.	73.0×10^8 Bbls.	29.3×10^{15}	.34	3.89
Texas	31.0×10^8 Bb.s Bbls.	12.4×10^{15}		
NATURAL GAS				
U.S.	27.9×10^{13} cu. ft.	30.7×10^{16}	3.58	34.9
Texas	10.1×10^{13} cu. ft.	11.2×10^{16}		
BITUMINOUS COAL AND LIGNITE				
U.S.	51.8×10^{10} short tons	11.8×10^{17}	90.8	37.84
Texas	80.6×10^8 short tons	12.1×10^{16}		
ANTHRACITE				
U.S.	80.4×10^8 short tons	22.8×10^{16}	2.66	----
Texas	0	0		
RECOVERABLE U_3O_8				
U.S.	54.6×10^7 lbs.	28.8×10^{14}	Trace	.48
Texas	29.1×10^6 lbs.	15.4×10^{13}		
TOTALS				
U.S.		85.6×10^{17}	99.9	99.8
Texas		32.0×10^{16}		

Source: U.S. Department of the Interior, *United States Energy Fact Sheets, 1971.*

FIGURE 2-2

AVAILABLE RESERVES OF THE PRIMARY SOURCES OF ENERGY IN THE UNITED STATES AND TEXAS (1971)



Source: U.S. Department of the Interior, *United States Energy Fact Sheets, 1971.*

Natural Gas

As would be expected of a state with an abundance of natural gas, Texas has come to rely heavily on natural gas as a fuel for many sectors of the economy. To analyze natural gas consumption, two general categories are considered. The first of these categories is the amount of natural gas delivered to consumers, and it includes the residential, commercial, industrial, electric utilities, and miscellaneous sectors. The second category, which includes all natural gas used in the production and/or delivery of the resources itself, is divided into three sectors: extraction loss, lease and plant fuel, and pipeline fuel.

1. Residential. The residential sector relies on natural gas to perform two types of functions; heating/cooling and cooking. In 1972, more than 2.5 million consumers in Texas burned 240,662 million cubic feet of natural gas. This represents 4.7 percent of the residential natural gas consumed in the nation.

2. Commercial. Specific uses of natural gas in the commercial sector are similar to those of the residential sector. During 1972, the commercial sector of the United States consumed 2,287 billion cubic feet of natural gas. Of this total, the Texas commercial sector consumed 94 billion cubic feet or 4.1 percent.

3. Industrial. In 1972, the industrial sector in Texas consumed 1,839 billion cubic feet of gas, representing 37.7 percent of the state's total gas consumption. Comparison with U.S. figures shows that the Texas industrial sector accounts for 22.5 percent of all industrial gas consumption in the nation. Table 2-3 illustrates the percentage of

industrial sector consumption attributable to various types of industries.

The figures from Table 2-3 should not be considered as absolutely accurate. Statistics of the Census of Manufacturers are not always precise, and consumption items such as extraction loss, lease and plant fuel, and pipeline fuel, and activities such as agriculture are omitted.

4. Electric Utilities. The generation of electricity produces one form of energy from another, but the process by which electricity is generated consumes more energy than is produced. The result is a net consumption less than the gross amounts presented here. According to statistics compiled by the FPC, electric utilities in the United States consumed 3,979 billion cubic feet of natural gas in 1972. Electric utilities in Texas consumed 1,285 billion cubic feet or nearly one-third of the national total for this sector.

5. Miscellaneous Consumers. This sector includes consumers of natural gas not accounted for in the four major sectors and comprises mainly deliveries to municipalities and public authorities for such uses as institutional heating and street lighting. Consumption of natural gas by this sector in 1972 was 47,092 million cubic feet in Texas and 321,421 million cubic feet in the United States.

6. Extraction Loss. Because natural gas is composed of a mixture of substances, it is rarely used in the form in which it comes out of the ground. As a result, before it can be delivered to a pipeline, natural gas must be carefully processed, a procedure which involves removal of valuable liquid hydrocarbons and various objectionable substances, such as water and sulfur. In the course of this operation, there are certain "shrinkages" or extraction losses. In 1972, these losses totaled 907,993 million cubic feet in the United States and 470,105 million cubic feet in Texas. In 1973, total losses were higher for the United States as a whole (916,551 million cubic feet) but lower in Texas (466,143 million cubic feet).

7. Lease and Plant Fuel. Lease facilities and processing plants are located where substantial production of natural gas occurs. The data for the comparison of natural gas, as lease and plant fuel, reflect the high level of production in Texas. In 1972, the 802,112 million cubic feet consumed in Texas was more than half of the 1,455,563 million cubic feet consumed by lease facilities and processing plants in the United States. It is clear that the natural gas industry is a large consumer as well as a producer.

8. Pipeline Fuel. Natural gas, like any energy resource, must be moved from place of deposit to point of consumption, but it is unique in that it is used to fuel pipeline delivery systems.

To provide a comparison of the figures presented in this section, Table 2-4 illustrates the consumption of natural gas by sector.

Petroleum Products

A problem in studying the consumption of petroleum products is the definition and categorization of specific fuels. The family of petroleum products in this section includes fuel oil, kerosine, gasoline, diesel, liquid petroleum gas (LPG), and ethane. Fuel oil is further divided into distillate fuel oil and residual fuel oil, and LPG is divided into propane, butane, and propane-butane mixture. Kerosine and gasoline are each treated as separate fuels.

1. Residential and Commercial. The residential and commercial sectors are combined in this analysis because of the close similarities in the manner in which they use petroleum products. In line with data compiled by the U.S. Department of the Interior, Bureau of Mines, consumption in the residential and commercial sectors includes LPG consumed for general residential and commercial purposes and for gas utility purposes. Fuel oil consumed for heating purposes and kerosine consumed for miscellaneous purposes are also included. Table 2-5 summarizes petroleum-product consumption statistics for the residential and commercial sectors in Texas and the United States.

2. Industrial. The industrial sector is by far the most unwieldy for the consumption of petroleum products. The pattern of consumption of petroleum products by this sector in Texas and in the United States is complex, but some general statements are in order about each of the two major petroleum products, fuel oil and LPG.

Given the size, population, and industrialization of Texas, the consumption of fuel oil in the state is surprisingly low, probably due to the state's mild weather and abundance of inexpensive natural gas. The single exception to the Texas industrial sector's low consumption of fuel oil is the relatively high usage rate of off-highway diesel, a statistic which can be attributed largely to the important role of agriculture in the state.

Consumption of LPG by the Texas industrial sector in 1972 was marked by two significant patterns. First, Texas was responsible for over 60 percent of the total national consumption of LPG by petrochemical plants. Second, nearly half of the LPG burned in internal combustion engines in the United States was consumed in Texas. Table 2-6 summarizes the consumption of petroleum products by the industrial sector in the United States and Texas.

3. Transportation. Petroleum products are used in all major modes of transportation. Fuel oil is consumed by railroads and vessels; diesel and gasoline are fuels for automobiles and trucks; and kerosine is used as jet fuel. The 1972 consumption pattern for the transportation sector is shown in Table 2-7. Diesel, which is actually a form of fuel oil, is dealt with separately in the table.

4. Electric Utilities. The only type of petroleum pro-

TABLE 2-3

INDUSTRIAL GAS CONSUMPTION BY PERCENT (1971)

	United States	Texas
Food & Kindred Products	7.4	1.8
Lumber & Wood Products	1.1	.3
Furniture & Fixtures	.3	.1
Paper & Allied Products	7.4	2.0
Chemicals & Allied Products	22.1	35.6
Petroleum & Coal Products	20.5	47.0
Rubber & Plastics Products	1.2	.1
Stone, Clay & Glass Products	10.9	5.1
Primary Metal Industries	17.1	6.0
Fabricated Metal Products	2.4	.7
Machinery, except Electrical	2.3	.5
Electrical Equipment and Supplies	1.7	.2
Transportation Equipment	2.2	.4
Miscellaneous Manufacturing Industries	3.4	.2
TOTAL	100.0	100.0

Source: U.S. Census Bureau, *Census of Manufacturers, 1972.*

duct utilized by electric utilities is fuel oil, both distillate and residual. Table 2-8 presents sales statistics for the past three years in Texas and the United States. Sales data are not the same as consumption data because in many instances electric utilities have engaged in stockpiling. Yet these figures clearly indicate a large increase in fuel oil supplies to electric utilities.

In 1972, a major change occurred in the consumption of petroleum products by electric utility companies in Texas. The sudden rise in usage of distillate-type fuel oil in the state reflects the reduced availability of natural gas during the winter months.

The increased use of fuel oil for power generation is made possible by current boiler technology, which permits both fuel oil and natural gas to be burned for limited periods, though not through the same nozzles.

5. Miscellaneous. Some consumption of fuel oil cannot be placed in an economic sector and requires a miscellaneous category. Table 2-9 provides 1972 figures for miscellaneous consumption in Texas and the United States.

Table 2-10 summarizes petroleum product consumption in Texas in 1972. Several significant facts are apparent. The industrial and transportation sectors are by far the major users, but there are even more interesting revelations within each of these sectors. The industrial sector is intensive in the use of LPG. The petrochemical industry, with its extraordinary rate of LPG consumption, comprised nearly 85 percent of the total industrial consumption of petroleum products in Texas. The transportation sector, as expected, consumed petroleum products mainly in the form of gasoline: almost 80 percent of this sector's usage of petroleum products can be attributed to gasoline. Table 2-11 places all these percentages within the perspective of overall petroleum-product consumption in Texas, and the role of each fuel and sector is clarified.

Electricity

Texas is the largest producer of electricity in the United States and is second only to California in sales. The state produces 7.5 percent of the nation's electricity and consumes 7.2 percent. Table 2-12 indicates the consumption of electricity in both the United States and Texas.

1. Residential. Residential consumption accounts for 31.1 percent of all electricity sales in Texas. This sector uses 32.4 percent of electricity supply nationwide.

2. Commercial. Of the electricity sold in Texas, 24.4 percent goes to the commercial sector. The national figure for this sector is 22.9 percent.

3. Industrial. The industrial sector accounts for 41.9 percent of Texas electricity usage. Throughout the nation, industries used 41.3 percent of the total. The amount of electricity used varied with the type of industry. The largest users were the primary metal and chemicals industries. Patterns of electricity consumption in the industrial sector

TABLE 2-4

NATURAL GAS CONSUMPTION BY SECTOR, TEXAS AND THE UNITED STATES, 1972
(trillions of B.t.u.)

	UNITED STATES		TEXAS	
	B.t.u.	%	B.t.u.	%
Residential	5284.9	22.3	248.1	4.9
Commercial	2357.4	9.9	97.1	1.9
Industrial	8420.2	35.5	1896.3	37.7
Electric Utilities	4102.0	17.3	1325.0	26.3
Other Consumers	331.4	1.4	48.6	1.0
Delivered to Consumers	20,495.9	86.4	3,615.0	71.8
Extraction Loss	936.1	3.9	484.7	9.6
Lease/Plant Fuel	1500.7	6.3	827.0	16.4
Pipeline Fuel	789.9	3.3	107.6	2.1
Non-Delivered	3226.7	13.5	1419.3	28.1
TOTAL	23,722.6	99.9	5,034.3	99.9

Source: U.S. Department of the Interior, Bureau of Mines, *U.S. Energy Fact Sheets, 1972.*

TABLE 2-5

RESIDENTIAL AND COMMERCIAL PETROLEUM CONSUMPTION, 1972
(thousands of gallons)

FUEL	TEXAS	UNITED STATES
Fuel Oil (Distillate)	188,286	23,006,886
Fuel Oil (Residual)	28,224	7,858,662
Kerosine	168,474	2,781,084
LPG	764,197	8,555,821
TOTAL	1,149,181	42,202,453

Source: U.S. Department of the Interior, Bureau of Mines, *U.S. Energy Fact Sheets, 1972.*

are complex because many industries produce electricity within the plant from oil, coal, or natural gas. Since electricity produced in this manner does not appear in sales statistics, these statistics present a somewhat misleading picture of industrial use.

4. Other. All other uses of electricity account for 3.4 percent nationally and 2.6 percent in Texas. This category includes public authorities, railroads, and interdepartmental use.

SUMMARY

Because of its role as the leading producer of oil and natural gas in the nation, Texas shows energy production and consumption patterns quite different from those of the country as a whole. (See Figures 2-3 and 2-4.) Any state energy policy should take this unique position into consideration.

In the past, adequate information has been available on Texas production and reserves of energy resources, but little attention has been focused on the consumption of energy. Table 2-13 summarizes the state's energy consumption by presenting the percentage of total consumption accounted for by each fuel in each sector; figures 2-5 and 2-6 graphically illustrate these percentages.

TABLE 2-6

INDUSTRIAL CONSUMPTION OF PETROLEUM PRODUCTS, 1972
(thousands of gallons)

FUEL	TEXAS	UNITED STATES
Fuel Oil	348,600	11,104,842
Diesel	168,630	1,970,850
LPG	7,212,002	12,962,311
TOTAL	7,729,232	26,038,003

Source: U.S. Department of the Interior, Bureau of Mines, *U.S. Energy Fact Sheets, 1972.*

TABLE 2-7

CONSUMPTION OF PETROLEUM PRODUCTS BY THE TRANSPORTATION SECTOR, 1972
(thousands of gallons)

FUEL	TEXAS	UNITED STATES
Fuel Oil	948,806	8,121,078
Diesel	587,748	7,013,202
Gasoline	7,093,000	102,617,000
Jet Fuel	720,000	10,314,991
TOTAL	9,349,554	128,066,271

Source: U.S. Department of the Interior, Bureau of Mines, *U.S. Energy Fact Sheets, 1972.*

TABLE 2-8

FUEL OIL SALES TO ELECTRIC UTILITIES, 1970-1972
(thousands of barrels)

FUEL OIL	TEXAS			UNITED STATES		
	(1970)	(1971)	(1972)	(1970)	(1971)	(1972)
Distillate	55	47	1,248	24,770	32,329	58,334
Residual	428	611	506	312,420	371,820	435,348
TOTAL	483	658	1,754	337,190	404,149	503,682

TABLE 2-9

MISCELLANEOUS FUEL OIL CONSUMPTION, 1972
(thousands of barrels)

FUEL OIL	TEXAS	UNITED STATES
Distillate	2,860	31,039
Residual	595	33,508
TOTAL	3,455	64,547

TABLE 2-10

CONSUMPTION OF PETROLEUM PRODUCTS IN TEXAS, 1972
(thousands of gallons)

FUEL	RESIDENTIAL AND COMMERCIAL	TRANSPORTATION	INDUSTRIAL	ELECTRIC UTILITIES	MISC.	TOTAL
Fuel Oil	216,510	348,600	947,906	73	145	1,513,234
Diesel	0	168,630	587,748	0	0	756,378
Gasoline	0	0	7,093,000	0	0	7,093,000
Kerosine	305,970	0	720,000	0	0	1,025,970
LPG	764,197	7,212,002	0	0	0	7,976,199
TOTAL	1,286,677	7,729,232	9,348,654	73	145	18,364,781

Source: U.S. Department of the Interior, Bureau of Mines, *U.S. Energy Fact Sheets, 1972.*

TABLE 2-11

CONSUMPTION OF PETROLEUM PRODUCTS IN TEXAS, 1972
(Percent)

FUEL	RESIDENTIAL AND COMMERCIAL	TRANSPORTATION	INDUSTRIAL	ELECTRIC UTILITIES	MISC.	TOTAL
Fuel Oil	1.2	5.2	1.9	t	t	8.3
Diesel	0	3.2	.9	0	0	4.1
Gasoline	0	38.6	0	0	0	38.6
Kerosine	1.7	3.9	0	0	0	5.6
LPG	4.1	0	39.3	0	0	43.4
TOTAL	7.0	50.9	42.1	t	t	100.0

Source: U.S. Department of the Interior, Bureau of Mines, *U.S. Energy Fact Sheets, 1972.*

TABLE 2-12

ELECTRICAL SALES BY CLASS OF SERVICE, 1972

	Million kwh	B.t.u.	Percent
RESIDENTIAL			
United States	1.75×10^{15}	511,423	32.4
Texas	1.20×10^{14}	35,106	31.1
COMMERCIAL			
United States	1.23×10^{15}	361,859	22.9
Texas	9.40×10^{13}	27,532	24.4
INDUSTRIAL			
United States	2.22×10^{15}	651,660	41.3
Texas	1.27×10^{14}	37,232	41.9
OTHER*			
United States	1.80×10^{14}	57,772	3.4
Texas	1.01×10^{13}	2,954	2.6
TOTAL			
United States	5.38×10^{15}	1,577,714	100.0
Texas	3.85×10^{14}	112,824	100.0

*Includes public authorities, railroads and railways, and inter-departmental uses.

Source: Edison Electric Institute, *Statistical Yearbook for 1972.*

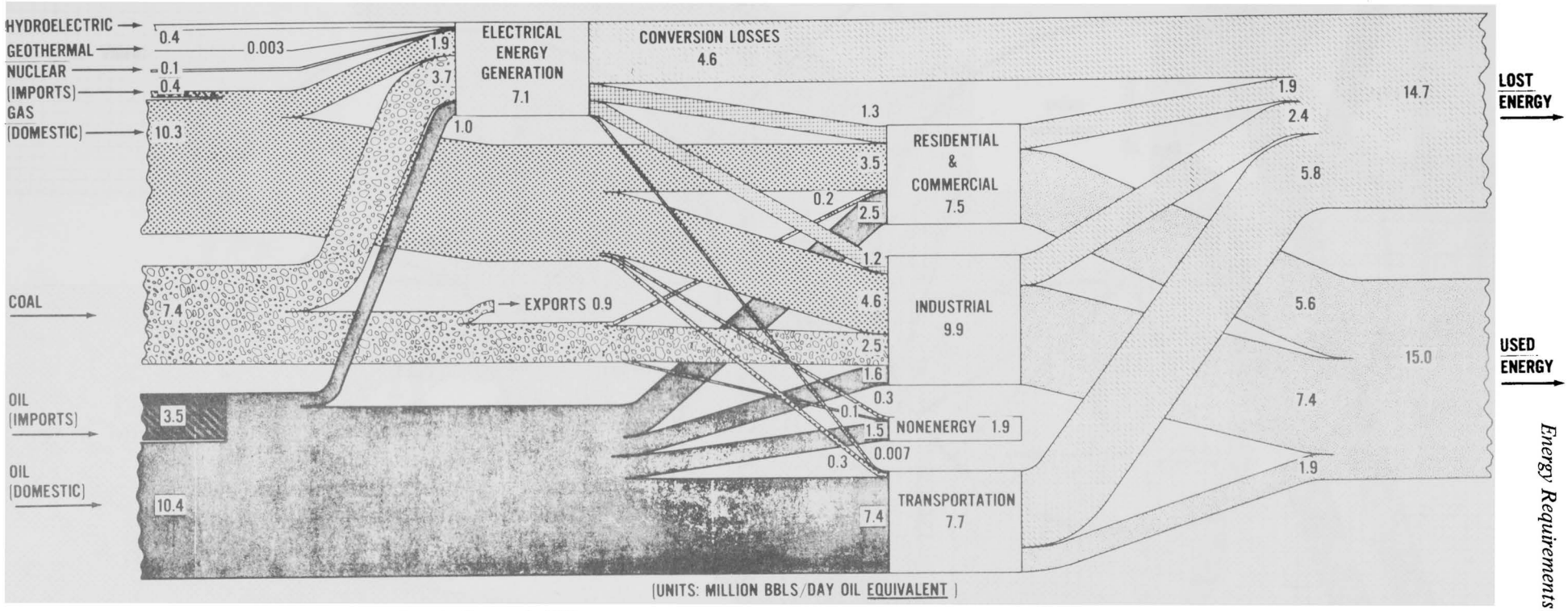
TABLE 2-13

TEXAS ENERGY CONSUMPTION, 1972
(Percentages)

	RESIDENTIAL AND COMMERCIAL	INDUSTRIAL	TRANSPORTATION	ELECTRIC UTILITIES	MISC.	TOTAL
Coal	0	t	--	t	0	t
Natural Gas	4.4	41.1	1.4	17.0	.6	64.5
Petroleum Production	2.2	13.1	15.8	t	t	31.1
Electricity	2.4	1.9	0	--	.1	4.4
	9.0	56.1	17.2	17.0	.7	100.0

FIGURE 2-3

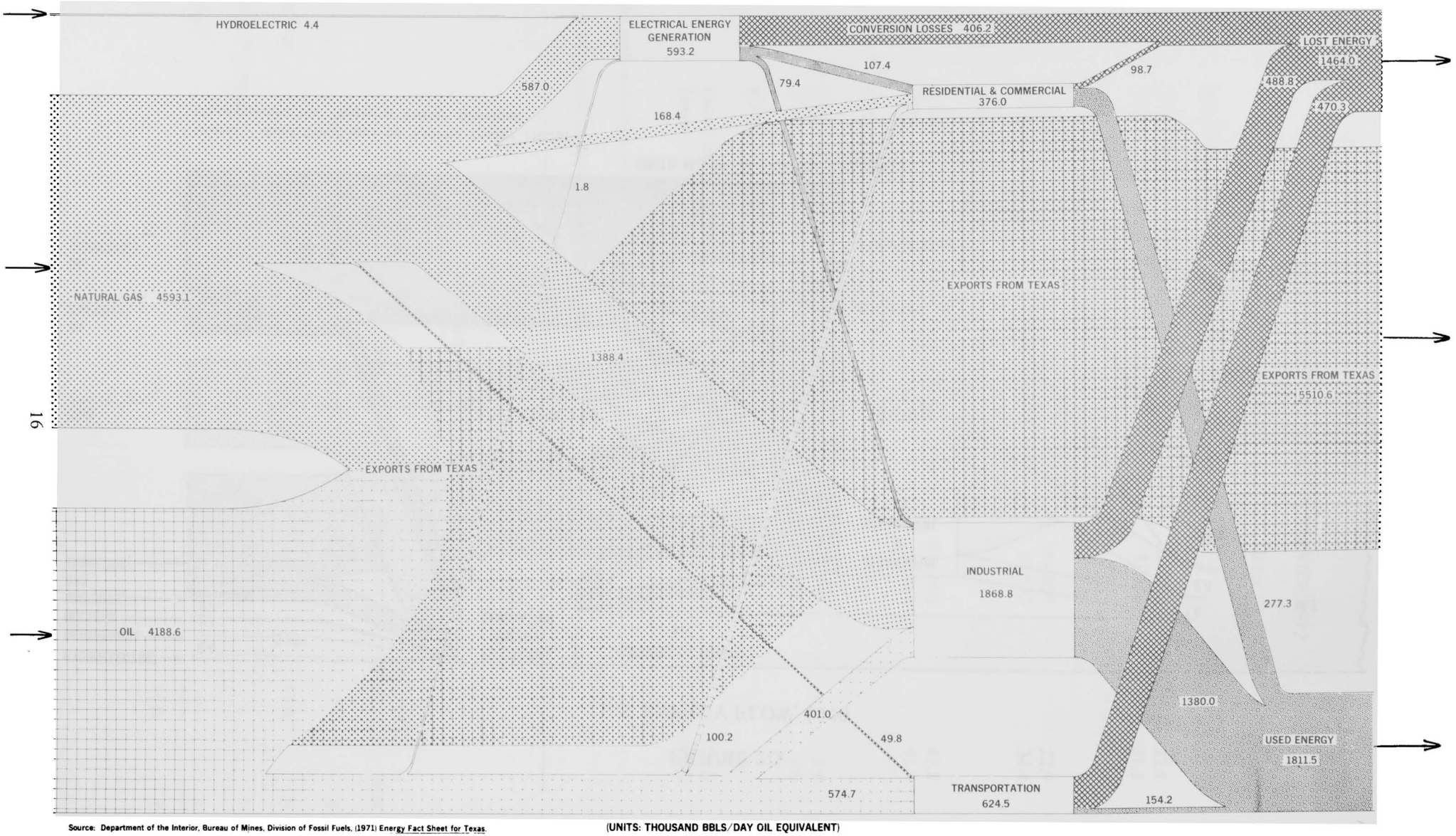
U.S. ENERGY FLOW, 1970



Source: Joint Committee on Atomic Energy (1973)
Understanding the "National Energy Dilemma"

FIGURE 2-4

TEXAS ENERGY FLOW, 1971



Source: Department of the Interior, Bureau of Mines, Division of Fossil Fuels, (1971) Energy Fact Sheet for Texas.

(UNITS: THOUSAND BBLS/DAY OIL EQUIVALENT)

Prepared by Policy Research Project on State Energy Policies.
LBJ School of Public Affairs; 1973.

FIGURE 2-5

TEXAS ENERGY CONSUMPTION BY SECTOR, 1972

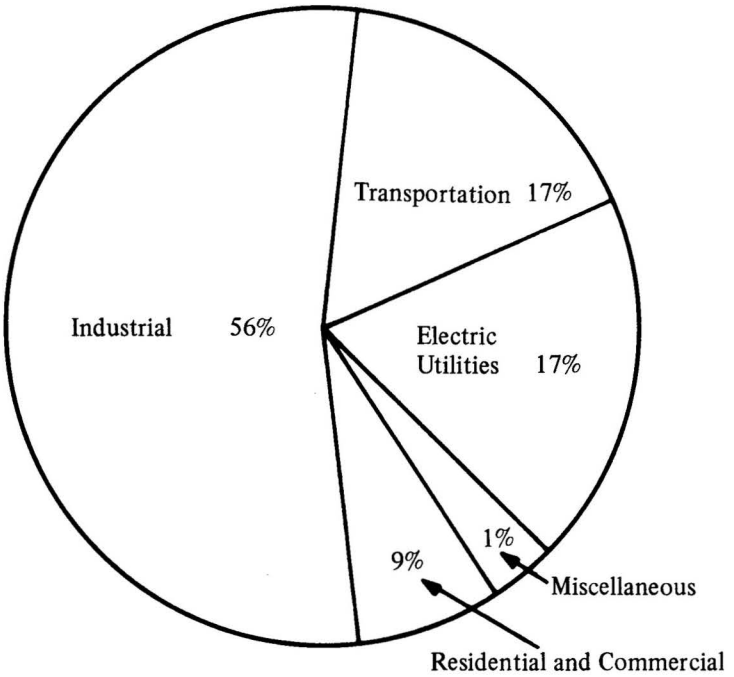
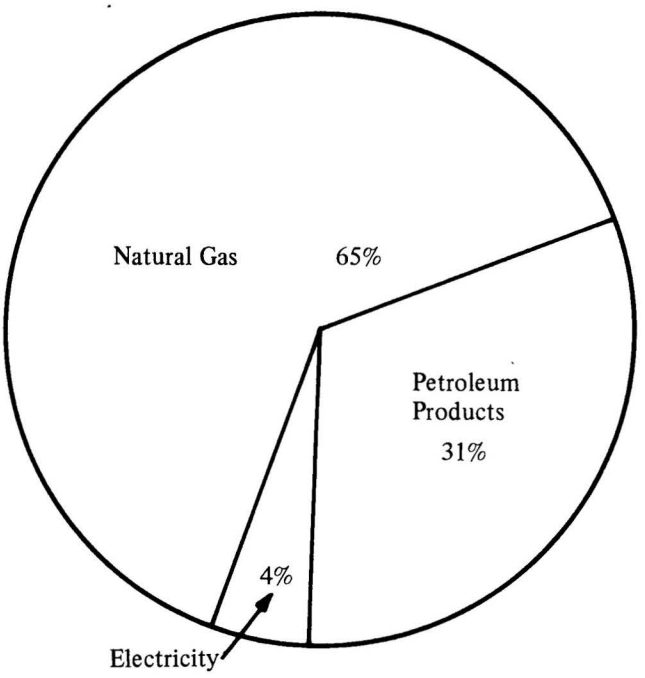


FIGURE 2-6

TEXAS ENERGY CONSUMPTION BY ENERGY SOURCE, 1972



CHAPTER THREE

STATE CONSERVATION OF ENERGY

INTRODUCTION

Although there is concern about the production of energy, comparatively little attention has been given to the conservation of fuels through improved methods of use. It has been estimated that five-sixths of the energy used in transportation, two-thirds of the fuel consumed to generate electricity, and a total of nearly one-half of the energy produced in the United States is discarded as waste heat.[1] Discussion in this chapter concerns state actions which could help to reduce energy consumption in the residential, commercial, industrial, transportation, and public sectors. Since in large measure the sectors are autonomous, the state is limited as to what it can do.

RESIDENTIAL SECTOR

Residential users account for one-fourth of all the electricity consumed in Texas.[2] Although reduction by residences of electrical consumption through "wiser use" would reduce the energy demands upon the state, it should be noted that residential conservation would not have as much economic impact on the state's growth and stability as would a reduction by the industrial sector. If all homes had the optimum level of insulation, the total energy needs of the United States could be reduced by about 4 percent.[3] The Atomic Energy Commission (AEC) estimates that if only 30 percent of the existing buildings in the country were modified so that their heating and cooling loads were reduced 40 percent and 30 percent, respectively, the total national energy use would be reduced by 3 percent.[4]

Although there are electrical appliances which people generally are not willing to do without (e.g., air conditioners), electricity use in the home can be reduced without hardship by (1) turning off unnecessary lights, (2) running the dishwasher only when full, (3) setting the thermostat at 78 degrees in the summer and at 60 degrees in the winter, and (4) using fewer electrical appliances. The Office of the Governor should inform residents of ways to conserve energy in the home; this could be accomplished by a public education program conducted through the use of television, radio, and publications.

It is known that the efficiency levels of the same types of appliances vary. For example, one air conditioner may produce twice as many B.t.u. per unit of energy as does another type. However, there is at present no system of labeling which allows the consumer to compare the efficiency of appliances. The state should establish a labeling system* that would identify the energy consumption levels (expressed in comparable energy units) of electric products sold in Texas, permitting the consumer to choose the more efficient appliances. The efficiency levels should appear on all advertisements for a product in which a price is quoted.

COMMERCIAL SECTOR

The commercial sector accounts for a large percentage of the total energy consumed in Texas. However, as is true of the residential sector, there are limits to what the state can do to influence the energy consumption practices of businesses.

One of the most wasteful energy practices is the use of an excessive amount of lighted commercial advertising. This practice has been encouraged by rate structures based on volume-use of electricity: "volume users" pay a lower unit charge the more they consume (up to a point). They are not encouraged to conserve, but rather to use energy. Lights in highrise office buildings are often left on overnight; that practice allows users to take advantage of the lower incremental cost for volume usage permitted by current rate structures.

There is also a tendency to want to "outdo" the competition by using larger and "flashier" modes of electrical advertising. Lighting fixtures are an important consumer of electricity in commercial buildings. Although almost everyone would wince at the prospect of direct

---

*A recommended labeling system is the Energy Efficiency Ratio (EER), which enables the consumer to compare the efficiency of appliances. The EER is computed by dividing the number of B.t.u. by the watts. Although the system is currently voluntary, it is being promoted by the National Bureau of Standards, U.S. Department of Commerce.

regulation of internal lighting, the state can and should move to limit the use of lighting for advertising.

INDUSTRIAL SECTOR

One of the most significant ways in which energy conservation can be achieved in the industrial sector is through the implementation of a state program of resource recovery, recycling, and reuse. The U.S. Environmental Protection Agency (EPA) estimates that although the quantity of solid waste grows at a rate of 4 to 5 percent per year, the recovery of waste materials supplies little of the total material used to provide energy required by the nation's population.

In determining the amount of energy which could be conserved, the entire recycling process of collection, separation, reprocessing, and transportation must be considered. Preliminary research and analysis has strengthened the resource-recovery argument by indicating that (when compared with the extraction and processing of virgin materials) the process lowers the quantity of atmospheric emissions, lowers the amount of waterborne, mining, and solid wastes, and consumes less energy. In assessing the potential of resource recovery, recycling, and reuse, it should be noted that inequitable policies exist which favor the extraction of primary natural resources. For example, there are few incentives for the development of new, large-scale waste technologies, particularly with regard to municipal waste recovery. This lack of incentive places the secondary resource recovery process in a low-priority position.

In order to change policies there must be recognition and acceptance of the notion that the secondary-resource recovery process offers economic and social savings. As long as policies exist which encourage materials to be extracted from the earth, processed, used briefly, and then discarded, reusable materials will be treated as waste rather than as a resource. The result will mean a loss to the economy, the environment, and to urban centers. The state should encourage, possibly through monetary incentives, greater industrial-resource recovery, recycling, and reuse of materials.

The role that the state can play in improving industrial energy-consumption techniques is limited. One important limitation on state action is the lack of data* indicating what improvements in energy utilization are technologically feasible and economically justifiable. Industry also lacks data which might indicate wasteful energy practices and facilitate energy conservation. The state should encourage an industry-led "energy awareness" program and include as participants trade associations, professional societies, and engineering design companies. Such an effort would help to distribute information on the technological and economic aspects of energy consumption.

*In the Office of the Governor, the Energy Resources Section, Division of Planning Coordination is working closely with specific industrial groups (petrochemical firms and refineries) to determine what their energy consumption is and how it can be reduced. The findings are published periodically in the *Texas Energy Report*. A reporting system has also been established that monitors the consumption of energy by certain industries.

TRANSPORTATION

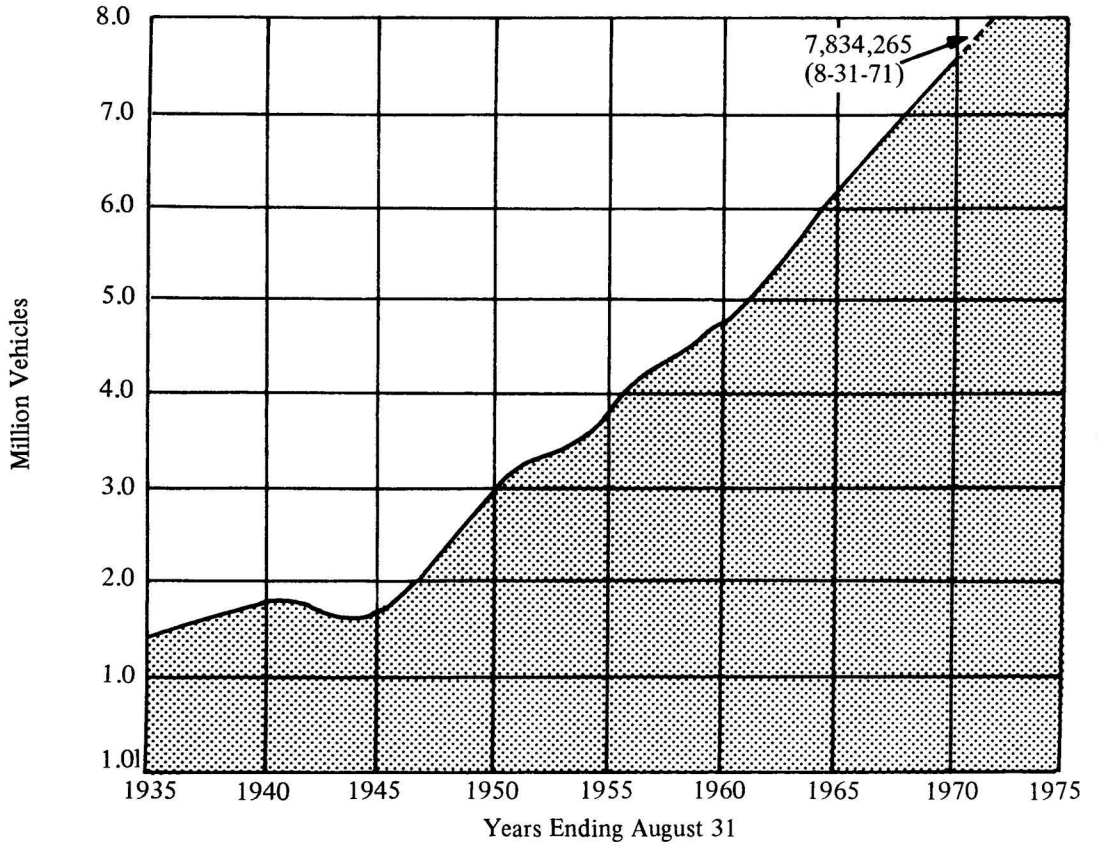
Transportation in Texas accounts for 18.9 percent of the state's total energy consumption.[5] Automobiles consume more than 55 percent of transportation energy.[6] Transportation systems, especially in metropolitan areas, are a powerful factor that shape and mold economic development. Between 1950 and 1970, national transportation energy use grew from 8,700 to 16,500 trillion B.t.u.[7] This increase was due in part to growth in passenger and freight traffic, and to the development of energy-intensive modes of transportation. Between 1950 and 1970 there was a tremendous increase in the use of the private automobile, truck, and airplane, and a significant decrease in the patronage of urban mass transportation. Figures 3-1 and 3-2 illustrate the growth of automobile and fuel consumption in Texas. Petroleum products represent 90 percent of the fuel consumed by the transportation sector in Texas. It is crucial that the state act to minimize the economic effects of fuel shortages. The following discussion of the state transportation agencies, the transportation budget, the automobile sector, and mass transportation illustrates means by which Texas should act to conserve energy in the transportation sector.

Government and Transportation

In order for any policy of fuel conservation within the state to be effective, it is essential that a balanced and comprehensive transportation policy be implemented. Currently, the primary responsibility for funding and developing transportation policies for Texas is divided among the Texas Highway Department, Texas Aeronautics Commission, Texas Railroad Commission, Texas Mass Transportation Commission, Department of Public Safety, and the Texas Turnpike Authority. (See Figure 3-3.) In addition, in March 1971, the governor created the Interagency Transportation Planning Council to advise him and the legislature on transportation matters and policies, to help resolve mutual problems among state transportation agencies, and to coordinate transportation planning activities among members of the council, regional organizations, and local governments. Members of the council include the directors of the transportation agencies and other individuals chosen by the governor.

FIGURE 3-1

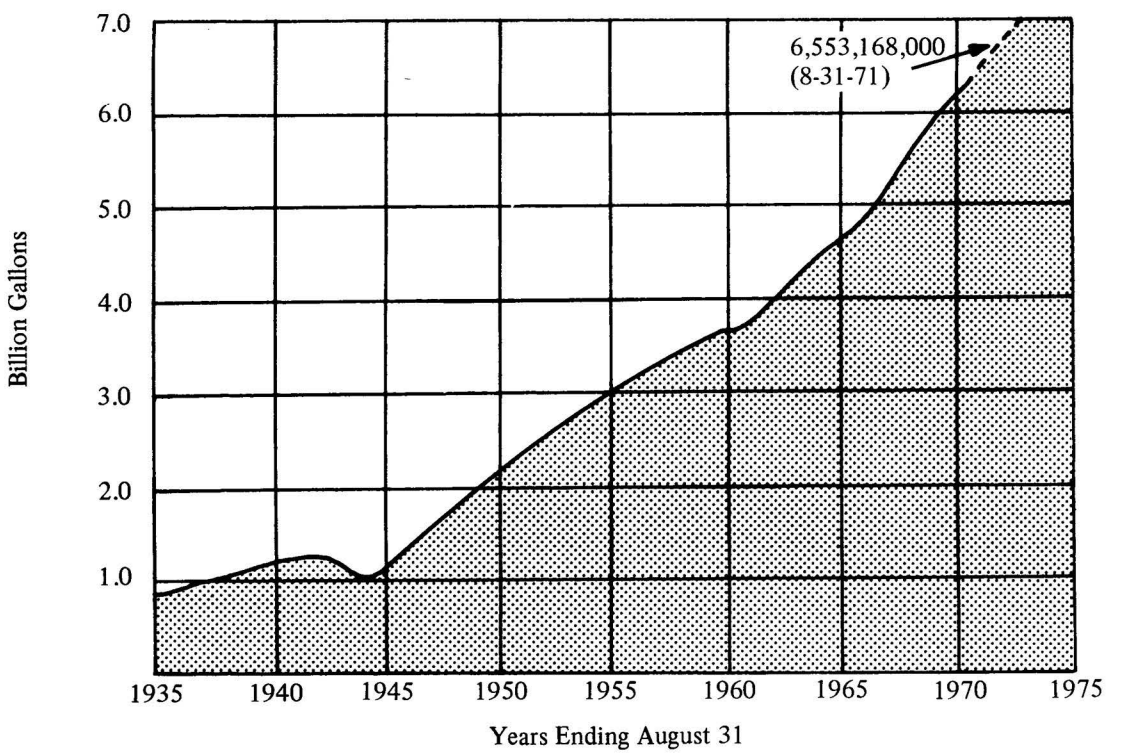
VEHICLES REGISTERED IN TEXAS



Source: Texas Highway Department, Planning Survey Division, *Texas Road, Street and Highway Finance Facts*, 1972.

FIGURE 3-2

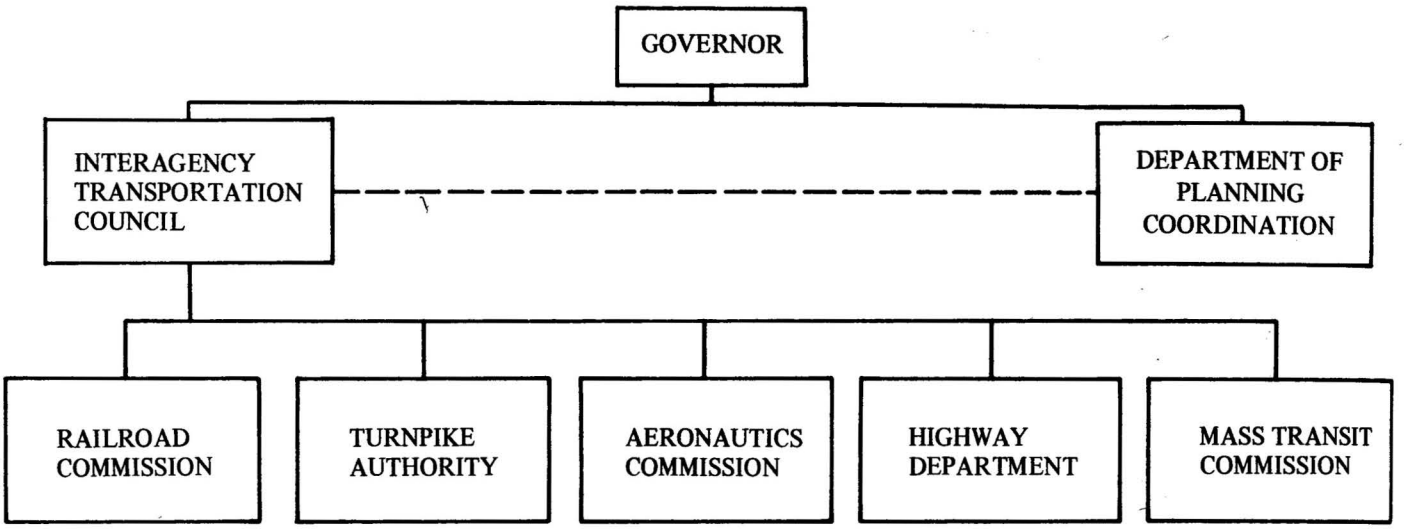
MOTOR FUEL CONSUMED IN TEXAS



Source: Texas Highway Department, Planning Survey Division, *Texas Road, Street and Highway Finance Facts*, 1972.

FIGURE 3-3

STATE TRANSPORTATION AGENCY STRUCTURE



Source: Office of the Governor, Division of Planning Coordination.

The local government structure in Texas also affects the formulation and implementation of transportation policies. According to the Texas Urban Development Commission:

> The existing structure of local government seems to resist rather than to encourage a coordinated approach to the urban transportation problem. Local public service responsibilities are divided among a variety of governmental jurisdictions operating independently of one another. . . . In the urban areas of the state, responsibility for each of the transportation modes has been fragmented. Operation of public transportation facilities, traffic control, regulation of freight movement, parking supply, and parking regulation are delegated to separate governmental units or, at best, separate departments of a single governmental structure. Little progress has been made in coordinating policies on an areawide basis to determine the roles of the major transportation modes within an entire metropolitan area or region.[8]

1. Transportation Budget. There is no central state agency whose primary function is to develop and coordinate a balanced transportation budget. Federal grant requests are prepared and submitted by individual state agencies in accordance with the goals and projects of that particular agency. Figure 3-4 shows the system of transportation funding. State appropriations to the various transportation agencies are often considered separately, without regard to the development of a balanced transportation policy.

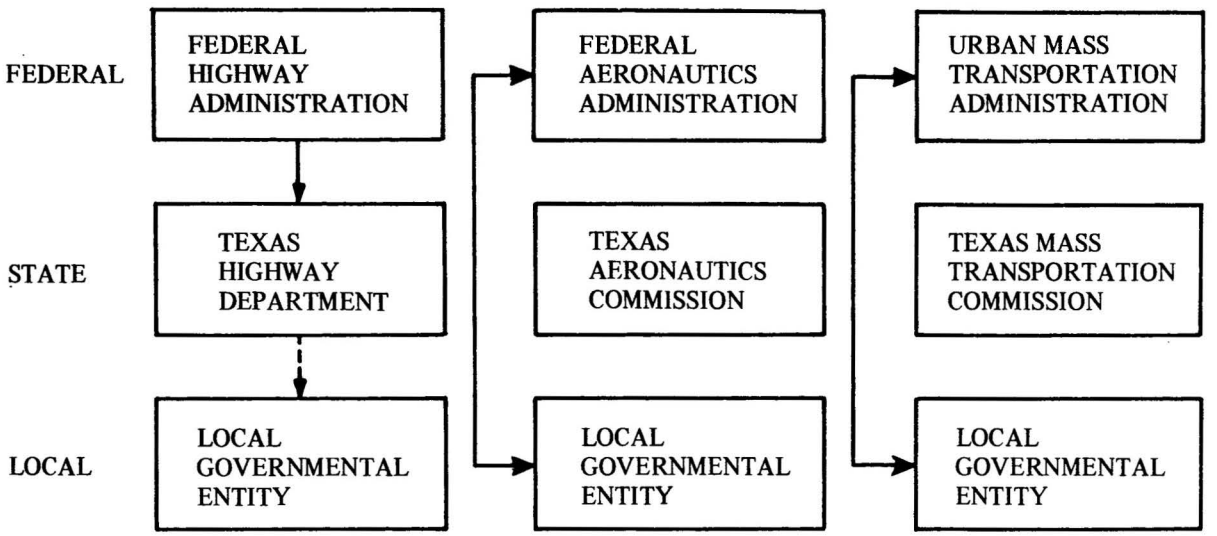
The earmarking of state funds for specific modes of transportation, particularly highways, further complicates the development and funding of a balanced state transportation policy because those funds can be expended only for the construction and maintenance of highways. Such earmarking brings about too much emphasis on the development of highways and urban freeways, to the detriment of the railroads and urban mass transportation. In addition, federal funds for urban mass transportation and aeronautical projects bypass the appropriate state agencies and go directly to local governmental entities. The Texas Mass Transportation Commission and the Texas Aeronautics Commission are unable to provide a comprehensive state program because they have little or no voice in the determination of the level of funding or in the distribution of federal funds for these two modes of transportation.

The problems brought about by the energy shortage indicate a need to modify the state's fragmented administrative and funding structure for transportation. Texas needs an efficient procedure for considering transportation alternatives if it is to minimize the effects of fuel shortages on the state's economy.

2. A Transportation Agency; Funding. A primary policy consideration should be the reorganization of the state's transportation agencies and funding structure. An effective

FIGURE 3-4

STATE TRANSPORTATION FUNDING



Source: Office of the Governor, Division of Planning Coordination.

means of reorganizing Texas transportation agencies would be to create a State Department of Transportation. In 1971, the Texas Urban Development Commission stated in its report to Governor Smith that, "If a State Department of Transportation could be created along the lines suggested by similar departments in other states, with modifications to meet the geographic, population distribution, and organizational arrangements that are peculiar to Texas, the benefits could be substantial."[9] Such a department would enable the state to actively pursue transportation systems, and it would encourage savings in energy consumption. The department should be governed by five members appointed by the governor for four-year staggered terms. Membership of the commission could include one member with highway interests, one member with mass transit interests, one member with urban and regional planning interests, one with aeronautics interests, and one with environmental interests. Administration of the department should be under the direction of a general manager.

> Rèsponsibilities of the Department would include the planning, design, construction, operation, and maintenance of all transportation and related facilities in the State as well as regulation of railroads, trucks, and public transportation. The Department would assume all transportation responsibilities currently under the Highway Department, Aeronautics Commission, Turnpike Authority, Mass Transportation Commission, and the transportation regulatory functions of the Railroad Commission.
>
> Staff divisions under the immediate direction of the General Manager would include: administration, State transportation planning and research, travel and operations, right-of-way, materials and tests, equipment and procurement, automation, and regulation. Responsibilities would be delegated to District Transportation Managers for planning, design, construction, maintenance, and operation of all modes including public transportation and highways, rail, air, and waterway transportation. The District Transportation Managers would coordinate all activities of privately owned transportation enterprises and would make recommendations to the State office on regulation of route coverage and fares. District Managers would be responsible for planning, constructing, maintaining and operating necessary parking facilities to augment the transportation networks. Districts would be charged with responsibility for creating a total transportation system which would be compatible with comprehensive plans developed by local governments and regional planning agencies.[10]

The present organization of the Highway Department into 25 geographic semiautonomous districts could be main-

tained after these transportation districts have been created.

"Pre-allocation of financial resources at the federal and state levels makes the development of a balanced transportation system very difficult."[11] Funding of a total transportation system using the transportation district concept requires the use of "transportation dollars" rather than highway funds, public transportation funds, and similarly earmarked revenue. The legislature must permit transportation funds, regardless of the source, to be expended for the mode of transportation recommended by each district transportation manager and approved by the State Transportation Commission. To correct the present situation according to which the state is bypassed in the distribution of federal transportation funds (mass transit and aeronautics), a channeling provision should be enacted requiring that all federal transportation funds pass through the State Department of Transportation. Funds other than those currently collected at the federal and state level should be available for the transportation system. These would include fares from publicly owned transit companies, from parking fees, and from contributions by the local governments through right-of-way acquisition and subsidies in the form of service fees for public transportation systems.

Automobiles

Because of its convenience for travel purposes and seemingly low cost of operation, the automobile has become the dominant mode of transportation in Texas. The number of automobiles registered in Texas reached 5,570,214 in 1972.[12] In 1970 urban traffic in the United States consumed 55 percent of the national total automobile fuel consumption.[13] Although complete figures are not available for Texas, the state pattern closely parallels the national pattern. Accompanying this increase in automobile traffic has been a rise in the energy-intensiveness of vehicles caused by the use of heavier and more powerful cars and by the use of optional equipment such as air conditioners and automatic transmissions. Since the automobile consumes a larger share of the transportation budget than all other transportation modes combined, energy efficiency improvements in this mode are crucial to a policy of transportation energy conservation.

The most important determinant of automobile fuel economy is vehicle weight. It has been estimated that 30 percent of transportation energy could be saved by a shift to smaller, lighter cars.[14] This is significant when we realize that the weight of the best selling standard-size passenger cars in the United States rose 800 pounds in 1962-1973.[15] Fuel economy and emissions tests undertaken by the EPA substantiate the argument that heavier cars consume higher levels of gasoline than do the smaller, lighter cars. Table 3-1 provides a brief illustration of the EPA test results.

Besides a reduction in weight, automobile fuel economy can be improved in other ways. A car equipped with a standard transmission uses 10 percent less fuel than one with an automatic transmission. The Federal Highway Administration estimated in 1973 that a 10 percent increase in gas mileage from 13.63 miles per gallon to 15.00 miles per gallon could result in an annual savings of 5,683 million gallons.[16] The use of low-loss tires, such as radials, can produce additional fuel savings.

The lowering of highway speed limits is yet another important energy conservation measure. In response to a nationwide fuel shortage, Texas was one of the first states to lower its highway speed limit to 55 miles per hour. Although the volume of fuel actually conserved by this action has not been calculated,* an estimate of savings through this action can be seen in Figure 3-5.

Mass Transportation

Although Texas and the nation have witnessed a continual decline in the patronage of mass transportation facilities, this mode of transportation, if sufficiently upgraded, could alter substantially the dimensions of the energy crisis. Urban mass transportation is generally defined as a public or private system of common carrier facilities for the movement of persons, offering transportation service on a payment basis and operating on established schedules along designated stops within a particular metropolitan area.

In Texas all urban mass transportation companies use buses; no city in Texas currently meets the minimum population density or corridor demand necessary to support rail rapid transit.

> Rail rapid transit systems have usually been built where urban areas exceed a population of one million, where employment in the central business district (CBD) is more than 100,000 people and where total CBD trip destinations amount to some 300,000 a square mile. The population density of rapid transit cities is typically in the range of 14,000 to 20,000 persons a square mile with one-way peak volumes exceeding 10,000 to 15,000 persons an hour per corridor. New York City, for example, has over 800,000 persons an hour leaving the nine-square-mile CBD on a weekday evening to provide an average corridor density of 60,000 passengers an hour.[17]

1. Difficulties Facing Urban Mass Transportation. The financial condition of urban mass transit companies in Texas is generally poor. Ridership, as indicated in Figure

*On December 1, 1973, the Texas Transportation Institute issued a report entitled *Fuel Conservation in Texas: Transportation* in which it estimated that the 55-mile speed limit would save 5.5 percent of the statewide fuel consumed on the highway.

TABLE 3-1

FUEL ECONOMY TEST RESULTS FOR AUTOMOBILES

Wt. Class	Model	Inertia Weight Class (lbs.)	Engine Disp. & Carb. Venturis	Trans.	Fuel Econ. (MPG)
	Pinto	2500	122-2	M4	21.4
	Cricket	2250	91.41-2	A3	18.4
2000-2750	Vega	2750	140-2	M3	19.7
	VW	2250	96.1-1	M4	23.6
	Toyota Corolla	2250	97-2	A2	22.6
	Comet	3500	302-2	M3	10.6
	Maverick	3000	200-1	A3	15.1
2750-3500	Nova	3500	250-1	A2	19.7
	Hornet	3000	232-1	A3	18.9
	Valiant	3500	225-1	A3	17.9
	Ambassador	4000	360-2	A3	11.2
	Charger	4000	318-2	A3	12.2
3500-4250	Matador	4000	304-2	A3	12.2
	Montego	4000	250-1	A3	14.1
	Dart	4000	340-4	M4	10.6
	Cutlass	4500	350-4	A3	10.8
	Cougar	4500	351-4	A3	8.7
4250-5000	Delta 88	5000	350-2	A3	9.9
	Chrysler	5000	440-4	A3	9.4
	Impala	4500	350-2	A3	12.0

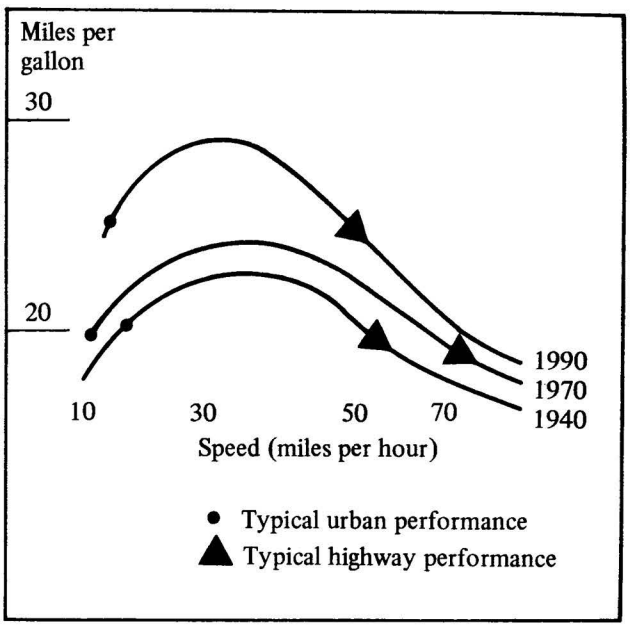
Source: EPA, "Federal Certification Results for 1973 Model Year," *Federal Register*, Vol. 38, No. 84, May 2, 1973.

3-6, has dropped markedly over the past two decades, and there has been an accompanying fall in fare box receipts, forcing many mass transit companies closer and closer to bankruptcy. The payment of taxes for fuel and property assessments has further complicated economic problems for the mass transit companies. Consequently, most urban centers in Texas have experienced a decline in the quality of service, frequency of pickups, and in some cases they have experienced a complete abandonment of service. According to the Texas Mass Transportation Commission, in 1955 there were 36 bus companies operating in Texas cities; in 1973, there were only 19.[18] More than 1,500 buses provided over 118 million transit trips to Texas riders in 18 cities in 1973. If those trips had been made by private automobiles, nearly 22 million gallons of gasoline would have been consumed by some 136,000 automobiles. This number of automobiles would have increased traffic congestion and would have produced an additional 144 million pounds of air pollution.[19] Yet, urban mass transit accounts for only 3 to 5 percent of energy consumption in the transportation sector, a small percentage in comparison with the automobile.[20]

2. Local Government Structure. As discussed previously, a factor complicating the efficient operation of many urban mass transit companies in Texas is the local governmental structure. Again, it should be emphasized that local public service responsibilities are divided among a variety of governmental jurisdictions which operate independently of one another. This fragmentation of services has affected detrimentally the provision of urban mass transportation service. Instead of a coordinated system of urban transportation, mass transit companies face competi-

FIGURE 3-5

ESTIMATED SAVINGS FROM LOWERED HIGHWAY SPEED LIMITS



Source: "Toward More Transportation with Less Energy," *Technology Review*, February 1974.

tive transportation services (especially the automobile) and governmental barriers which have prevented the implementation of efficient metropolitan-wide mass transit systems. Substantial fuel savings in the cities are possible if the state makes a positive commitment to assist in the planning and operation of efficient metropolitan mass transit systems. Cities in Texas will not be the only beneficiaries; the fuel savings realized by better mass transportation service will mean a greater supply availability for agricultural areas.

Although the state is limited as to how it can implement conservation measures for the residential, commercial, and industrial sectors, it can have a large impact upon transportation. The state has the ability and responsibility to encourage energy savings by offering a substitute to the private automobile. More specifically, the state should:

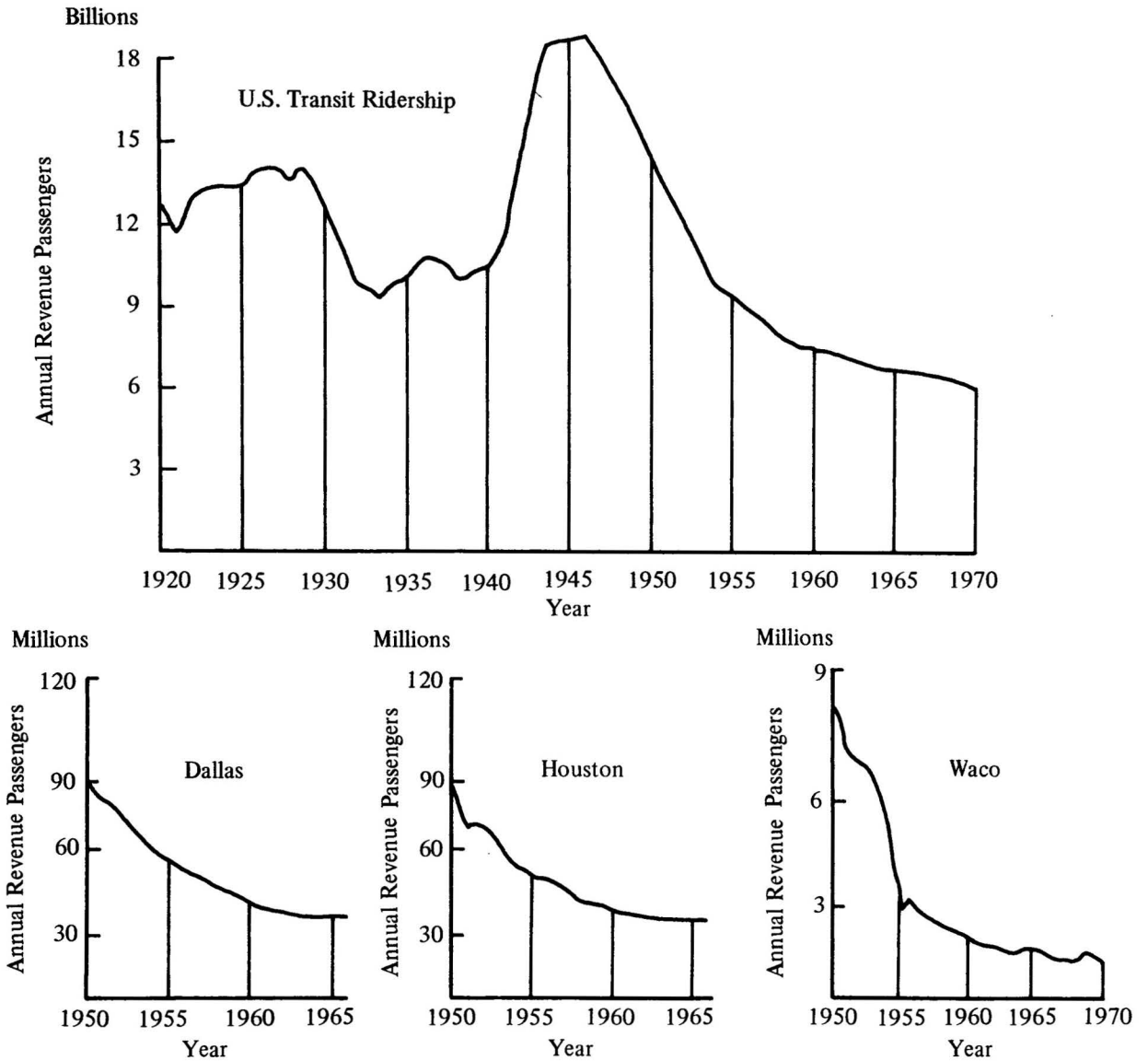
- act as an initiator and coordinator of mass transportation efforts;
- permit the 24 counties in Texas with populations of 50,000 or more to institute countywide transportation authorities;
- allow two or more counties to form regional or metropolitan authorities for purposes of planning and operating urban transportation systems;
- encourage cities to study the feasibility of park and ride services and/or contra-flow lanes on main traffic arteries;
- create a special task force to investigate the various means by which the state can financially assist urban mass transit systems (recommended membership to include representatives from the Texas Mass Transportation Commission, the governor's office, the legislature, and the Interagency Transportation Planning Council); and
- exempt mass transit companies from paying the property tax, gross receipts tax, franchise tax, motor fuel tax, and/or motor bus registration fees (upon condition that all revenue realized by these exemptions would be reinvested for the maintenance, planning, operation, and expansion of mass transit services).

PUBLIC SECTOR

The public sector is comprised of local and state governments. In this section discussion underscores the actions which the legislature may take to encourage energy conservation by the state.

FIGURE 3-6

ANNUAL TRANSIT RIDERSHIP



Source: Texas Transportation Institute, *The Role of the Texas Mass Transportation Commission*, 1971.

State Purchasing Practices

Because the state is an important purchaser of goods and equipment, its energy-purchasing practices should be analyzed. The state owns and operates large numbers and varieties of vehicles, including trucks, cars, boats, and airplanes. When purchasing such transportation vehicles, the state should consider gas mileage and should match the vehicle with the task to be performed. There are many other energy-consuming devices which the state purchases, including typewriters, dictating machines, and reproduction equipment, and purchasing practices in the past have not considered the energy requirements of these machines. In part, this is the result of labeling that does not reveal energy consumption. The State Board of Control should require energy efficiency labels for equipment, and this information should be considered in making purchasing decisions.

Building Design and Operation

The shape and orientation of every structure affects its energy consumption. In the process of designing a building the cost of land and materials, the amount and location of available land, building codes, and time are considered. An increasingly important factor in design is the building's energy requirements, especially when viewed against rising fuel costs and energy shortages. Energy consumption and project design should be integrated into a standard planning process.

An energy budget specifies energy consumption levels for buildings. At present, designers are aware of the cost relationship of building components, but the energy interrelationship of these components is not well-known. For a comprehensive energy budget, additional information on available energy sources, climatic conditions, and the nature of building-use patterns must be considered. The State Building Commission should require that energy budgets be included as an integral part of all design plans and contracts for future state facilities. The State Building Commission should also establish energy budgets for existing state-owned or -operated structures.

To understand the energy consumption levels for state buildings, it is essential to collect energy consumption data for types of buildings. The data should be analyzed and related to each building's use, local and regional climatic patterns, and types of available energy sources. The American Research Corporation has compiled such data with a view to reducing the energy consumed by federal buildings. Professor Francisco Arumi of The University of Texas at Austin is preparing a computer-simulated model which analyzes aggregate flows of energy in types of buildings and then correlates the energy flow with the type of system, system performance, building materials, design features, and locations. Once such a model is available, it can serve as a guide for measuring energy reduction success by any proposed conservation measure. Architectural style, including the number and size of windows, the amount of ventilation, and the ratio of outer wall surface to the total volume of the structure affects the costs of cooling and heating. The nature of a building as a system composed of work subsystems must also be considered. Because the problem is complex, however, there is no one optimum design feature.

The building design process has traditionally been divided into three phases: (1) programming and planning, (2) schematic design, and (3) design development. Dr. Sital Daryanani, chief mechanical engineer for the architectural firm of Syska & Hennessy, Inc., identifies the first phase as providing the best opportunity for energy savings. In this phase, work subsystems are identified so that design features relate to work systems. Furniture is arranged to improve efficiency of space usage, lighting fixtures are placed near intensive work areas, and natural illumination is used where desirable. It is during the schematic design phase that the mechanical and electrical systems are selected. At that point energy-efficient systems should be considered. Some materials used in construction, such as aluminum, require more energy to produce than do other usable materials, such as steel. The design development phase should include consideration of other materials to be used in the structure. The state should implement a design process that would call for consideration of energy consumption at all phases, and the process should be a mandatory part of all contracts for future state facilities. One important point is the effect of energy-saving features on construction and operation costs; most of the energy-saving ideas, if properly considered and applied during the design phase, could reduce the construction cost and save energy during operation.

In the past, design has not been closely related to energy conservation. A major reason for that was the low cost of energy, especially in comparison with construction costs. It has been estimated that 10 to 25 percent of the energy consumed by a building could be saved by the installation of double doors, storm windows, and other heat-loss control devices.[21]

Large office buildings require the use of internal climate-control systems which regulate humidity and temperature levels. Existing practices in the system's design and operation often do not permit section-by-section shutdown, which means that unused areas are cooled or heated. New systems should permit flexibility in methods of climate control. Lighting systems consume an important percentage of a building's energy consumption. The most widely recognized technique to save energy is through the substitution of fluorescent light fixtures for incandescent fixtures, which not only reduces direct electrical demand, but also reduces the load imposed on the cooling system. An additional refinement is the substitution of high-frequency power sources for the system used presently. This reduces the start-up current requirements of fluorescent fixtures and yields some increase in operating efficiency.

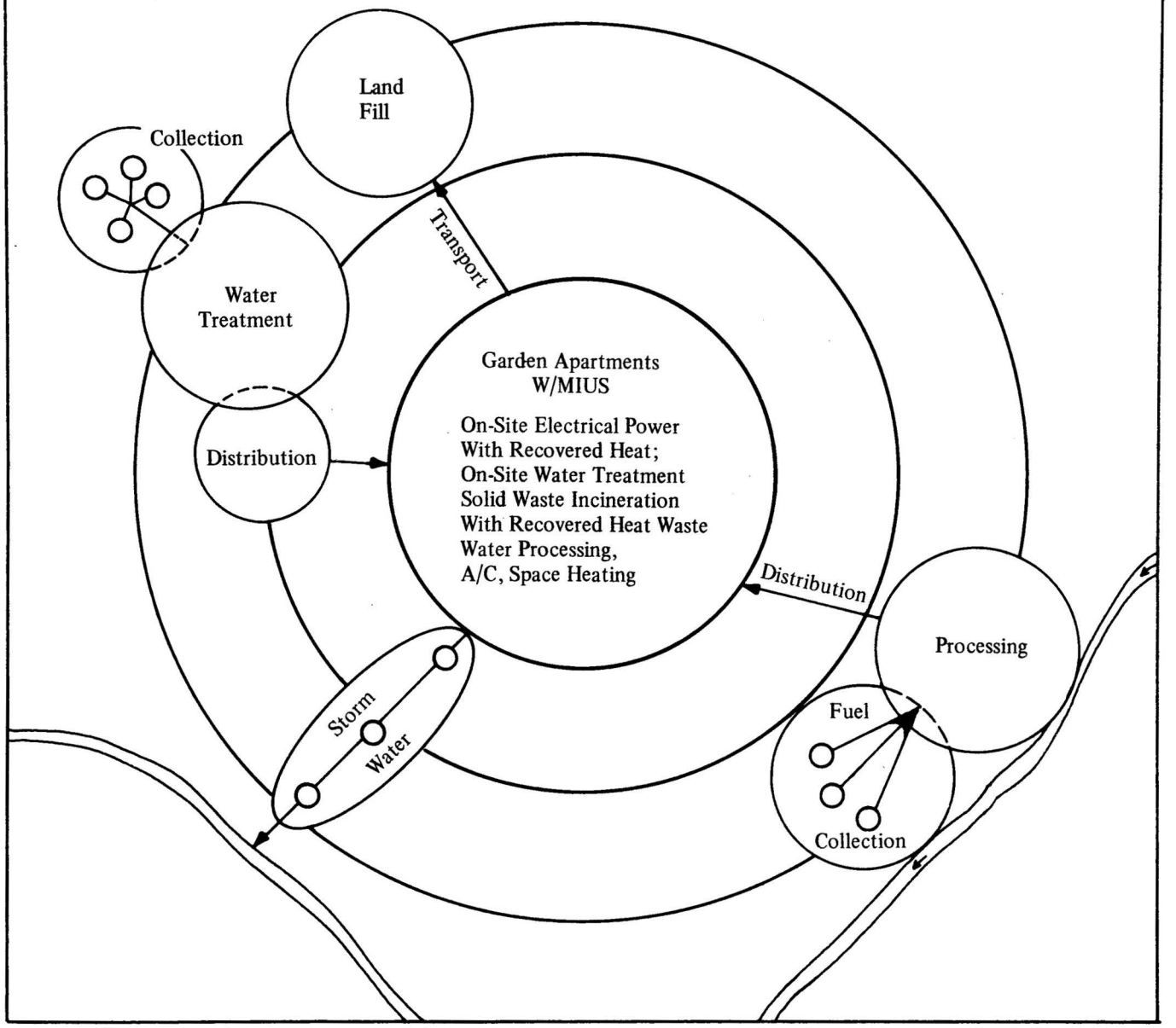
The practice of using lighting for decoration or to achieve a certain ambience should be reassessed. Furthermore, lighting is often employed without regard to need. Modern technology offers another method for reducing the electrical energy demands of both lighting and air conditioning through a micro-computer central control system. This system allows for a gradual system turn-on, thus reducing peak load requirements and allowing energy consumption to be related to use.

AN INTEGRATED SYSTEM

The Modular Integrated Utility System (MIUS) is a total

FIGURE 3-7

MIUS MODEL SERVICES FOR APARTMENT COMPLEX



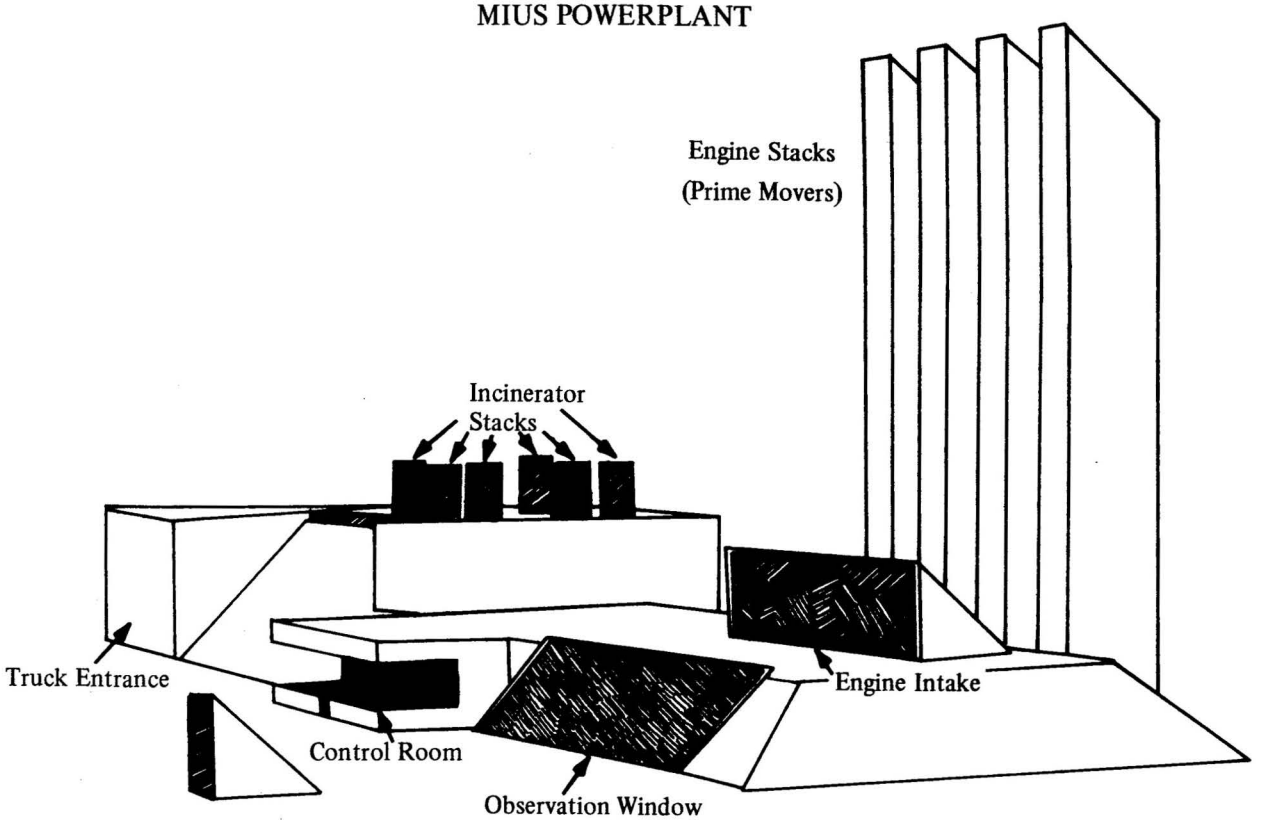
Source: NASA, Johnson Space Center.

energy system patterned after the recycling techniques used in manned spacecraft operations. Unlike the other recommended conservation policies, MIUS affects all economic sectors. As an integrated utility system, its purpose is to combine all utility functions into one plant (see Figures 3-7 and 3-8), putting to use energy presently lost by separate utilities and simultaneously minimizing harmful environmental consequences. The purpose in using MIUS is to provide a means of greatly reducing both the economic and external costs inherent in the present utility structure.

Water which has been used by customers returns to MIUS, which removes combustible wastes. These are burned, along with natural gas or fuel oil, to produce electricity. Noncombustible wastes are also removed, and the purified water can be reused by the cutomers in toilets, irrigation, and outside faucets. Since combustible wastes from both garbage and sewage are used to generate electricity, the amount of residue which must be hauled away is greatly reduced. Instead of being released into the air or water, the heat which does not contribute to the

FIGURE 3-8

MIUS POWERPLANT



Source: NASA, Johnson Space Center.

generation of electricity is used for space and water heating, which in turn reduces the amount of power currently required for these purposes.

The major advantages of MIUS are the conservation of natural resources, the reduction of total energy consumption, and the minimization of environmental impact. This utility system also has the capability of expanding easily with the development or redevelopment of a community and it can be a transportable system for emergency relief.

Using figures based on a conceptual MIUS design study conducted by NASA, the following savings can be expected (relative to present systems) in a 648-unit garden apartment complex:

Energy Reduction	33 percent
Water Inflow Reduction	9 percent
Liquid Waste Outflow Reduction	48 percent
Solid Waste Load Reduction	74 percent*

*26 percent will have to be hauled away, whereas 100 percent must be hauled away now

If such a MIUS program were implemented on a large scale, there would be substantial fuel savings and environmental benefits.

MIUS faces a great deal of institutional friction from the currently separate systems of electricity generation, sewage disposal, garbage disposal, and water supply. MIUS holds the most promise for new developments in situations where no plumbing changes are necessary, where the conventional utility system infrastructure has not penetrated, and where a community can enjoy an independent power source capable of growing to meet its needs. The community needs to be large enough to accommodate 300 units to make MIUS economical. Initial costs for MIUS are greater than those for a conventional electric-generating plant of equal capacity, although subsequent costs are less.

If a developer chooses to build a MIUS, he can operate and maintain it himself or he can sell it to homeowners. However, neither the large-scale housing developer nor the homeowner wants to incur the high initial cost of MIUS. Even though the high initial cost may be worthwhile in

light of the reduced water and power rates, the initial cost of MIUS could cause the price of housing units to appear exorbitant.

Municipal ownership of MIUS is more promising than private ownership because the municipality can undertake the initial costs more easily. Moreover, private developers may find that savings in operating costs (relative to the conventional plants) are heavily taxed, while a municipality does not face this problem. MIUS also provides services which are not normally the developer's responsibility but which can be beneficial to the entire municipality and to the environment. Since many of the advantages of MIUS involve cleaner air and water, their realization is a public good which cannot be translated into a private profit.

As described, MIUS promises many advantages both for customers and for the environment. Until there are some MIUS plants in operation, however, it is impossible to know whether unanticipated problems will arise or whether the anticipated problems will actually occur. The state should encourage the experimental development of MIUS.

CONCLUSION

While the state considers policies to increase production, it should also be aware of the role it can play in aiding conservation through wiser use of energy. Although the residential, commercial, industrial, and transportation sectors are in almost full control of their own energy consumption practices, the state can inform these sectors of conservation measures. The education of the economic sectors should begin immediately. An important step in that educational process is the creation of a statewide labeling system that would allow consumers to compare products on the basis of their energy requirements. Another important step in disseminating information would be to encourage an "energy awareness" program led by industry.

Besides this "public relations" role, the state should take specific actions to conserve energy directly. It should limit the use of lighting for advertising and should recognize and encourage industrial resource, recycling, and reuse of materials. There is also a need for state government to plan comprehensive energy-transportation policies through the creation of a State Department of Transportation.

Of course, the state has the greatest degree of control over the public sector. Because the state is an important consumer, it should be a wise shopper when it purchases energy-consuming goods and when it contracts for the construction of state buildings. For those buildings already constructed, the State Building Commission should establish an energy budget.

Although the state is at present limited in what it can do to influence the economic sectors in Texas, it is recognized that there should be a continuous monitoring of these sectors by an Energy Conservation Council. Such a council would study and recommend energy conservation measures (including demonstration projects) to the Texas legislature, and would coordinate energy conservation efforts of citizens, businesses, and public institutions.

RECOMMENDATIONS

1. ***Public education campaign.*** The Office of the Governor should conduct a public education campaign to inform Texas residents of ways to conserve energy in the home.

2. ***Efficiency labels for appliances.*** Legislation should be passed requiring retailers to label appliances sold in Texas with efficiency labels using comparable energy units.

3. ***Insulation standards.*** Minimum insulation standards for new buildings should be set by law.

4. ***Limitation of lighting for advertising.*** The legislature should limit commercial lighting for advertising.

5. ***Industrial energy awareness program.*** The state should encourage, coordinate, and assist in the funding of an "energy awareness" program led by industry to distribute information on the technical and economic aspects of energy conservation.

6. ***Industrial life-cycle planning.*** In order to encourage greater industrial life-cycle planning, including recovery and recycling procedures, the legislature should help initiate and fund related projects by providing subsidies or tax considerations for participating industries.

7. ***MIUS.*** The legislature should pass a resolution encouraging the development of Modular Integrated Utility Systems (MIUS).

8. ***Energy Conservation Council.*** The legislature should create an Energy Conservation Council to study and recommend energy conservation measures, including demonstration projects, and to coordinate energy efforts of citizens, businesses, and public institutions.

9. ***Energy budgets for state facilities.*** The State Building Commission should establish energy budgets for existing state-owned or -operated structures. The commission should also require that energy budgets be included as an integral part of design plans and contracts for future state facilities.

10. ***Equipment purchasing policies.*** The State Board of Control should require energy efficiency labels for equipment, and this information should be considered in making purchasing decisions. The Board of Control should formulate guidelines that require adherence to energy savings in the purchase of state vehicles.

11. ***State Department of Transportation.*** A Texas State Department of Transportation should be established with responsibilities for the planning, design, construction, operation, and maintenance of all transportation and related facilities of the state.

12. ***State transportation funds.*** Legislation should be

passed which would permit transportation funds, regardless of their source, to be expended for the mode of transportation recommended by the State Department of Transportation.

13. ***Local transportation authorities.*** The legislature should pass a law permitting the 24 counties in the state with populations of 50,000 or more to institute county-wide mass transportation authorities. Two or more counties should be permitted to form regional or metropolitan transportation authorities that would plan and operate urban transportation systems.

14. ***Park and ride services and contra-flow traffic lanes.*** The legislature should pass a resolution to encourage the cities of Texas to study the feasibility of park and ride services and/or contra-flow lanes on main traffic arteries.

15. ***Freeway lanes reserved for mass transit vehicles.*** The legislature should enact a law giving the cities of Texas the option of reserving freeway lanes during the morning and afternoon rush hours for the exclusive use of public transit and/or multiple-occupant motor vehicles.

16. ***Tax exemption for urban mass transit companies.*** The state should exempt urban mass transit companies from paying the following taxes and fees, whether state or local: property tax, gross receipts tax, franchise tax, motor fuel tax, and motor bus registration fees. The exemptions should be granted only if all revenue realized is invested in maintenance, planning, purchase of rolling stock, operation, and service of the urban mass transit systems.

17. ***Task force to investigate assistance for urban mass transit systems.*** The legislature should create a special task force to investigate the various means by which the state could financially assist urban mass transit systems.

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CHAPTER FOUR

ALLOCATION OF ENERGY RESOURCES

INTRODUCTION

As a major energy-producing state, Texas has been able to provide oil and natural gas to meet the needs of its citizens, but, as a result of increasing demand, fuel resources are no longer adequate. In order to effect equitable distribution of limited energy resources among consumers, governmental allocation policies are necessary. Present federal and state policies that have an impact on the allocation of energy resources in Texas are described in this chapter. First, the need for governmental allocation is explained and second, the different means for distributing fuels are defined. Third, allocation plans of the Federal Power Commission (FPC) and the Federal Energy Office (FEO) are described according to their influence on state policies. Fourth, allocation policies of Texas state agencies are presented.

NEED FOR GOVERNMENTAL ALLOCATION POLICIES

Governmental allocation policies are instituted when the free market is not capable of performing its allocation role. In the present situation, energy supply is less than energy demand, and the free market is not allocating supply to meet citizen goals. The federal government has established allocation systems for interstate natural gas and for petroleum products in order to meet national objectives, but because national goals need not be the same as Texas objectives, a listing of allocation goals for intrastate natural gas is also necessary. In establishing allocation policies, the State of Texas should consider equity problems to avoid undue hardship brought about by lack of energy. Maintaining a healthy economy to provide jobs for all Texans and eliminating market operation problems are also objectives of allocation policy, and the conservation of our energy resources to prevent wasteful use should be a further objective.

METHODS FOR ALLOCATING ENERGY RESOURCES

Any allocation method will, of necessity, be involved with changing the economic supply and demand for a product. However, because discussion of allocation in terms of aggregate supply and demand tends to be highly theoretical, this chapter will concentrate only on current methods of allocation and enforcement procedures.

Allocation Methods

The three general types of allocation methods are quantity, price, and time. Quantity allocation limits the amount of a good that can be purchased. Price allocation in its pure form allows prices to increase until demand for the good is equal to supply. This can be accomplished either in a free market or in the present regulated market. Time allocation can involve setting times for the sale of products or limiting the amount of a product that can be bought or sold during any set period of time.

Enforcement Procedures

Allocation policies can be implemented by voluntary compliance, mandatory regulation, and/or taxation. Voluntary compliance is often referred to as moral suasion. The government requests that a policy be followed, and the public is free to comply or not. Mandatory regulations give an allocation policy the force of law. The FEO regulations, FPC rulings, and Texas Railroad Commission orders are examples of mandatory regulation. Taxation is an enforcement procedure that best applies to price allocation, since taxes are used to force an increase in prices.

ALLOCATION BY THE FEDERAL GOVERNMENT

State energy allocation policies are limited by the activities of the federal government. The FPC regulates interstate natural gas, and the FEO controls allocation of petroleum products.

FPC and the Regulation of Natural Gas

The authority of the FPC to control interstate sales of natural gas is derived from the Natural Gas Act of 1938. The FPC has the jurisdiction to regulate the transportation and sale for resale of natural gas in interstate commerce and

can regulate the volumes of gas transported for direct sales. National curtailment policies and end-use controls are also within the authority of the FPC under its stipulated powers over transportation of natural gas in interstate commerce. However, the FPC does not have jurisdiction over natural gas in intrastate commerce.

In Opinion No. 606 of October 5, 1971, the FPC called for a uniformly-applied natural gas curtailment plan. A national plan of general end-use priorities was deemed necessary in order to accomplish optimum allocation of declining gas reserves. On October 31, 1972 the FPC issued Opinion No. 634, which first established an interim system of priorities for curtailment. That curtailment plan, in decreasing order of priority, is as follows:

Priority One. Residential, small commercial (less than 50 thousand cubic feet (Mcf) on a peak day), and residential needs associated with industrial requirements served directly or indirectly.

Priority Two. Large commercial requirements and industrial requirements for plant protection, feedstock, and process needs.

Priority Three. All industrial requirements not specified in Priorities Two, Four, and Five.

Priority Four. Industrial requirements for boiler fuel use at less than 3000 Mcf per day, but more than 1500 Mcf per day, where existing alternate fuel capability is present.

Priority Five. Industrial requirements for large volume (in excess of 3000 Mcf per day) boiler-use fuel where existing alternative fuel capability is present.[1]

A more comprehensive curtailment program was established by FPC Order No. 431, which required every jurisdictional pipeline to report to the FPC whether curtailment of its deliveries to customers would be necessary because of an inadequate supply of natural gas. All pipelines facing shortages which necessitate curtailment are required to file reasonable allocation schemes as amendments to their existing tariffs, or to state that the existing tariffs are adequate. When emergency or other conditions arise and it appears to be in the public interest to place a plan into effect, the FPC may accept the filing, implement it, and employ the plan as a working guideline while hearings continue.

The FPC's power to regulate curtailment of natural gas was affirmed in the case of *Federal Power Commission v. Louisiana Power & Light Company*, 92 S.Ct. 1827 (1972). The principal question in the case was whether restrictions in the Natural Gas Act prohibit the FPC from applying Order 431 to curtail direct sales deliveries in times of natural gas shortage. The Court held that the FPC under its jurisdiction over transportation of natural gas, has the power to regulate curtailment by pipeline companies of direct interstate sale of natural gas. The Natural Gas Act limits the FPC's rate-setting authority to interstate sales of natural gas for resale, but its power to regulate curtailment includes direct sales. In the opinion of the Court, the FPC possesses broad power to devise effective means to regulate service curtailment programs of natural gas companies in the event of gas shortages. The commission is free, within the ambit of its statutory authority, to make the practical adjustments which may be called for by particular circumstances.

In the Louisiana Power & Light case the Court seemed to lean toward total federal pre-emption of the regulation of natural gas even while it attempted to limit itself to discussing only interstate gas. To the extent that the states may constitutionally promulgate curtailment plans, the Court contended, the inevitable result will be varied regulatory programs of state courts and agencies, interpreting a countless number of different contracts and applying a variety of state agency rules. The Court noted also that a state agency empowered to regulate these contracts would be obliged to regulate in the interest of the state, and not in the national interest and the unavoidable conflict between producing states and consuming states would create contradictory regulations that could not be equitably resolved by the courts. With these problems in mind, the Court concluded that uniform federal regulation of natural gas curtailment is desirable.

FEO and the Regulation of Petroleum Products

On January 15, 1974, the FEO issued Mandatory Petroleum Allocation and Price Regulations under powers granted to it by the Emergency Petroleum Allocation Act of 1973 and the Economic Stabilization Act of 1970, as amended. The regulations establish administrative rules and procedures to be utilized by the FEO in its national mandatory allocation program for petroleum products. Allocation offices were to be designated by each state to administer the state allocation program established by the FEO.

The FEO allocation program should be distinguished from a rationing program. Allocation, according to the FEO, means that the federal government regulates the volume of fuel that wholesale petroleum distributors can make available to their customers. Retail dealers, with the major exception of gasoline service stations, are also told how to allocate supplies to the final users of the products. However, rationing occurs when the product is allocated to the final user.[2]

When the mandatory petroleum allocation program of the FEO was established, both domestic and imported crude oil was allocated to refiners on a pro rata basis. The FEO announced a supply/capacity ratio quarterly; any

refiner whose supply exceeded the ratio was required to offer excess supplies for sale, and refiners with supplies below the ratio were eligible to buy available stocks until the proper ratio was reached. These regulations were enforced by FEO.

As a result of recent developments, the FEA* no longer announces supply/capacity ratio for each quarter. Instead, for each quarter, each refiner-buyer is entitled to purchase the equivalent of one quarter of the volume of his 1972 crude oil runs, less runs for the period February through April 1974 as adjusted by the section (section 211.65 Mandatory Petroleum Allocation Regulations, May 14, 1974). A refiner-seller must offer for sale to refiner-buyers a fixed percentage share determined by FEA from the total refining capacity of all refiner-resellers (section 211.65(d)(1) Mandatory Petroleum Regulations, May 14, 1974). A buy-sell list is published by FEA for each allocation quarter, indicating the quantities that each refiner-buyer is eligible to purchase and through which each refiner-seller is obligated to offer for sale (section 211.65 (e) Mandatory Petroleum Allocation Regulations, May 14, 1974).

The state office has no direct enforcement powers in this area.

FEO regulations also include a mandatory refinery yield control program which requires refiners to maximize production of aviation fuels, distillates, residual fuels, and petroleum feedstocks by reducing the total production of gasoline. Refiners are permitted to produce for sale a total amount of gasoline not greater than the historic ratio of gasoline produced per barrel of crude during the corresponding quarter of 1972, multiplied by a gasoline production fraction. The FEA bases the gasoline-production fraction on reported refinery production and on actual production required to meet most closely the needs of the allocation program. The production fraction is adjusted on a quarterly basis as circumstances warrant.

Specific percentage-allocation levels for each petroleum product received by each type of purchaser are set out in the FEA regulations. The allocation level varies with the class of purchaser or the end-use to be made of the allocated substance. The percentage-allocation levels are not, however, arranged in sequence of priority: suppliers of each specified petroleum product are instructed to distribute available supplies without regard to order of listing. They are further instructed to continue serving their old customers plus those purchasers assigned to them by the FEA.

*The Federal Energy Office (FEO), created by executive order December 4, 1973, is replaced by the Federal Energy Administration (FEA), established by Congress May 2, 1974. Hereinafter, the name FEA will be used.

FEA regulations call for "state set-asides" of certain fuels. A set-aside is a certain amount of fuel which the FEA gives to a state, to be administered by the state allocation office in order to handle emergency allocations. The monthly set-aside volume is a percentage of the estimated volume of the particular fuel that enters the state for consumption within the state. The original figures published by the suppliers are estimates. However, as the month progresses, these figures are updated to reflect current market data. State set-asides are established each month by the FEA for propane, middle distillates, motor gasoline, and residual fuel oil (except as used by utilities or as bunker fuel for maritime shipping).

The FEA has indicated recently that it will ask Congress to change a law that mandates oil refiners to share crude oil equally. This requirement, according to the FEA, might distort and even reduce production of petroleum products. The Gulf Oil Corporation filed suit in federal court on February 14, 1974, seeking an injunction to halt the program, but no immediate court action is expected.[3]

ALLOCATION BY THE STATE

At present there is no overall state allocation policy. Instead, three state agencies distribute energy resources in Texas: the Railroad Commission controls intrastate natural gas, the General Land Office manages in-kind state royalties, and the State Allocation Office distributes state petroleum set-asides.

The Texas Railroad Commission

The Texas Railroad Commission has had a role in state allocation of fuels under its power to control the production of oil and natural gas. However, the extent of the authority of the Commission to distribute fuels is uncertain. Since January 1973, several events have illustrated this condition.

1. Curtailment program. Prior to 1973 the Texas Railroad Commission controlled the allocation of fuels only at the level of production. Prorationing limits were set to conserve fuel resources and to maximize long-term recovery. On January 5, 1973, the Railroad Commission issued an order on Docket No. 489 which established curtailment programs for natural gas transported and sold within the state. The Railroad Commission took such action under the authority of its statutory mandate to conserve oil and natural gas.

The order included three specific rules. Rule One instructed every natural gas utility that engages in intrastate operations to file a curtailment program with the Railroad Commission by February 12, 1973. This program was to include, in verified form, all relevant data concerning the utility and its supplier(s). Rule Two of the order sets out a

priority system to be used until such time as the commission has specifically approved a utilities-curtailment program. The priorities, in descending order, are as follows:

Priority One. Deliveries for residences, hospitals, schools, churches and other human needs.

Priority Two. Deliveries of gas to small industrials and regular commercial loads (defined as those customers using less than 3000 Mcf) and delivery of gas for use as pilot lights or in accessory or auxiliary equipment essential to avoid serious damage to industrial plants.

Priority Three. Large users of gas for fuel or as a raw material where an alternate cannot be used and operation and plant production would be curtailed or shut down completely when gas is curtailed.

Priority Four. Large users of gas for boiler fuel or other fuel users where alternate fuels could be used.

Priority Five. Interruptible sales made subject to interruption or curtailment at the seller's sole discretion under contracts or tariffs which provide in effect for the sale of such gas as the seller may be agreeable to selling and the buyer may be agreeable to buying from time to time.[4]

Under Rule Three, each gas utility, "which has obtained Commission approval of a curtailment program [and] continues to curtail deliveries to its customers," is to file on or before April 1 of each year a specific curtailment program as required by Rule One. Without commission approval, no such utility is to make sales of gas to any new customers or increase volumes sold to existing customers, except those new or existing customers that fall under either priority one or two.

The order has been modified somewhat to deal with particular cases. On May 25, 1973, an "emergency order" giving second priority to electrical generating plants served by the Lo-Vaca Gathering Company was issued after gas shortages in Austin, San Antonio, and in areas served by the Lower Colorado River Authority (LCRA) brought those three large users to the brink of rationing electricity. A month later the order was revised for priority deliveries to certain industrial users. Specifically, second priority went to natural gas utilities to feed electrical generating plants serving human need customers. In awarding that second priority, the Railroad Commission added that powerplant customers would remain in this category only so long as they solicited efforts of their individual customers to conserve electricity and actively developed the use of alternative fuels.

2. Allocation of Liquefied Petroleum Gas. In July 1973 the Railroad Commission also ordered suppliers of liquefied petroleum gas (LPG) to continue serving existing customers rather than to divert available gas to other markets. The order was approved because Railroad Commission members held that the nation's supply of food and vital petrochemical products would become severely short unless an adequate supply of LPG was maintained.[5] However, attorneys for several LPG processors have argued that the commission lacks authority to enforce its order and that the existing state law under which the order was issued is unconstitutional.[6] The order was issued under Article 6049d, Section 6-a, Title 102 (Oil and Gas) of *Vernon's Annotated Civil Statutes*, which deals with "Conservation of petroleum oil and natural gas; duties of the Railroad Commission." Section 6-a is specifically concerned with administration of the conservation policies of the Railroad Commission. A suit was filed by the Skelly Oil Company in the Austin district court charging that the Railroad Commission order was unconstitutional and amounted to confiscation of property without due process of law. However, the case was subsequently dismissed at the request of Skelly and the order has since been rescinded in light of mandatory allocations of petroleum products issued by the FEA.

3. Intrastate Pipeline Allocations. By an Emergency Order and Notice of Hearing in May 1973, the Railroad Commission established curtailment priorities governing the delivery of gas by Lo-Vaca to its general-system customers. On July 16, 1973, the Attorney General of Texas asked the 200th District Court in Austin to appoint a receiver "to control and manage the property" of the Lo-Vaca Gathering Company.[7] Lo-Vaca, a wholly-owned subsidiary of Coastal States Gas Producing Company, controls and operates intrastate pipelines serving Austin, San Antonio, and the LCRA, among others. Court action was filed on behalf of members of the Railroad Commission who were of the opinion, based upon testimony and exhibits presented at public hearings held in May and June of 1973, that Lo-Vaca had violated certain statutes, rules, and regulations of the commission.[8] The Railroad Commission charged that since Lo-Vaca had shown itself unable to meet the natural gas requirements of its customers and to apportion the available supply on an equitable basis, it could not function effectively as a natural gas utility.[9] Under the circumstances, the Railroad Commission urged the court to place Lo-Vaca in receivership. Instead, on July 17, 1973, the 53rd District Court of Travis County created a five-person board of directors, with a manager to direct Lo-Vaca's operations. Lo-Vaca protested the change in its managerial structure, *but the Railroad Commission's powers to apportion a gas utility's supply of gas among its customers was not challenged*.

Two weeks later, however, considerable disagreement arose over whether the Railroad Commission had the power to divert gas not belonging to the customers of a gas utility (although flowing through its lines) and apportion it among the utility's customers during periods of public necessity. The issue in question grew out of contracts between Lo-Vaca and several non-system purchasers for the delivery

of natural gas (through Lo-Vaca's public utility pipelines) that "was either being used by or was available to Lo-Vaca for the service of its general-system customers."[10] On July 31, 1973, Austin, San Antonio, the LCRA, and the Board of Regents of The University of Texas (all general-system customers of Lo-Vaca) filed an application with the Railroad Commission requesting that it order an indefinite suspension of these gas deliveries to the Texas Utilities Fuel Company and others, and that the gas deliveries be apportioned among Lo-Vaca customers. The request was made in view of critical deficiencies in available gas in the Lo-Vaca system for supplying basic human needs.[11]

The Railroad Commission dismissed the application on two principal grounds. First, the commission argued that it lacked jurisdiction to grant relief because the issues in conflict involved questions of "both utility and non-utility buyers, sellers, and consumers."[12] The substance of these questions was inherently judicial in nature and beyond the powers conferred upon the commission. Second, the commission insisted that the application brought into issue "contractual transactions" that were in litigation in both state and federal district court and not properly subject to regulatory decision.[13]

In November 1973 Austin, San Antonio, the LCRA, and the Board of Regents of The University of Texas brought suit against the Railroad Commission and asked the court to reinstate their application before the commission for consideration on its merits. District Court Judge Herman Jones ruled on January 30, 1974, that there was no substantial evidence to support the Railroad Commission's refusal of jurisdiction.[14] Moreover, the court found that the plaintiffs application did not "challenge any party's title to natural gas or any contractual or property rights as they [might] have been conveyed or vested by the transactions involved."[15] Thus, the Railroad Commission was ordered to reinstate the application.

Judge Jones' decision notwithstanding, the Texas Railroad Commission continues to hold that statutes concerning the commission's jurisdiction in such matters are not clear, and it has indicated that, if necessary, it will appeal the decision to the Supreme Court of Texas. In the opinion of the Railroad Commission staff: "A Texas Supreme Court decision is as firm as the statute itself. With a Court decision upholding Judge Jones we would have a concrete law."[16]

The General Land Office

The General Land Office is authorized to lease all state-owned lands for the drilling of oil and natural gas. In 1973 the Texas legislature passed a law allowing the state to take lease royalties in-kind, in actual mineral production rather than in cash. These royalties may then be sold by the General Land Office at current market prices. However, the location of existing pipelines greatly limits the sale which the office can practically make. Without a delivery mechanism, no sale can be consummated through in-kind royalties.

Moreover, a number of attorneys at the General Land Office feel that the obligation of the School Land Board is to seek the highest rate of return for the Permanent School Fund; to do less would be malfeasance, in their opinion. Thus, in the performance of its statutory obligation, the General Land Office would not be able to accept a lower bid in preference to a higher bid where hardship conditions existed.

State Allocation Office

The State Allocation Office was established in November 1973 and has authority under the Mandatory Petroleum Allocation and Price Regulations issued by the FEA to certify and resolve hardship cases in the state. Effective June 1, 1974, state set-aside volumes may be utilized by the state office to meet hardship and emergency requirements of all wholesale purchase-consumers and end-users.[17] As amended, the regulations distinguish between wholesale purchasers who purchase or obtain specified quantities of a product and those who resell or otherwise transfer allocated products (wholesale purchaser-resellers). A wholesale purchaser-reseller may be supplied from the state set-aside in order to facilitate relief of hardship and emergency requirements of wholesale purchaser-consumers and end-users. Thus, while the regulations do not provide for use of state set-aside volumes for the relief of wholesale purchaser-resellers' emergency requirements, the state office may release set-aside products through such resellers for the relief of wholesale purchaser-consumers and end-users.

Created without statute, the State Allocation Office has an ad hoc posture that makes performance of its task difficult for several reasons. First, it does not have a formal budget. Second, its temporary nature leaves many of its employees in an insecure position. Finally, its status relative to other state agencies (such as the Railroad Commission) is unclear.

CONCLUSION

State allocation policies are limited by FPC regulation of interstate natural gas and by FEA regulation of petroleum products. However, the state retains control over intrastate gas and state petroleum set-asides. In order to clarify authority, the legislature should direct the Railroad Commission to develop an end-use allocation plan for all intrastate natural gas. The commission should also be given clear authority to implement the plan whenever the governor declares an emergency situation caused by shortages of natural gas. Assuming a continuing need for a state set-aside program, the State Allocation Office should be

given statutory existence, including a separate budget and well-defined policy goals.

RECOMMENDATIONS

1. ***An allocation plan for intrastate natural gas.*** The Texas Railroad Commission should be directed by law to develop an end-use allocation plan for all intrastate natural gas. The commission should also be given clear statutory authority to implement the plan whenever the governor declares an emergency caused by shortages of natural gas.

2. ***State Allocation Office.*** The State Allocation Office should be legislatively enacted with a budget and given statutory authority and guidelines within which to carry out the allocation of petroleum products.

REFERENCES

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4. The Texas Railroad Commission Docket No. 489, January 5, 1973.
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CHAPTER FIVE

INCREASING OIL AND GAS SUPPLIES

INTRODUCTION

Texas is the country's leading producer of crude oil, natural gas liquids, and natural gas. Due to the historical abundance and low cost of natural gas in the state, the industrial sector has become highly dependent upon natural gas. Texas electric utilities, too, use natural gas almost exclusively. Refining capacity in the state can be maintained only if a supply of crude oil is assured; significant shortages of oil and natural gas would create serious problems for the state. Because much of the petroleum and natural gas produced in the state is exported, Texas must consider measures to guarantee its own supply. This chapter deals with ways for Texas to increase oil and gas supplies to meet energy demands. Although limited in its ability to restrict fuel exports, the state can encourage and control production on public lands for the benefit of its citizens. Improved recovery methods can serve to increase petroleum production. In addition, Texas can utilize supertankers and an offshore terminal as means of increasing oil and gas supplies.

LIMITATION OF EXPORTS

Of the total production of oil and natural gas in Texas, approximately 61 percent is exported to the rest of the nation.[1] Increasing demands are being made on Texas oil and gas producers to supply larger quantities to meet the energy needs of the nation. These out-of-state demands have caused a shortage of fuel for municipalities and industries in Texas. Methods of limiting export of fuels from the state should, therefore, be evaluated. Although legal and ethical considerations prevent general restrictions on the export of natural resources, the state does have the authority to control production of oil and gas on public lands.

General Restriction on Export of Oil and Gas

During the Southern Governors' Conference in September 1973 the governors of the large oil- and gas-producing states of Texas, Oklahoma, Louisiana, and Mississippi threatened to shut off fuel for the crowded, industrialized states of the northeast.[2] Such threats, however, are not entirely credible, because oil- and gas-producing states are severely limited in their ability to protect their residents from energy shortages. Actual curtailment of the supply of fuel would clearly interfere with interstate commerce and could contravene the Commerce Clause of the U.S. Constitution.

1. The Commerce Clause. Under the Commerce Clause the power to regulate interstate commerce is expressly entrusted to Congress and thus forbidden to the states. In the past, state efforts to control the exportation of natural resources have challenged federal jurisdiction over interstate commerce. However, certain Supreme Court decisions regarding state power to restrict the exportation of resources have illustrated conflicts in interpretation of the Commerce Clause.

In *Geer v. Connecticut*, 161 U.S. 519 (1896), the Court held that the state, due to its proprietary interest, could make the privilege of killing wild birds conditional upon their not being removed from the state. In the case of *Hudson County Water Co. v. McCarter*, 209 U.S. 349 (1908), the Court ruled that New Jersey had the power to retain its natural fresh water for its own benefit and could stipulate that none be piped out of the state.

In 1911 the direction of Supreme Court decisions changed. In *Oklahoma v. Kansas Natural Gas*, 221 U.S. 229 (1911) the Court held that a state could not deny the use of highways, pipelines, and the privilege of eminent domain to corporations transmitting natural gas to points outside the state. Other early attempts by producing states to restrict interstate production of gas were invalidated in *Pennsylvania v. West Virginia*, 262 U.S. 553 (1923). In that decision the Court struck down a state requirement that natural gas distributors satisfy local needs before exporting.

Several theories have been advanced to explain the conflict among these cases. Perhaps the most effective theory is that the early cases have either been overruled or may be distinguished as regulating items of little commercial value.[3] Since 1911 the law holds that any direct restriction on the exportation of state resources is a forbidden burden on interstate commerce. This interpretation was restated in *Hood & Sons, Inc. v. DuMond*, 336

U.S. 525 (1949), which labeled unconstitutional a New York state official's refusal to license a milk-receiving depot on the basis that the depot would cause a scarcity in New York by diverting milk to the Boston market.

Two Supreme Court decisions provide the legal arguments against state authority to restrict export of natural resources. In *Oklahoma v. Kansas Natural Gas Company*, the State of Oklahoma argued that the supply of natural gas was waning in the state and was no longer sufficient to satisfy local and other needs. By Oklahoma Laws 1907, chapter 67, the state attempted to prohibit the construction of pipelines for natural gas and the transportation of the gas by such lines, except by domestic corporations. The charters of those corporations were to provide that the gas would be transported only between points within the state and not to any person or corporation engaged in transporting or furnishing gas to points outside the state. The domestic corporations were also to have the exclusive right of eminent domain and the use of the highways. Oklahoma argued that this attempt at limitation of exports was a legitimate measure of conservation in the interest of the people of the state. The Court, however, ruled that such curtailment was unconstitutional because it interfered with interstate commerce and therefore could not be justified as an exercise of the police power of the state to conserve its natural resources.

The Court held in *Pennsylvania v. West Virginia* that a state cannot accord to its own consumers a preferred right of purchase over consumers in other states. In the 1923 case, the Supreme Court vitiated a West Virginia statute requiring that consumers in West Virginia be accorded a preferential right over consumers in other states to purchase natural gas produced in West Virginia. The Legislature of West Virginia had enacted a statute, Acts 1919, chapter 71, giving a public service commission the power to require every person engaged in supplying natural gas within the state to furnish "a supply of natural gas reasonably adequate for the purposes . . . for which natural gas is consumed or desired to be consumed by the public . . . in this state" before offering the gas in the interstate market. The Court ruled that this was an unconstitutional burden on interstate commerce:

> Natural gas is a lawful article of commerce, and its transmission from one state to another for sale and consumption in the latter is interstate commerce. A state law, whether of the state where the gas is produced or that where it is to be sold, which by its necessary operation prevents, obstructs, or burdens such transmission, is a regulation of interstate commerce—a prohibited interference. The West Virginia act is such a law.

Furthermore, the Court held in *Pennsylvania v. West Virginia* that although pipeline companies were engaged in business of a quasi-public character in West Virginia, the state had no right to interfere with interstate commerce by requiring such companies to subordinate their interstate business in order to meet the needs of local business within West Virginia. The attempt by West Virginia to regulate interstate business to the advantage of local consumers was ruled unconstitutional.

2. Taxation Policies. Attempts to keep within Texas its natural wealth of oil and gas could focus on manipulating the state's tax structure so as to discourage exportation, but, taxation can be of only minor importance because a tax cannot constitutionally discriminate against interstate commerce.[4] The Texas legislature has attempted unsuccessfully to place restrictive taxes on the production of natural resources. In 1959 a natural gas Severance Beneficiary Tax was set by the 56th Legislature. Two years later the tax was declared unconstitutional on the grounds that it placed an undue burden on interstate commerce [*Calvert v. Tennessee Gas Transmission Co.*, (Civ. App. 1961) 341 S.W. 2d 677, error refused]. In 1961 a Dedicated Reserves Gas Tax was imposed as an occupation tax on the business of producing gas as a severance beneficiary. *Calvert v. Panhandle Eastern Pipe Line Co* , (Civ. App. 1963) 371 S.W. 2d 601, declared the tax unconstitutional because it, too, interfered with interstate commerce.

3. Ethical Considerations. A state does have the responsibility to promote the welfare, peace, happiness, and prosperity of its citizens. Yet in the case of *Oklahoma v. Kansas Natural Gas Co.*, the Supreme Court laid down that "in matters . . . of interstate commerce there are no state lines" and "the welfare" of the several states "transcends that of any state." The Court ruled that this was the purpose of the Commerce Clause.

In *Hood & Sons, Inc. v. DuMond*, Mr. Justice Jackson, who spoke for the Court, stated that "the established interdependence of the states only emphasizes the necessity of protecting interstate movement of goods against local burdens and repressions." Justice Jackson traced the history of the Commerce Clause and observed that "our economic unit is the nation, which alone has the gamut of powers necessary to control the economy." He also stated that:

> The economic system of the nation, fostered by the commerce clause, is that every farmer and every craftsman shall be encouraged to produce by the certainty that he will have free access to every market in the nation, that no home embargoes will withhold his export, and no foreign state will by customs, duties, or regulations exclude them, and under that system, every consumer may look to the free competition from every producing area in the nation to protect him from exploitation by any.

Although a state is recognized to have broad power to protect its inhabitant against perils to health or safety, the courts have placed repeated emphasis upon "the principle that the State may not promote its own economic advantages by curtailment or burdening of interstate commerce." Thus, a natural gas- and oil-producing state is not supported in its efforts to stockpile its natural resources at the expense of the consuming states.

Possible Control of Oil and Gas Produced on State Land

Although the State of Texas cannot limit the export of oil and natural gas, an alternative method for fulfilling in-state requirements for fuel is to control production on state-owned lands.

1. The Public Domain. When Texas was annexed to the United States in 1845, the debt of the Texas Republic exceeded $10 million. Texas offered the United States 175 million acres of the public domain in exchange for the federal assumption of the $10 million debt. Congressional opponents to statehood felt that the Texas lands were not worth the assumption of the debt and so refused the exchange. In final resolution, Texas was to keep its public domain and the United States was to disclaim any responsibility for the Texas debt. Thus, Texas was the only state to enter the Union with title to its public lands.[5]

Today the state retains 22.5 million acres in the public domain.[6] Through the General Land Office the state leases its lands for oil, gas, and mineral production. The oil and gas leases are sold to the highest bidder at scheduled sales. Oil companies or individuals pay the state a bonus in competitive bidding for the right to lease state lands for a specific period, usually three to five years. If oil and/or gas production actually results, the state receives an additional royalty payment of not less than one-eighth of gross production or the value of same.[7] The income from leases and royalty payments passes through the General Land Office and is deposited in various state funds. Until recently, the state minimum royalty interest on leases has been one-sixth of gross production, and the state leasing term was set at five years. In March 1974, the School Land Board adopted new terms for oil and gas leases on public school lands, raising the minimum royalty interest on state leases to one-fifth and reducing the leasing term to three years. The policy change is designed to give Texas higher royalty interest and income, and to encourage drilling on state-owned lands.

2. In-Kind Royalties. In the past, the commissioner of the General Land Office has accepted the state royalty payments in the form of cash or checks only. Determination of the royalty amount is based on a contract price. In 1973 the 63rd Texas Legislature passed legislation which specifically authorized the state to take its royalties "in-kind," that is, to take the royalty percentage in actual mineral production rather than in cash value. The commissioner of the General Land Office has stated that all state oil and gas leases issued after passage of the act are to include the provision which gives the state authority to take its royalties in-kind.

In-kind royalty payments give the state at least two major advantages. First, the state can sell its gas at the higher intrastate market price, which is not subject to FPC regulations. The state can also negotiate for sale of its oil and gas to Texas customers.

Royalty payments are not subject to FPC regulations because a royalty owner is not a natural gas company within the meaning of the Natural Gas Act of 1938. Royalty provisions do not constitute sales of natural gas for resale in interstate commerce and should not, therefore, be subject to FPC jurisdiction under the Natural Gas Act.[8]

At present it is unclear whether the authority for in-kind royalties includes oil and gas leases which were under contract before passage of the 1973 legislation. In response to this question, the attorney general of Texas has filed suit in Travis County district court against 26 of the major oil and gas producers who do business with the state. The attorney general has alleged the state's right for payment of royalty based on fair market value as opposed to contract price. He is also pleading for the right to take state royalty in-kind from producing wells. On January 18, 1974, the state won the in-kind right in one case in litigation, *State of Texas v. Shell Oil Co*.[9] The general land commissioner has been contacting some of the major oil companies to negotiate voluntary arrangements for in-kind payments pending disposition of the lawsuits in district court.[10]

In-kind royalty payments are also in question with regard to lands covered by the Relinquishment Act. After 1845, much of the public land of the State of Texas was sold or granted to various private land holders. In 1913, the state established the right to retain mineral interests in any future sales of its surface lands. A Relinquishment Act was enacted in 1919 which made the private owner of the soil the agent of the state to execute mineral leases and to promote development of minerals in public lands. By provisions of the act, the state relinquishes to the owner of the soil an undivided fifteen-sixteenths of all oil and gas produced, whereas the remaining one-sixteenth is royalty payment to the state.[11] New in-kind royalty legislation does not include lands under the Relinquishment Act. The Texas legislature should consider legislation which would authorize the state to take relinquishment land royalties in-kind.

3. State Lease Provisions. In order to limit exports of oil and gas from the state, the legislature should consider ways of keeping new production from public lands in Texas. The states of New Mexico and Louisiana have already taken such action. In 1973 the New Mexico legislature enacted a

law which requires the commissioner of public lands to incorporate into any lease issued after June 15, 1973, the provision: "The state has a continuing option to purchase at any time and from time to time, at the market price prevailing in the area on the date of purchase, all or part of any minerals that may be produced from the lands covered by this lease." A waiver of requirements for reservation of the rights may be granted if the commissioner of public lands finds, according to evidence presented at a public hearing, that the waiver would be in the best interests of the people of New Mexico, considering long- and short-range benefits. The commissioner is to dispose of any minerals reserved under the act at the best price available in order to gain the maximum benefits for the state and its people.[12]

On March 14, 1973, the Louisiana Mineral Board adopted a rider, to be attached to the 1966 Louisiana Lease Form, which requires producers drilling on state acreage to make a "good faith" effort to market the gas intrastate. The rider requires anyone producing oil or other liquid hydrocarbon minerals from state-leased lands to make a diligent effort to obtain an intrastate market for such minerals "that will cause them to be refined or processed in the State of Louisiana." In no event, however, is a producer required to sell such minerals to an intrastate market at a price less favorable than that which could be negotiated in the interstate market. If an equally profitable intrastate market cannot be found after 90 days, producers are authorized to sell the oil and/or natural gas in interstate commerce.[13]

Legislation was introduced in the 63rd Texas Legislature which sought to insure that Texas citizens receive first priority on gas produced on state-owned lands. S.B. 184 was reported favorably by the Natural Resources Committee, but no action was taken by the senate. The bill would have required that all future state leases contain a provision making unlawful the execution of an oil, gas, or mineral lease "unless such lease shall include provisions that no gas produced from the mineral estate subject to such lease shall be sold or contracted for ultimate use outside of the State of Texas unless and until the Texas Railroad Commission shall find" that neither the lessor, certain health-care facilities, public and private schools, state and other public facilities, nor any resident of Texas "requires said gas as fuel to meet needs for heat and electricity."

As required by the legislation, the 22.5 million acres in the public domain of the State of Texas can be made the subject of a lease, such as a normal landlord/tenant lease, or an oil and gas lease. When public land is leased for oil and gas development under the existing law, the state as lessor possesses the same rights enjoyed by a private owner to place the conditions it desires in the lease, so long as those conditions do not violate any principle of ownership of real property. Therefore, the state has authority to place a condition in all future leases that gives the people of Texas first call to purchase oil and gas produced from state-owned lands.

State efforts to limit the flow of oil and natural gas from Texas are not likely to survive court challenge. To the extent that related gas is destined for interstate markets, the case of *Pennsylvania v. West Virginia* has indicated that restrictive state action would contravene the Commerce Clause. The State of Texas does have authority to exert control over oil and gas produced from public lands. The Texas legislature should consider legislation which would authorize the General Land Office to take relinquishment land royalties in-kind. Provisions for limiting exportation of oil and gas produced from public lands should be considered: specifically, the legislature should provide in future state leases a continuing option for the state to take all or part of the oil and gas produced from state wells by paying the prevailing market price. However, particular attention should be paid to possible challenges to similar legislation in New Mexico and Louisiana.

INCREASING PRODUCTION ON PUBLIC LANDS

When oil was discovered in 1921 on state lands under lease, the public land became a most valuable economic asset to the State of Texas. Today income from leases for oil and gas production on state-owned lands is a major source of revenue for various state funds; the Permanent School Fund alone receives an average of $2.5 million per month in royalty payments.[14] State oil and gas income can be increased by revising leasing provisions. Exploration and production should be encouraged through variable royalty bidding and by unitization of oil and gas fields.

Present Leasing Practices

The public lands of Texas are owned by various departments and agencies of the state. In each agency controlling state lands, a "board for lease of lands" is charged with the responsibility for leasing. All lands, or any parcel, may be leased for oil and gas production by the appropriate agency board, but actual leasing arrangements are handled by the General Land Office.

Whenever in the opinion of a board there is demand for the purchase of oil or gas leases on a lot or tract of land subject to control of the board, such leases may be offered for sale. Oil companies and/or individuals may nominate specific state-owned acreage. Nominations are reviewed by the exploration and development division of the General Land Office.

The leases are sold to the highest bidder at scheduled sales in the General Land Office. At these sales, oil

companies and individuals bid competitively for the right to lease a tract of land for a specific period, usually three to five years. Bidding is by sealed bid, and a separate bid is made for each tract offered for lease. At its discretion, each agency board for lease may either fix the royalty and provide for bidding on the basis of the highest cash bonus offered, or it may fix the cash bonus and provide that the bidding be on the basis of the highest royalty offered. A board has the right to reject any and all bids. However, if a board does not reject any bids, the highest bid must be accepted.[15]

If actual oil or gas production results, the producer pays the state a royalty of the gross production. Regardless of the bidding method, no bid may be accepted which offers a royalty of less than one-eighth of gross production, or offers a cash bonus of less than $2.00 per acre. Minimum bonus and royalty may be increased at the discretion of each agency board.[16]

Boards for lease have adopted the bidding policy of highest cash bonus offered. State minimum royalty has been set at one-sixth of gross production. However, in March 1974, the School Land Board for lease increased the minimum royalty for lease of public school lands to one-fifth of gross production and the minimum lease period was reduced from five to three years. The changes in terms for oil and gas leasing are designed to give Texas a higher royalty interest and income, and to encourage drilling on state lands. The revised provisions may be expected to become state policy for all new leases.

With few exceptions, all nominated state lands are offered for lease. This is quite different from the federal policy of auctioning only a small portion of its nominated lands. State boards for lease also lease small parcels of lands, including submerged acreage, for oil and gas exploration. The smaller tracts reduce the size of the necessary bonus bid and, therefore, the size of the initial investment, making the market for state leases more competitive by allowing the small developers to compete in lease bidding.

Increasing Production

Production of oil and gas on public lands can be increased by variable royalty bidding and by unitization of oil fields.

1. Variable Royalty Bidding. In order to encourage greater exploratory efforts on state lands, the boards for lease should adopt the variable royalty bidding method. By this method, competitive bidding occurs in terms of the percentage of the royalty to be paid to the state, if production results. Instead of paying a bonus for the right to explore state lands, oil companies or individuals would simply pay a filing or bid fee and a nominal bonus for the right to explore state lands. This method reduces the initial costs and risks for the lessor which exist under the bonus bid method. By variable royalty bidding, the state assumes part of the risk of exploration because no revenues accrue to the state unless oil or gas is discovered. However, total state revenues should actually increase as new reserves are discovered and developed through greater exploration. Texas benefits also from higher royalty interest and income. Increased in-kind royalties may be sold for higher intrastate market prices.

2. Unitization. In order to increase secondary and tertiary recovery of petroleum and natural gas, public acreage should be included in any law which requires majority-consent unitization. If state lands are excluded, the effectiveness of a unitization law will be greatly reduced in areas where state holdings are extensive.

IMPROVED RECOVERY METHODS

Primary petroleum recovery methods extract between 20 and 30 percent of the oil from underground reservoirs, leaving more petroleum underground in each reservoir than is produced. The recovery of the remaining oil would significantly increase energy supplies of Texas and of the nation. The following section emphasizes the need for secondary and tertiary recovery of oil in Texas; it describes several improved recovery methods and reviews the arguments surrounding majority-consent unitization of oil fields.

Petroleum Recovery

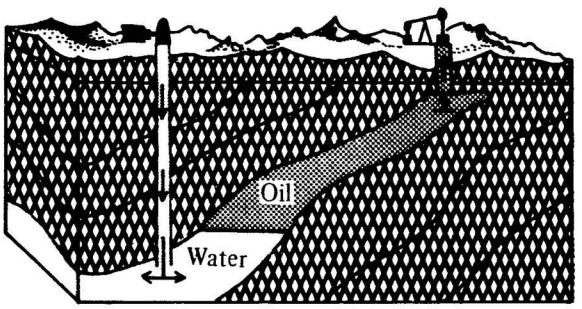
Petroleum recovery is dependent largely on pressure in the reservoir containing the oil. This pressure is generated by water or natural gas. Where it is water that coexists with oil in a reservoir, the oil is floated to the top because of its lower specific gravity. Natural gas, on the other hand, concentrates the petroleum at the bottom of the pool. In either instance, a well bore provides a point of least pressure toward which the oil flows. (Figures 5-1 and 5-2 illustrate water-drive and gas-drive reservoirs, respectively.) When crude oil is taken from a reservoir, the pressure differential between various parts of the reservoir declines as the water or gas escapes. Once the pressure falls below a certain level, recovery of petroleum from that reservoir by primary methods is severely limited.

Another problem which develops in the recovery of petroleum is the scattering of the oil. As a reservoir is developed by several producers, a single pool of oil may be separated into many smaller pools. The reservoir's water and gas pressure cannot then be adequately utilized for recovery of the scattered oil pools and continued production becomes difficult or impossible. The scattering effect is illustrated in Figure 5-3.

Several methods of regenerating pressure have proven effective for extracting reserves after primary recovery

FIGURE 5-1

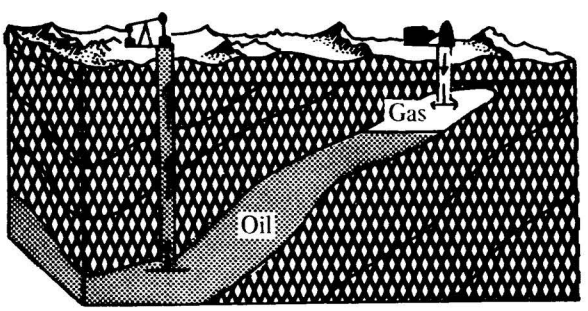
WATER-DRIVEN OIL RESERVOIR



Source: The Texas Conservation Committee for Unitization, December 1972.

FIGURE 5-2

GAS-DRIVEN OIL RESERVOIR



Source: The Texas Conservation Committee for Unitization, December 1972.

methods are rendered useless. These secondary and tertiary recovery methods can serve also to combat the scattering effect.

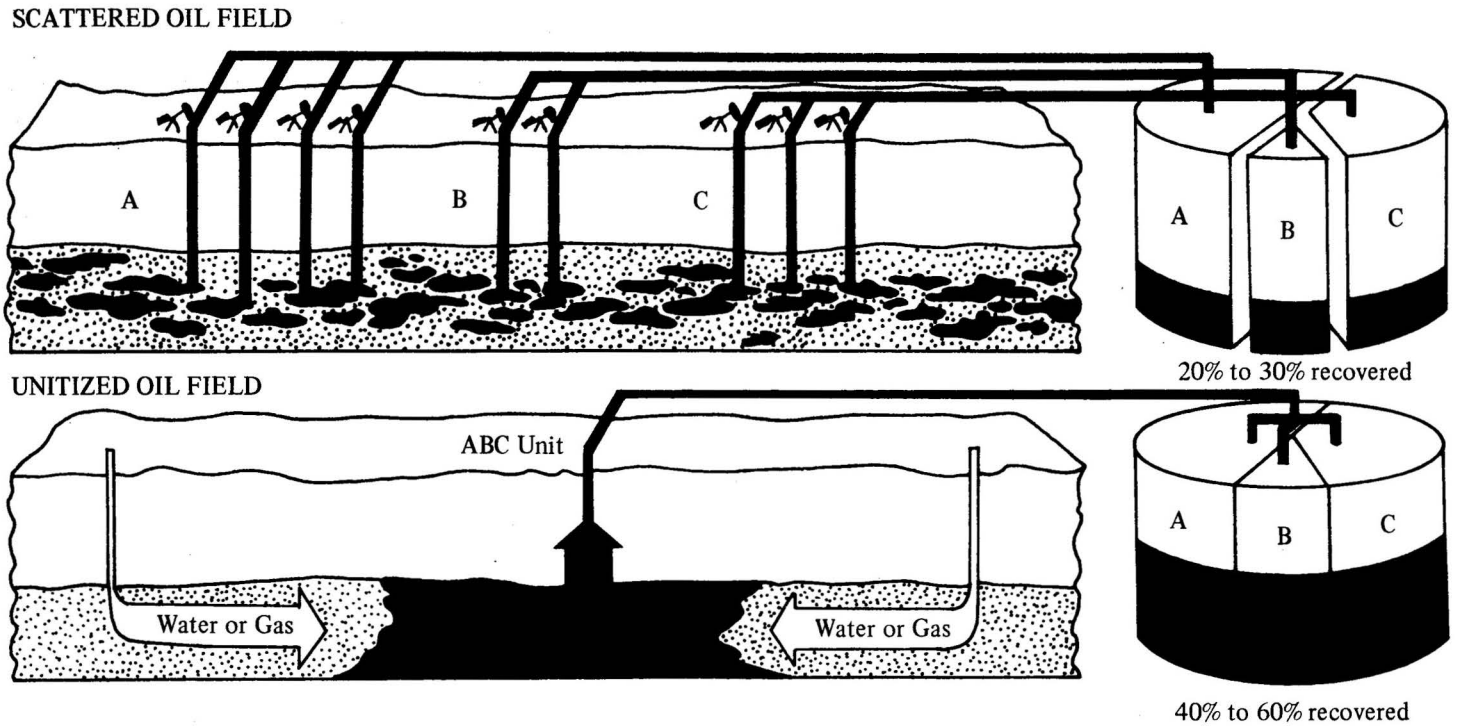
The Need for Improved Recovery

The discovered oil fields in Texas are estimated to have originally contained 146 billion barrels of petroleum. As of 1972, 35 billion barrels of that total were produced, leaving some 111 billion barrels in the ground. Of the remaining reserves, only 13 billion barrels are considered recoverable by primary methods. The remaining 98 billion barrels will be unused unless secondary and tertiary recovery methods are implemented.[17]

Of those nearly 100 billion barrels, the amount which could be recovered through the use of improved recovery methods cannot be quantified. Each reservoir possesses different characteristics and the gains to be made by utilizing improved recovery methods vary from reservoir to reservoir. In general, however, improved recovery methods can be expected to yield a 40 to 60 percent rate of recovery, as compared with the 20 to 30 percent rate shown by primary recovery methods. Based on results achieved in limited use of improved recovery methods, an

FIGURE 5-3

SCATTERED AND UNITIZED OIL FIELDS



Source: The Texas Conservation Committee for Unitization, December 1972.

additional 30 billion barrels could be expected from discovered oil fields.[18] In other words, if improved recovery methods are used, more oil is still to be produced in Texas than has been recovered since the beginning of oil production in the state.

Improved Recovery

Several secondary and tertiary methods have been demonstrated effective for increasing the recovery of petroleum.

1. Waterflood. Waterflood is probably the most frequently utilized recovery method and is also one of the simplest. Water is pumped into the ground to replace the pressure lost when oil is extracted. This method concentrates the oil at the top of the pool so that it may be recovered by strategically located wells. (See Figure 5-1.)

2. Gas Injection. The principle involved in gas injection, as in the waterflood method, is to increase the pressure driving the oil. However, gas forces the oil down instead of up, and pressure then pushes the oil up a well bore. (See Figure 5-2.) Some circumstances warrant the use of both water and gas in order to capture the oil.

3. Miscible Treatment. In many cases oil is considered irrecoverable because it is actually imbedded in the grains of rock. If liquefied petroleum gases are injected into a reservoir, the oil can sometimes be loosened from the rock. The separated oil can then be recovered by using a waterflood to force the oil toward a producing well.

4. Fire Flood. By far the most exotic improved recovery method is the fire flood. When the oil in a particular reservoir is too thick, the flow is not adequate for profitable production. If this heavy, sticky oil is ignited in place, temperatures and pressures are increased in the reservoir, thinning the oil and improving the flow toward the well bore.

5. Other Methods. Several other improved recovery methods are in the development stage. One process under study is the injection of chemicals into a reservoir to mix with the oil to make it flow more freely.

The environmental effects of improved recovery methods vary, depending upon the method employed and characteristics of reservoirs. A few general statements can be made. Air pollution should be negligible from the use of any of the described methods, with the possible exception of the fire flood. Improved recovery can actually improve

land-use patterns by allowing for the dismantling of the majority of wells in an oil field. The injection of fresh water or natural gas into an oil reservoir is usually environmentally safe, but injection can cause land shifts, and pollution of surface and ground waters may also be a problem. To be sure, the improved recovery method to be used in each reservoir should be carefully chosen. Attention must be given to prevention of possible environmental damage: if proper safeguards are utilized, the environment can be protected.

Unitization

In order for the improved recovery methods to be utilized in an oil field, the field must be operated as a unit. When a field is unitized, one operator must be designated to implement whatever methods are agreed upon. Improved recovery requires that wells be carefully placed to maximize possible production; if several operators drill wells, the necessary pressure for recovery may be reduced scattering the petroleum into small pools once again and making recovery of the oil difficult if not impossible.

Unitization is also required for proper development of reservoirs of oil. In many instances, a reservoir can be developed beyond the point at which improved recovery methods prove beneficial. For this reason, a small minority of lease holders should not be allowed to impair the proper development of an oil field.

When an improved recovery method is used in a field, most wells in that field will cease production entirely because the oil will be forced toward a few wells which will experience production increases. (See Figure 5-3.) For reasons of equity, profits should be shared on a field-wide basis by a formula which insures every owner the amount which could have been expected without unitization, plus a fair share of the revenues from the overall production increases.

Voluntary unitization has been legal in Texas for many years. If all lease owners in an oil field agree to operate the field as a unit, the Railroad Commission will authorize unitization. However, if one owner disagrees with the proposal for any reason, the unitization effort can be blocked. Obviously, if an owner is fortunate enough to be pumping oil from a rich pool, it is not likely he will agree to unitization of the field.

Several states have enacted majority-consent unitization laws, requiring that a field be operated as a unit if a designated percentage of lease owners and operators in the field agree. The percentage required for unitization varies from state to state; Tennessee, with 50 percent, requires the lowest.[19]

Those who oppose majority-consent unitization in Texas believe that it is an infringement on individual rights, and smaller operators opposed to majority-consent unitization fear that the major oil companies will gain excessive amounts of economic power. It is true that a small minority of owners and operators may have the will of the majority imposed on them in unitization agreements, but if 75 percent agreement is required, the resolution of conflicts should be simplified. To protect against an inordinate increase in the economic power of the major oil companies, the state would have to monitor closely all operations in unitized fields. This function should be assigned to the Texas Railroad Commission or to an appropriate agency as determined by the legislature.

As previously mentioned, the gains to be derived from the implementation of improved recovery methods are significant. Secondary and tertiary recovery methods should be used in every discovered oil field whenevery desirable. Improved recovery methods should be utilized reservoirs to insure proper development. The necessity for a majority-consent unitization law is also apparent. The legislature should enact such a law, providing for the operation of an oil field as a unit if 75 percent of the field operators and 75 percent of the royalty owners agree to the unitization.

INCREASING IMPORTS

Most authorities agree that the United States will need to import a large percentage of its crude oil supply in the near future. By 1985 the necessary imports may be in the range of 50 percent of United States consumption.[20] Consideration should be given to determining the most efficient means of transporting this oil, with the least adverse effect on the environment. Supertankers and an offshore terminal may be a means of increasing crude oil supplies for Texas.

Tankers and Port Capabilities

The average size tanker in the world today is 47,000 deadweight tons (DWT). Several countries are replacing these relatively small tankers with larger ships which can carry crude oil at less cost. The average supertanker now under construction exceeds 200,000 DWT, and tankers of 700,000 DWT are planned.[21]

The U.S. tanker fleet has remained small because the shallow waters of ports in this country limit the draft of tankers which can be handled. The maximum size vessel which Gulf or East Coast ports can admit is 80,000 DWT, and West Coast ports are capable of admitting vessels of 100,000 DWT.[22] Under present port constraints, the United States is unable to take advantage of the savings available through use of supertankers for importing crude oil.

Supertanker Savings

Use of the supertanker can cut costs because of economies of scale. The crew for a 500,000 DWT tanker is virtually the same as for a tanker of 47,000 DWT.[23] This is possible because the larger tanker can take advantage of automated equipment. Savings are realized in fuel costs, insurance rates, construction costs, and in repair and maintenance expenses, too.

If 47,000 DWT tankers are used, our 1985 import needs will require 2,700 vessels. With 250,000 DWT tankers and an offshore terminal, only 525 tankers would be necessary to handle America's petroleum imports.[24] Andrew E. Gibson, former Assistant Secretary of Commerce for Maritime Affairs, has estimated that the savings available through use of the supertanker would be $2 billion annually by 1985.

Presently, over 50 foreign port facilities capable of handling vessels of 200,000 DWT are in operation, under construction, or planned.[25] Plans for such facilities in the United States have been successfully challenged and defeated, resulting in the decision by major oil companies to establish new deepwater ports in the Bahamas and Canada. This location of petroleum facilities will affect both our defense capability and our balance of payments, and petroleum prices for the American consumer will also increase.

Environmental Effects

An offshore terminal could serve to reduce dangers of environmental pollution. In the year 1969-70 nearly five million tons of oil polluted the world's oceans as a result of tanker mishaps.[26] A study of these accidents indicated that supertankers "can transport a given quantity of oil over a given distance some seven times safer than tankers below 80,000 DWT, from a viewpoint of tanker casualties and subsequent pollution."[27] Analysis of the accidents showed that 49 percent of the pollution resulted from structural failures, 29 percent from groundings, 8 percent from explosions, 8 percent from collisions, and the remaining 5 percent from fires and breakdowns.[28]

The majority of structural failures occur in tankers 12 to 24 years after launching. Tankers between 15 and 19 years of age have a probability of structural failure five times that of tankers less than 12 years of age.[29] The use of the modern supertanker, which replaces up to 10 conventional tankers, could substantially reduce the oil pollution caused by structural failure. There should be a thorough inspection, with complete reclassification and recertification, of every tanker reaching 12 years of age.

Pollution due to tanker groundings would be lessened with the use of an offshore terminal because the tanker would rarely, if ever, have to venture into shallow water. Oil pollution due to tanker collisions could be reduced also if an offshore terminal were constructed. Of the 82 tanker collisions which resulted in ocean pollution in the year 1969-70, 78 occurred in harbors or coastal areas.[30] The use of a superport, located offshore and away from the congested traffic areas of busy Texas ports, would ease the congestion in the ports and reduce substantially the possibility of collisions involving supertankers. Should an oil spill occur at a terminal off the Texas coast, more time would be available to contain the spill before it reached the important estuarine and marshy environment of the coast. Should a spill occur in today's crowded harbors or along the coast, damage to the Texas coastal areas could be immediate and extensive.

The U.S. Corps of Engineers has summarized its research of superports by concluding that an offshore terminal would have "less direct impact environmentally than the other systems (the present policy or a dredged channel); (and) that environmental damage from offshore oil spills would be minimal in comparison to a spill in the near shore waters, estuaries or marshes."[31] Herbert C. Kelleher, counsel for Save Our Texas Bays and Beaches, has praised the concept of an offshore terminal, saying that it "follows our conclusion that an offshore facility will best satisfy our economic and environmental requirements."[32]

Refining Capacity

The problem inherent in increasing Texas refinery capacity is primarily one of crude supply. Whereas factors such as restrictions on land usage and environmental ordinances tend to slow the building of refineries, the chief concern of a refinery owner is access to a stable flow of crude oil. Unless there is a reasonable guarantee of such a supply, investors will not be willing to spend the huge sums necessary to build a refinery.

A national policy of energy self-sufficiency by 1980 has been announced by the White House. While there is a reasonable basis for doubt as to the attainability of such a goal by that time, one result of such a policy—the reduction of imported crude oil—would have an effect on the expansion of domestic efining capacity. What seems likely to happen, however, is a continued reliance on foreign crude well beyond the 1980s, and the growth of refineries in areas with access to this crude.

Should domestic crude replace foreign crude sources in the distant future, refining centers will likely remain in their present locations because the costs of transporting the crude within the nation would be cheaper than building a new refinery/pipeline/storage complex. Thus, decisions made in light of near and mid-term expectations could influence the long-range location of refineries as well.

Refining plays a major role in the Texas economy. The

jobs attributable to refinery operations in the state have made an immense contribution to the economic growth of the state, but they will continue to do so at a decreasing rate unless adequate provisions are taken to sustain and expand existing refining systems.

In 1970 our national refinery capacity was approximately 11 million barrels per day, with Texas refineries accounting for approximately 25 percent of the total. By allocating the projected national demand for refinery products among existing refinery centers, it is anticipated that by the year 2000 refinery capacity will have to expand from 3.2 million Bbls./day to nearly 9 million Bbls./day.[33] This projection assumes the continuing availability of crude oil.

Studies have shown that employment in industries related to refining has gained 38 new jobs for every 5.5 new refinery employees. Employment in the new refineries will be approximately 14,600 by the year 2000, with the total employment increase, including that of related industries, estimated at 114,145 by 2000.[34] This increase will be made possible if sufficient crude is available to supply the new refineries.

Studies by the Office of the Governor, Division of Planning Coordination, have shown that for every dollar of output of refined petroleum products, $1.93 is generated in the state economy from related activities.[35]

Should refineries not have the necessary crude to maintain the state's percentage of national refinery output, a loss can be projected of $4.5 billion/year by the year 2000. Wages from the construction of the refineries are expected to total $77 million annually in the period 1975-1980 and $30 million/year from 1981 through the year 2000.[36]

With the aid of the Texas Input/Output Study prepared by the Office of the Governor, the "spin off" from these construction costs can be calculated. The studies show that $3.22 in total commerce is generated for each dollar spent in refinery construction. New refinery construction will generate approximately $1,772,000,000 in total benefits to the state economy from 1974 through 1980, and $690,000,000 from 1981 through 2000. These figures represent the economic effect on Texas should the refineries be built to maintain the state's share of total national refining capacity.[37]

These refineries will be built only if they are assured a supply of crude oil. A practical way to assure this supply, and thus to increase Texas refining capacity, is to build an offshore terminal for supertankers. If Texas does not have such a terminal, the refineries will, in all likelihood, locate in proximity to such a facility somewhere else.

Crude oil prices are increasing. Texas crude production has peaked and it is likely that it will ebb slowly in the future. If Texas wishes to maintain the economic benefits it derives from its refining industry, it must take steps now to insure their future presence. Refineries are an integral part of the Texas economic system. Their historical presence in Texas will be jeopardized with the lessening of crude production in Texas and the advent of the supertanker. If an offshore port is built on the Texas coast, Texas will continue to enjoy its position as a national refining center with the resultant economic benefits.

A Texas Offshore Terminal

The Texas Offshore Terminal Commission was established by House Bill 52 of the 62nd Legislature, Fourth Called Session. The commission was charged with the task of preparing a plan leading to the development of deep draft harbors or terminals for Texas. In discharging this responsibility, the commission heard testimony in public hearings from environmentalists, labor leaders, private citizens, and experts in engineering, finance, and international law. After several months of research and public testimony, the commission issued its report calling for an offshore terminal to be built off Brazoria County.

1. Alternatives. The commission did consider alternatives to a superport off the Texas coast, such as dredging present harbors deep enough to accommodate the supertanker. That was found to be more expensive than an offshore terminal and less environmentally desirable. The process of large-scale dredging disrupts the seabed and causes silting with resultant damage to fisheries. Dredges must dump the fill somewhere, usually farther out in the ocean. When the fill is dumped, disruption and damage to the environment may result.

A second alternative considered by the commission was a deep water port in the Bahamas. By this plan supertankers would deposit their petroleum in storage tanks in the Bahamas, and the fuel would be shipped to the Texas Gulf Coast via smaller tankers. Such a proposal is impractical because the additional handling of the oil from a supertanker to an onshore tank, and then to smaller tankers, adds to the risk of an oil spill. Moreover, the additional activity that the smaller tankers would impose on harbors and coastal areas increases the probability of collisions and groundings.

2. Site. An area 25 to 30 miles off Freeport in Brazoria County offers a favorable site for an offshore terminal for Texas. Freeport does not have an appreciable barrier island structure and associated estuary which would be disturbed when petroleum pipelines are laid from shore to the facility. A study conducted under the supervision of Professor C.M. Walton of The University of Texas concludes that the Freeport site is the most attractive environmentally.[38] The Texas Offshore Terminal Commission concurs in the choice of site location.[39]

Location at Freeport would place the terminal near the Texas refining complex and close to the existing onshore pipeline network. Water depth at the site is 95 to 105 feet and the danger of grounding is minimal. The site is four miles from existing sea lanes, providing the tankers with easy and safe access.

3. Structure. A practical type of offshore terminal facility is the monobuoy, basically a floating platform anchored to the ocean floor and connected to onshore storage tanks by an undersea pipeline. The tanker connects its hoses to the platform and the oil is pumped to the storage tanks onshore.

Construction of an artificial island has been proposed as an alternative to the floating monobuoy facility. Such islands are appropriate if the offshore terminal is to be designed to handle bulk cargo as well as petroleum. However, an island requires a long lead time, is more expensive than the monobuoy, and disrupts the environment. There would also be congestion around such an offshore terminal, increasing chances for collisions and oil spills.

The advantage of the monobuoy over a fixed island structure is that a tanker may orient itself to the condition of the wind, waves, and current when docking at the floating platform. The vessel is free to move according to the least resistance and there are no artificial stresses imposed on the hull by the action of the sea, forcing the tanker against a wharf or pier.

4. Private v. Public Ownership. The question of who should own the proposed offshore terminal, the state or private interests, has generated considerable debate. SEADOCK, Inc., a Texas corporation formed by a consortium of oil companies and one pertrochemical company, as well as others, has testified in favor of private ownership of the terminal (see Appendixes 1 and 2). SEADOCK has spent $2.6 million over the past two years for planning and environmental studies of the terminal.[40] Its members feel that a private terminal can offer the same services as a public terminal, while not necessitating state ownership of such a massive business venture. Supporters of a private terminal believe the facility could be constructed sooner and operated more efficiently than if owned by the state. They argue that state regulation would insure the maintenance of proper environmental safety features in the private terminal while not forcing the state to take responsibility for a $400 million project.[41]

The Texas Offshore Terminal Commission has recommended that a deepwater port be owned by the state and operated by a state agency (see Appendix 3). Those favoring public ownership feel that only through the state can the best interests of the people be served and the best method of ensuring a positive plan for environmental protection be provided. They feel that this method preserves the traditional position of ports as public-purpose facilities and results in a facility which best serves the public interest. Additionally, the public terminal, because of the absence of the necessity for a profit, would result in lower tariffs to the users and hence, lower eventual costs to the consumer.

The State of Texas needs an offshore terminal because the facility would furnish the best means for importing crude oil to meet the needs of the refining industry in Texas. An offshore port would enable the state to take advantage of the savings available through use of the supertanker. The terminal should be publicly owned and regulated because that method apears to have the advantages needed to provide necessary environmental safeguards and to serve the interests of consumers and citizens of Texas.

CONCLUSION

In order to meet energy demands, Texas must increase oil and gas supplies in the state. Constitutional restrictions preclude the limitation of exports, but the state can encourage production on public lands through state leasing provisions. Variable royalty bidding for state leases can encourage exploration for new fuel reserves. Production throughout the state can be improved by extensive use of secondary and tertiary recovery methods, but improved recovery will require majority-consent unitization of oil fields. In order to import crude oil to meet the expanding needs of the state, Texas should approve construction of an offshore terminal to handle supertankers. By these methods, Texas can move to prevent significant shortages of oil and natural gas in the state.

RECOMMENDATIONS

1. ***In-kind relinquishment land royalties.*** The legislature should authorize the state to take Relinquishment Act land royalties in-kind.

2. ***State oil and gas lease option.*** In future state leases, the legislature should require an option for the state to take all or part of the oil and gas produced from state wells by paying the prevailing market price.

3. ***Variable royalty bidding.*** The boards for lease of state lands should be required to conduct the sale of leases for oil and/or gas production according to the variable royalty bidding method.

4. ***Majority-consent unitization.*** A majority-consent unitization law should be enacted. An oil field should be operated as a unit if 75 percent of the field operators and 75 percent of the royalty owners agree to the unitization of that field. Payments to royalty owners should be made according to a formula which insures to every owner the

amount which could be expected without unitization, plus a fair share of the revenues from the overall production increase.

5. ***Unitization of state lands.*** State lands should be included in the scope of any majority-consent unitization law passed by the legislature.

6. ***Construction of an offshore terminal.*** **The legislature should approve the construction, with proper environmental safeguards, of an offshore terminal.**

7. ***Public ownership of the offshore terminal.*** **The offshore terminal should be publicly owned and regulated.**

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CHAPTER SIX

POWERPLANTS: THE USE OF LAND AND WATER

INTRODUCTION

Land and water are ancillary energy resources utilized in the operation of powerplants. These resources are affected by the construction and operation of electric utilities. This chapter examines the relationship of land and water in the generation of electricity and proposes state actions that would help to insure an adequate electric power supply while protecting land and water resources.

POWER GENERATION IN TEXAS

Electricity produced in Texas is heavily dependent upon steam-generating equipment. In 1973 steam accounted for about 97 percent of all power generation, with hydro and combustion turbines making up about 1 and 3 percent, respectively.

Hydroelectric Plants

Hydroelectric power is produced by converting to electric energy the potential energy of water at a higher elevation by passing the water through hydraulic turbines at lower levels. In such a process, water is used but not consumed. Because of the large volume of water and heat needed to produce bulk power, there are relatively few sites remaining in Texas for hydroelectric plant development.

Steam-Electric Plants

In a steam-electric powerplant water is converted to steam, which expands through a turbine and turns a generator to produce electricity. With current technology, the best thermal efficiency* of steam-electric plants is about 40 percent. Nuclear powerplants have about a 33 percent efficiency. The higher the temperature and pressure of the steam, and the less its moisture, the greater the efficiency. Water is used in steam-electric plants, whether fired by fossil or nuclear fuel, as both steam to drive turbines and as a coolant to condense the steam.

*Thermal efficiency is the quotient of the plant electrical output, expressed in B.t.u. divided by the heat input in B.t.u.

1. Water for Generation. The Electric Reliability Council of Texas (ERCOT) is composed of utilities representing 85 percent of the electric capacity of the state.[1] Major utilities not in ERCOT are: El Paso Electric Company, Gulf States Utilities Company (Beaumont), Southwestern Electric Power Company, Southwest Public Service Company (Amarillo), the City of Lubbock, and the City of Brownsville. In 1971, the total statewide kilowatt capacity was about 22,000 megawatts.[2] As of June 1974, the ERCOT members alone had a net generating capacity of 30,208 megawatts. ERCOT supply by 1985 is expected to reach 61,367 megawatts.[3] This amount of additional electricity will require 59,050 acre-feet of surface water (calculated at 1.5 acre-feet of surface water for every megawatt generated).[4]

2. Water for Cooling. Water is used in a cooling process to condense steam, thereby increasing the temperture of the cooling water. The typical Texas powerplant increases the temperature of its condenser water by about 15 degrees Fahrenheit. In fossil-fueled plants 35 to 40 percent of the heat produced is converted into electricity, 15 percent is lost through the stacks or dissipated within the plant, and 45 percent is discharged with the condenser cooling water. However, in a nuclear-fueled plant 62 percent of the heat is discharged with the condenser cooling water, 5 percent is dissipated within the plant, and 33 percent is converted into electricity. Nuclear plants also discharge about 50 percent more waste heat into the condenser waters than fossil-fueled powerplants producing an equal amount of electricity. The amount of water required for cooling depends upon the heat rate of the plant and the permissible water termperatures as set by the Environmental Protection Agency (EPA). A fossil-fueled plant requires about 130 quarts per second per kilowatt-hour for cooling, but a nuclear-fueled plant requires about 190 quarts per second per kilowatt-hour.[5]

For a utility, a once-through cooling system which takes water from a river and returns it to the river at a higher temperature is desirable. Because Texas does not have rivers than can supply a sufficient quantity of water for a once-through system, almost all utilities use cooling systems

that take water from a reservoir and return it to the reservoir for reuse.

There is considerable public concern over the potential adverse environmental effects of reservoir cooling systems. The impact of waste heat can be beneficial or detrimental depending upon the amount of heat and the characteristics of the natural environment.[6] Assessments of environmental impact caused by waste heat discharges must be evaluated in light of the conditions at particular locations and at downstream receiving waters.

Land Requirements of Electric Utilities

Decisions about the siting of generating facilities must take into account topographical, geological, soil, and foundation conditions, extremes of weather, proximity to load centers and transmission systems, land costs and availability, and the cost and ease of transportation of fuels and services. Nuclear plants require a careful consideration of site geology, hydrology, and meteorological conditions in order that installations may be protected from the dangers of earthquakes, floods, and other violent weather conditions. These facilities also require sizable open areas surrounding the plants and must not be located too near population concentrations. Gas- and oil-fueled plants require relatively small sites of 100 to 350 acres. Plants using coal require additional land for fuel storage and ash disposal, whereas nuclear plants require more land for safety and public protection. A principal difficulty in the siting of powerplants and transmission systems is the incompatibility of these facilities with competing land uses. The number of potential sites is narrowed even further by the need to find land suitable for the construction of a cooling pond where once-through cooling systems are not feasible. Proximity to load centers is also an important factor if energy losses in transmission are to be minimized. A sizable parcel of land meeting these criteria often has a number of competing potential uses. In the part of Texas which has the most abundant water, East Texas, potential powerplant sites are highly valued as timberland, agricultural lands, or park areas.

There are 15 million surface acre-feet of water in reservoirs throughout the state, and one out of every four reservoirs is used all or in part for electric generation. To continue to supply adequate volumes of water requires continued development of the state's waters; such development can be most effective if there is a long-range planning process for electrical generation which would identify major users of energy and locate suitable sites. At present, there is no agency that plans for the siting or development of electrical powerplants.

FEDERAL POWERPLANT POLICIES

There is no overall federal powerplant siting agency. Instead, there are a number of agencies, each having certain permitting functions. The most important federal agencies involved in regulating aspects of electrical generation are the EPA, the Atomic Energy Commission (AEC), the Army Corp of Engineers (COE), and the Federal Power Commission (FPC). The AEC grants permits for the construction and operation of nuclear powerplants, the COE issues permits for dredging and filling operations on navigable streams and waterways, the FPC grants licenses for non-federal hydroelectric facilities that affect navigable waters and regulates production of electricity for interstate transmission (although it does not review any of the rates charged by Texas companies). The EPA sets water and air quality standards.

Of the four agencies, the EPA has the most comprehensive control over the use of water for electrical generation because the agency has a responsibility to protect the environment. Electrical generation affects the temperature of water and may have adverse effects upon ecosystems. The focus of EPA policies is not on encouraging or guaranteeing that water used for generation will be returned to streams and rivers, but rather on seeing that if the water is returned, it will not be at a temperature that would damage the ecosystem.

The Land Use Policy and Planning Assistance Act, S.B. 268, has passed the Senate, and the House is presently considering a similar bill. Directed at assisting state and local governments to develop land-use planning capabilities, it concerns particularly areas of critical environmental concern, the location of key facilities, and large-scale developments. The bill provides a basic framework for comprehensive land-use planning on the state level, and it outlines many elements of a land-use planning effort, allowing a broad range of organizational options. Although it does require the establishment of a state-level planning agency with an intergovernmental advisory council of local representatives, the method and level of program implementation may be determined by the state. The bill describes a number of conditions which require control but does not mandate specific actions or techniques: each state is free to develop the planning structure and range of controls best suited to its own land-use goals and objectives. The bill does, however, require a method of assuring state and local program consistency with state land-use objectives. This requirement is especially important for Texas because coordination of land-use activities has often been difficult, if not impossible.

There is an increasing interest by the Congress in creating a central powerplant siting agency. S.B. 935 outlines the functions required to provide 10-year public notice of utility plans to secure the timely construction of powerplants. Although the bill calls for public review, citizen participation is not required, and public hearings are not to be held on individual site decisions except in cases of significant public controversy.

The proposal provides considerable detail about requirements to include the comments of state agencies in the decision-making process. In that way, the particular expertise of certain agencies is recognized, although the primary responsibility for siting decisions is centered in one agency. The bill allows each state to place the siting responsibility in an existing agency or to create a new one for this purpose, and there are no specific organizational requirements beyond those of a state-level mechanism for considering the comments of other state agencies. If this bill is passed, the state may respond by placing this powerplant siting function within an existing agency, into a land-use planning agency, or into a new single-purpose organization.

The powerplant siting bill provides for the Secretary of the Interior to perform the required functions if a state fails to establish an acceptable state vehicle for these responsibilities. It is unlikely that many states will allow, by default, such federal encroachment. In the case of the land-use planning legislation, federal incentive is provided by the availability of 90 percent funding for the program during its first five years. Although an amendment to penalize non-participating states failed, its consideration by two successive Congressional sessions suggests a significant alteration in federal policy. Coupled with the availability of large grants for planning and implementation, this shift in position may encourage a number of states to begin land-use planning rather than risk more forceful federal action later.

The EPA was directed by the Federal Water Pollution Control Act, as amended, to establish guidelines concerning cooling water intake structures: "... any standard established pursuant to section 301 or section 306 of this Act and applicable to a point source shall require that the location, design, construction, and capacity of cooling intake structures reflect the best technology available for minimizing adverse environmental impact." The EPA must also set thermal pollution control regulations, which have not yet been established. By the terms of the act, the EPA can enforce its standards through its veto authority over all or part of a state's permit program, as well as over individual permits, and it has the authority to require powerplants to install closed-cycle cooling systems, either through the use of cooling towers or cooling ponds.

Cooling Ponds

Cooling ponds and lakes are used mainly in areas where land is relatively inexpensive and there are not abundant water supplies to dissipate heat. The area of land needed for a cooling pond is about 1 acre of pond and 10 acres of drainage area for each megawatt. The ponds also lose water through evaporation. A cooling pond may be cheaper for the utility than other methods available.

Cooling Towers

There are two types of cooling towers, evaporative and dry. The technology for the dry cooling tower has not been sufficiently developed to be of wide use, especially for the large steam-electric plants. The other, and most common method of cooling, is that done by the evaporative cooling tower. With this method, heat is dissipated through water evaporation and carried away by the wind. One environmental effect of the process is the discharge of large amounts of water vapor near the ground. If the cooling water contains chemicals, there can be biological damage; that problem is even more relevant for cooling towers using sea water because the salt content may do corrosive damage to structures, equipment, and land. Since cooling in this structure is done by evaporation, huge volumes of water are lost from the water source.

The power needed to pump the water through the system and the increased cost of generating power are further factors to be considered when cooling towers are used. Currently, very few of the major powerplants in Texas use cooling towers.

1. The Use of Cooling Towers. In the past, federal policy encouraged multi-purpose projects. In addition to providing water for cooling, these projects were used for fishing, flood control, irrigation, and recreation. However, in view of its commitment to the protection of water quality, the EPA is unofficially encouraging the use of cooling towers rather than cooling ponds. Because of evaporative losses, cooling towers significantly decrease the return flow of water, which may affect water users downstream and may prove costly to the water resources of the state. It should be noted that there is a great distinction between allowing water to be used for cooling and then returned to the source from which it came, and allowing water to be entirely evaporated. The latter produces a greater cost to the state's water supply. Since about 17 percent of the electric-generating capacity of Texas involves cooling towers, encouragement of the use of cooling towers should be carefully analyzed.

2. The Use of Marine Water for Cooling. The EPA sets the same water-quality criteria for both fresh and salt water when used for cooling purposes. Such a policy provides no incentive for the use of salt water and salt water is used when fresh water is unavailable. Moreover, marine water is not used often because of its corrosive character, and because in the past, powerplants have had ample access to fresh water. As fresh water becomes scarce, however, powerplants will be forced to use salt water for cooling, but it is generally advisable to encourage the use of marine water so that fresh water may be conserved for other uses. The EPA has not encouraged this practice.

A number of benefits can be derived from withdrawing

salt water for use in a once-through system, and returning it with a slight increase in temperature. Where feasible, salt water should be used rather than fresh water, allowing appropriation of fresh water to other users. A once-through system would not necessitate cooling towers, and evaporation of huge volumes of water and the depositing of salt on land would be avoided. It should be noted that there are sites in Texas suited to the use of marine waters, such as Galveston, Matagorda County, and Corpus Christi.

STATE POWERPLANT POLICIES

At present, Texas has no state agency with the authority to regulate electric companies or to plan for the supply of electricity. The state exercises minimal control primarily through the permitting functions of the Texas Water Quality Board, the Texas Air Control Board, and the Texas Water Rights Commission. Municipalities regulate the operation of non-nuclear powerplants and set their rates.* The state does prohibit discrimination in rates, prices, and services. The Texas Air Control Board grants construction and operating permits. The Texas Water Rights Commission grants appropriative water rights to powerplants, and the Texas Water Quality Board grants a permit for thermal discharge into the waters of the state. It should be noted that although a number of state agencies are involved in permitting, there is no uniform or comprehensive certification and planning process.

As discussed earlier, availability of water is vital to the operation of a powerplant. All surface waters are the property of the state and are subject to appropriation by the state. The surface water in Texas is considered appropriated if (1) it was used prior to 1913, or (2) the Texas Water Rights Commission grants a permit for its use. Since not all surface water has been appropriated by the permit system, there are legal questions involving claims to the same water. This confusion has recently led to a massive adjudication of water rights, beginning with the Rio Grande River Basin. The adjudication process is far from completed, and so the exact number of water rights is undetermined.

If there is sufficient water, the Texas Water Rights Commission appropriates water for electric generation. Powerplants may also purchase water from water-development projects. However, when there are competing requests for the same water, the Wagstaff Act of 1931 provides priorities for its appropriation. The preferences of the appropriation doctrine, in decreasing order of priority, are:

1. domestic and municipal uses, including water for sustaining human life and the life of domestic animals;
2. industrial uses, that is, processes designed to convert materials of a lower order of value into forms having greater usability and commercial value, including the development of power by means other than hydroelectric;
3. irrigation;
4. mining and recovery of minerals;
5. hydroelectric power;
6. navigation;
7. recreation and pleasure; and
8. other beneficial uses.[7]

These priorities are applied *only* when there are competing demands for the same water. If there are no such competing demands, large volumes of water may be appropriated to a low priority use, such as recreation and pleasure. Furthermore, when an appropriator has used water from a source of water supply under the terms of a certified filing or a permit for a period of three years, he acquires title to his appropriation by limitation against any other claimant of water from the same source of water supply and against any riparian owner on the same source of water.[8] Under these conditions, when water in an area becomes scarce, a high-priority user may be unable to obtain water because of the appropriation made when there was no competing demand for the water. Another factor which may lead to misallocation when water is scarce is the "first in time, first in right" doctrine. Under this doctrine, in times of water shortage each appropriated water right takes its numerical place, with the first-appropriated water right being served in full. This may result in a total cut-off from water supplies for later water users, some of which may be high-priority users.

However, as for any appropriator, a utility is protected from loss of water rights. If a public utility needs additional water in an area where the water has been totally appropriated, there are two alternatives open to it: (1) it may purchase water from current users, or (2) it may condemn water rights. The purchase of water could involve many difficulties, such as the user's unwillingness to sell, the price at which the user will sell the water, and legal arrangements between the utility and the user. There has been no instance in Texas where water has been condemned by a public utility, and so the extent of the authority to condemn water is not known. Most legal experts agree that the issue is "up in the air" and that a more specific statute is needed. These two alternatives do not involve the state, but the state could function as an appropriator when water becomes scarce.

*"The governing body of all incorporated cities and towns in this State incorporated under the General Laws thereof shall have the power to regulate, by ordinance, the rates and compensation to be charged by all persons, companies, or corporations using the streets and public grounds of said city or town and engaged in furnishing . . . light power . . . to the public" (Article 1119, Tex. Rev. Civ. Stat.).

As originally envisaged under the Wagstaff Act, scarce water resources should be allocated by the state to priority users. Yet, under current procedures, the application of priority criteria occurs only at the first certification of water rights, and then only if there are competing demands. To provide water for the highest beneficial use and for the benefit of the greatest number of people requires more continuous evaluation of water uses. Future water appropriations could be made conditional upon displacement by higher-priority users.

The state should examine its policies as they affect water supply. With a limited natural resource such as water, it is questionable whether the perpetual allocation of water is in the public interest. Even though a crisis situation does not exist, it is unwise for the state to allocate its waters for an unlimited time to low-priority users. To guarantee that administrative policies actually support the water preferences of the state, future water appropriations might be considered subject to displacement by a high-priority use.

CONCLUSION

Water and land are limited natural resources which have competing demands on their use. An adequate availability of water and land is necessary to provide electricity to meet increased energy demands. The siting of electric plants is already concentrating in East and Central Texas, where the water supply and energy demand is largest. In order to cope with changing energy conditions, the state should establish a Powerplant Siting Agency to develop a comprehensive powerplant siting policy, including consideration of the effect of electrical generation on land and water. The agency would inventory potential sites and issue site certificates to the utilities prior to construction of the powerplant.

Of importance in any site-selection process is the consideration of the environmental effects of a power facility. Disturbance of natural areas by installation of the facility and by its transmission lines should be subject to regulation as an integral part of the siting function. The agency should also encourage the use of marine water where feasible and should evaluate proposed cooling systems on the basis of their effect on water supply.

To guarantee that adequate sites are available for powerplants the state has two options: It can reserve sites by limiting the uses of selected land to purposes which do not preclude later powerplant use (interim uses could include such activities as farming and ranching), or it can acquire in advance identified sites (which would require large, long-term investment of state funds).

The state should discontinue its practice of allocating surface water on a perpetual basis. Presently, more water is appropriated than is the firm yield of the state's water resources. If drought conditions worsen, high-priority users will be without water.

RECOMMENDATIONS

1. ***Powerplant Siting Agency***. The legislature should create a Powerplant Siting Agency to develop a comprehensive state powerplant-siting policy. The agency should encourage the use of marine water where feasible and should evaluate proposed cooling systems on the basis of their effect on water supply.

2. ***Allocation of water***. The state should modify the present practice of allocating water on a perpetual basis so that high-priority users may have access to a sufficient water supply.

REFERENCES

1. Telephone conversation with Harold Tynan, Executive Secretary of ERCOT, March 4, 1974.

2. *Ibid*.

3. *Ibid*.

4. *Nuclear Power and the Environment*, prepared by IAEA in co-operation with WHO, 1971.

5. U.S. Congress, Joint Committee on Atomic Energy, *Selected Materials on Environmental Effects of Producing Electric Power*, August 1969, p. 98.

6. Hubbs, Clark, Proceedings, "Implications of Nuclear Power in Texas", p. 134, The University of Texas at Austin, March 1973.

7. Wagstaff Act of 1931, U.C.T.A., Water Law, Section 5.024.

8. V.T.C.A., Water Code, Section 5.029.

CHAPTER SEVEN

FUTURE ENERGY SOURCES

INTRODUCTION

In the past, Texas has been able to rely completely on oil and gas as sources of energy but increasing energy demands and the depletion of the state's oil and gas reserves will prevent such total reliance in the future. Therefore, the state should begin ensuring future energy supplies from other sources. This chapter reviews the technology and costs of possible alternative sources and evaluates their applicability to Texas.

NUCLEAR

By 1982, six light-water nuclear reactors should be generating about 11.8 percent of the electricity produced within the area covered by the Electric Reliability Council of Texas (ERCOT). Fulfillment of these plans is, of course, dependent upon final approval by the Atomic Energy Commission (AEC) of utility company reports detailing plant specifications and safety and environmental considerations.

Currently, the cost of nuclear-generated electricity is slightly higher than than of electricity from gas- or coal-fired plants. Slightly lower costs are predicted for light-water reactors in the next several years because of lower construction and fixed costs.

Slightly lower costs are predicted for light-water reactors in the next several years because of lower construction and fixed costs.

Because nuclear power will become a reality in Texas in the next few years, the legislature should designate (and empower) an appropriate agency to seek out ideal sites for nuclear powerplants, using the criteria of health, safety, environmental impact, and proximity to highly populated areas.

A more detailed account of the role of nuclear power in Texas can be found in a tandem report entitled *Energy in Texas Volume I: Electric Power Generation* to be published by the LBJ School of Public Affairs, The University of Texas at Austin.

COAL

Because Texas is the nation's largest producer of crude oil and natural gas, the importance of coal as an energy source has until recently been given little attention in the state. The future use of coal will increase and diversify the state's energy supply, thus helping to ease the impact of petroleum and gas shortages.

Technology

The three distinct energy forms that can be produced from coal are direct combustion heat, synthetic natural gas, and liquid hydrocarbons.

1. Direct Combustion Heat. In view of the impracticality of using coal for space heating in residences and commercial facilities in Texas, this section considers only the technologies of direct combustion to produce electricity. The conventional direct combustion technique requires the burning of coal below a boiler in order to produce steam which is in turn used to drive a turbine to produce electricity. The direct combustion of coal in fluid bed boilers can be done in two different ways. The first method uses Ignifluid boilers: coal is burned in the boiler bed in order to produce combustible gases, and the gases are then burned to produce steam for a conventional steam turbine system. The second way is to use a fluidized bed boiler. This process uses a bed of fluid material to cover the boiler system; water contained in tubes in the inert bed changes into steam to drive generators.[1]

2. Synthetic Natural Gas. Converting coal into synthetic natural gas will make coal energy available for residential and commercial use as well as for industrial and utilities use. All gasification technologies produce a pollution-free fuel which can be upgraded to pipeline-quality gas. There are several processes for converting coal into synthetic natural gas, all of which involve burning the coal and capturing the resultant gas which is then purified and methanated to produce a usable gas. There are five principal gasification processes. The Lurgi Process is limited to non-caking coals, primarily lignites. The Hygas, Bi-Gas, Synthane, and Carbon Dioxide Acceptor Processes can be used with both lignite and subbituminous coals. One other process is *in situ* gasification in which the coal is ignited in its natural deposits. The gas is then captured and upgraded.[2]

3. Liquid Hydrocarbons. The technologies for producing liquid hydrocarbons from coal are not as advanced as the technologies for coal gasification and direct combustion. The two principal processes of liquification are Char-Oil-Energy-Development (COED) and Solvent Refined Coal. COED breaks down coal through four successive heatings, each of which produces a different chemical compound. This is a non-polluting technology using bituminous coal.[3] The Solvent Refined Coal process uses either a liquid or gas solvent to dissolve coal which is then refined in its liquid state.

Table 7-1 lists each technology and the date that a commercial plant using that technology could begin construction; dates given become less accurate the farther into the future the processes are predicted.

Economics

The costs involved in each process are important considerations.

1. Electric Generation. Capital costs and power-generation costs are used to compare the economics of the various technologies. For the computation of capital costs, as presented in Table 7-2, a cost of $75 per kilowatt of capacity is assigned for stack gas clean-up for both the conventional method and the Ignifluid process.[4] The generation costs presented in Table 7-3 were determined by assuming a 30-year plant life, the listed plant service factors, thermal efficiencies, and capital costs, including an 8 percent interest rate and annual inflation of 6 percent. The selling costs given are for 1978, under the assumption that any plant started today would not be in full operation until then.[5]

It is apparent after consideration of Tables 7-2 and 7-3 that the low B.t.u. power gas-conventional combined cycle system is the least costly. The next-best systems are Ignifluid, conventional, and low B.t.u. gas without combined cycle, in that order. Advanced combined cycles, newer gasification technologies, and greater efficiencies will lessen generation costs. The rise in capital and construction costs, however, will probably offset any savings from technological advances.

2. Production of Synthetic Natural Gas (SNG). The Lurgi Process is the only commercial method for coal gasification that is presently being planned for use in the United States.

The Burnham Coal Gasification Complex, planned in New Mexico by El Paso Natural Gas Company, has a

TABLE 7-1

COMMERCIAL AVAILABILITY DATES FOR COAL TECHNOLOGIES

Process	Date
Conventional Method	1973a
Ignifluid	1973a
Fluidized Bed	1975a
Lurgi	1973
Hygas	1980b
Bi-Gas	1976c
Synthane	Unknown
Carbon Dioxide Acceptor	1976
in situ gasification	Unknown
COED	1980c
Solvent Refined Coal	1976

Sources: a Ashworth and Bolez, "A Dollar and Cents Approach to the Clean Conversion of Coal to Electric Power," presented at the Geological Society of America's Annual Meeting, November 1973.
b Linden, "The Role of SNG in the U.S. Energy Balance," a report to the Gas Supply Committee of the American Gas Association, 1973.
c Office of Coal Research, "Annual Report," 1973.

TABLE 7-2

CAPITAL COSTS

Conventional Method	$305/KW
Ignifluid Process	$290/KW
Low B.t.u. Power gas	$310/KW
Low B.t.u. Power gas with Combined Cycle	$260/KW

Source: Ashworth and Bolez, "A Dollar and Cents Approach to the Clean Conversion of Coal to Electric Power," presented at the Geological Society of America's Annual Meeting, November 1973.

TABLE 7-3

POWER GENERATION COSTS
(Average Selling Costs)

	Efficiency	Plant Service Factor	Cost in mills/KWhr
Conventional Method	38%	87	19
Ignifluid Process	38%	87	18
Low B.t.u. Power Gas	31%	82	20
Low B.t.u. Power gas with Combined Cycle	38%	77	17

Source: Ashworth and Bolez, "A Dollar and Cents Approach to the Clean Conversion of Coal to Electric Power," presented at the Geological Society of America's Annual Meeting, November 1973.

projected capital cost of $491,356,000 for the plant itself and $113,520,000 for the associated mine. The complex will produce 288,000,000 cubic feet of gas per day. Gas from the El Paso plant has a project selling price, averaged over a 25-year period, of $1.26 per thousand cubic feet (MCF).[6] This price is expected to be lower than that charged for imported liquid natural gas, but it is considerably higher than the 42 cents per MCF now allowed by the FPC for new natural gas.

The capital costs and prices for low B.t.u. power gas will be less than those for pipeline quality SNG. Because the methanation step is eliminated, less investment is required and a lower price can still provide a normal rate of return on the investment. Unfortunately, the only cost and price figures available for low B.t.u. power gas are for the gas used in conjunction with electric generation as given in Tables 7-2 and 7-3.

For the systems which have not been commercially built, cost estimates are more difficult. An estimate, however, is that each gasification plant, regardless of technological type, will have investment costs of between $400 and $500 million for 250,000 MCF/day. The COED process is the only exception to this estimate because of its cost sharing with syncrude production. An investment of $300 million is projected for a 250,000 MCF/day COED plant. No estimates of capital costs can be projected for *in situ* gasification.

Prices for SNG will vary greatly, depending on the process involved. HYGAS prices are expected to be between $.90 and $1.20 per MCF of pipeline quality gas.[7]

BI-GAS prices should be less than HYGAS prices because a separate hydrogen-producing unit is not required. Synthane and Carbon Dioxide Acceptor SNG prices are expected to be about the same as those of BI-GAS. The price for gas produced from the COED process is correlated with the price of crude oil. Given present crude oil prices, the price of COED gas would be between $1.38 and $1.64 per MCF. As the crude oil price rises, the price of COED gas decreases, because the syncrude sold in conjunction with the gas brings a higher price. Finally, the price of SNG produced through *in situ* gasification will be about $2.00 per MCF.[8]

3. Production of Liquid Hydrocarbons. The COED process is estimated to require a capital investment of at least $5,000 per barrel/day of capacity.[9] This would mean a cost of $136.3 million for the proposed production of 27,275 barrels/day of syncrude oil.[10] A newly-proposed solvent refined coal plant and power generation plant complex has been estimated to cost $310 million.[11] The cost of a plant responsible only for the production of solvent refined coal has not been determined, but a demonstration plant at Ft. Lewis, Washington, should provide the information within two years. The price of syncrude produced by the COED process will be the market price of crude oil. No prices have been projected yet for solvent refined coal.

Environmental Impact

The use of coal has inherent liabilities. These are the effects of strip mining, water requirements, pollution, and the reduction of Texas coal reserves. The use of coal is discussed in this section with reference to its effects on land, water, and air.

1. Land. The bulk of Texas lignite is capable of being strip-mined. Because this is the least expensive method of coal mining, it is expected that coal conversion plants will depend on strip-mined lignite. Texas is fortunate in that its lignite-bearing areas are relatively flat and have abundant rainfall, two factors that aid reclamation. Reclamation according to fixed standards is not presently required in Texas. Consequently, the mitigation of environmental damage from strip mining may depend on regulations that are yet to be adopted.

In order to encourage the development of coal resources in Texas and to regulate the effects of strip mining, the state should require all strip-mining operations to be licensed by the General Land Office. A permit should be granted only after the requesting company has filed plans with the agency, outlining steps to be taken for preventing despoliation of surrounding lands and pollution of ground and stream waters. Plans for the reclamation of the mined land should also require approval. Finally, the company should be required to post a bond with the General Land Office. Such a bond would be refundable only after the reclamation process was completed. Compliance with both the protection and reclamation plans can be enforced by site inspections; if violations are detected, the operators should be permitted a reasonable time to correct the deficiencies, but continued violations should warrant fines and compulsory cessation of mining activities.

The General Land Office should also designate some lands as unsuitable for mining if they are not physically or commercially reclamable, if their use for strip mining is not compatible with governmental land-use plans, or if the area is of critical environmental importance.

A model for state legislation as outlined above is S.B. 425, which was introduced into the U.S. Senate during 1973. The bill has passed the Senate and is currently under consideration by the House of Representatives.

2. Water. Water requirements for coal gasification are very large. The El Paso Natural Gas Company's Burnham Complex will require 9,400 acre-feet of water annually. The Michigan-Wisconsin Pipeline Company has requested an annual appropriation of 17,000 acre-feet of water for their proposed 250,000 MCF/day plant in North Dakota.[12] The other gasification technologies, including COED, will use similar quantities of water. In order to place these water requirements in perspective, let us assume that one plant will use 10,000 acre-feet of water per year and will operate for 30 years; that plant will have a lifetime requirement of 300,000 acre-feet of water. This figure is approximately 13 times the capacity of Austin's Town Lake.

In addition to the problem of high water requirements, there is the fact that most of the stream water in Texas has already been allocated. Water for gasification plant can come only from a lessening of other water allocations or from new reservoirs.

Even conventional, lignite-fueled plants require large amounts of water because they need a cooling system of some kind. The usual method of cooling uses water from a nearby lake or river, but this practice has caused much public discussion of the effects of thermal discharge into bodies of water. The alternative is to use cooling towers which rely on the evaporation of water to remove heat. Cooling towers waste water, so their use must be balanced against the adverse effects of heat discharge to lakes and rivers. On the other hand, studies of Texas reservoirs and estuaries indicate that in many cases thermal discharge may have beneficial effects.

Presently, any discharge into a lake or stream must be approved by the Texas Water Quality Board. Requests to discharge heated water into a lake or stream are appraised individually by the Water Quality Board. The maximum temperature of 90° Fahrenheit suggested by the National Technical Advisory Committee is not applicable to Texas conditions where naturally high temperatures of 96 degrees

or greater occur regularly in the summer months.[13]

3. Air. Air-pollution control will not be a major problem as long as stack gas clean-up systems become available in the near future. The Lone Star Steel Company of Dallas has recently announced the development of what it calls the "Steam-Hydro" air-cleaning system. They report that this system removes nearly 100 percent of discharged particles and sulphur dioxide gas. If this system proves effective, it will make lignite-burning plants safe with regard to air pollution.

GEOTHERMAL ENERGY

Deep within the earth's core, tremendous amounts of heat energy are generated by the natural decay of radioactive materials and from frictional forces resulting from solar and lunar tides, as well as from the motion of the crustal plates. Theoretically, this potential energy source can be reached by drilling a hole deep enough to extract the heat. In reality, in most areas of the world the earth's crust is much too thick to make that possible. Certain areas exist, however, where hot fluids rise relatively close to the earth's surface and form what are known as hot springs and geysers. The hot fluids do not necessarily break through to the surface. Magma may spread out just as easily at some depth, mix with the rock at that level, and crystallize. Such areas of thermal uplifts are found in zones of recent volcanism and crustal shifting.

Geothermal energy was first utilized as an energy source in Italy in 1904, but not until the mid-1950s did the United States become seriously interested in geothermal power. The first power plants in this country to use geothermal energy only are in California's Geyser Field; they supply over 300 megawatts of electrical power.

Potential in Texas

Research for potential geothermal reservoirs in Texas has been limited: little has been done to explore geothermal fields or determine their possible energy output. An exception is a study entitled *Potential Geothermal Resources in Texas*, produced by Myron Dorfman for the Bureau of Economic Geology at The University of Texas at Austin. Dorfman presents evidence substantiating the existence of at least three different forms of geothermal reservoirs within the border of Texas, and he provides estimates on the potential energy production from each source.

1. Areas of Recent Volcanism and Crustal Rifting. Although few thermal investigations in West Texas have been undertaken, evidence of geothermal reservoirs (in the form of steam or water-dominated convective systems) does exist. The most promising area, roughly between El Paso and Presidio, has the geologic structure common to the western portions of the United States that contain geothermal fields. Several oil and gas wells drilled in this area of the state have shown hot water at shallow depths. Infrared photographs of the area, taken by the Earth Resources Technology Satellite, have indicated that it contains high surface heat along the boundaries of faults. This evidence indicates that an area encompassing approximately 4,150 km.^{2} may contain energy reserves of as much as "5,000 megawatt centuries of power."[14] (The term "megawatt century" refers to the number of megawatts which can be effectively produced over a 100-year period.) In addition to its value as a power source, this geothermal field would provide a usable water source for an extremely dry region through the desalination of extracted water. Such a process has proven valuable at the Salton Trough plants where the desalinized water is used for consumption and irrigation.

2. Dry Rock System. Cenozoic igneous rock outcrops have been known to retain high heat values. Formations of this kind appear to a great extent in the Sierra Blanca area, the northern part of the Quitman Mountains, east of the Hueco and Presidio bolsons, and north of Big Bend National Park. If only 10 percent of the known Cenozoic formations in Texas produce geothermal energy, they can produce up to 31,000 megawatt centuries of power.[15]

3. Geothermal Sands. A geopressured sand system occurs from moderate to great depths along the entire Gulf Coast. Estimates of potential goethermal reserves are difficult because information is scarce. Unlike the other types of geothermal deposits, geopressured sands show no evidence of high heat flow at or near the surface.

The Dorfman report states that the Eocene Wilcox formation is the first zone of potential geothermal energy in coastal Texas. Studies by Fisher and McGowan indicate a linear development of sands covering an area some 1,456 km. in length and 100 km. in width.[16] The area extends from the Mexican border north of Laredo, Texas, to the Louisiana border north of Beaumont, Texas. Numerous wells have encountered geopressured zones with temperatures in excess of 180 C° at depths of 3,000 meters. The estimate of the geothermal energy available within the Wilcox formation is 1.1×10^3 megawatt centuries. Deeper drilling will doubtlessly encounter higher temperatures.

Along with the Wilcox formation, there exist two other major zones, the Yegua and Jackson systems. These two systems will add a minimum of 100 percent to the potential geothermal reservoirs of the Eocene type. Therefore, it is estimated that the Wilcox, Yegua, and Jackson systems together possess a minimum potential of 22,000 megawatt centuries of power.[17] Even considering the conservative nature of this estimate of the geopressured sands, the Gulf Coast region could be provided with at least two-third of its energy needs. The reservoirs will also provide fresh water

for the dry areas of the lower Rio Grande Valley, since the geothermal fluid is fresh water.

Figure 7-1 illustrates the location of geothermal deposits in Texas.

Cost

Estimates of the cost of geothermal energy are based on data from Pacific Gas and Electricity (PG&E) Company in California. Geyser Field steam is bought by PG&E for 2.7 mills per net KWH of energy generated at the site. This cost includes the cost of returning waste material to the earth. PG&E has estimated total fixed charges per year to be $1,851,000 for two 55 megawatt plants.[18] Assuming an operating plant factor of 85 percent, the fixed charge per energy unit is:

$$\frac{\$1{,}851{,}000}{110{,}000\text{KWx}8{,}760\text{hrs.x}0.85} = \$2.26\text{x}10^{-3}/\text{KWH} = 2.26 \text{ mills/KWH.}$$

Hence, the total geothermal energy costs (steam costs + fixed charges) are 4.96 mills/KWH.[19] This compares favorably with the cost of nuclear-generated power, which runs about 9 to 11 mills/KWH. Geothermal cost is also comparable to that of fossil fuels. Until recently, the cost of oil and gas was so low that the incentive to produce geothermal energy did not exist. Now that the cost of hydrocarbons has increased, geothermal energy should be considered a viable power source for Texas.

Technology

Drilling for geothermal energy is similar to drilling for oil and gas, but there are important differences. The high temperatures associated with geothermal wells affect the circulatory systems, cementing procedures, and design of the casing and drilling string. The hardness of the rock involved creates further problems. A typical steam well in the California area costs approximately $300,000 to drill and complete for production.[20]

The design of geothermal powerplants is such that a cluster of wells serves one plant in order to minimize heat loss. Each plant is usually served by 10 wells. The steam powers the turbines that drive the generators which produce electricity. The steam later condenses and may be used for various purposes or returned to the earth.

A geothermal system can be developed within a period of two years from drilling, whereas fossil-fuel plants require five years, and nuclear plants require from eight to ten years. This difference in time results from the smaller scale of geothermal plants and the less complex requirements for obtaining permits and licenses.

Environmental Impact

When compared to other fuels, geothermal energy is a clean source of energy; yet, there exist two potential areas of environmental concern. The first of these is the problem of the corrosive and odorous brine from geothermal reservoirs. On existing wells in California, corrosion has not been a major problem, and the desalination of the water has provided a means to clean the water and to create a new mineral source. The second problem is that of land subsidence due to the withdrawal of large volumes of fluids. When the wells pump the fluids from the earth, a compaction of the underground clays may occur and cause the land surface to sink. There is no certainty that this will happen, and if it does it can be counteracted by reinjecting water into the geothermal zone or into oil and gas reservoirs which may be present at shallower depths.

State Policy

Presently in Texas there exists no legislation regarding geothermal energy. Within a few years, the exploration of the fields will be completed and the potential for development of this energy source will be known. However, not until the state formulates a policy about geothermal energy will private industry take the initiative to develop this power source.

The state should establish a clear indication of the ownership rights to geothermal energy. It should specify whether geothermal deposits are mineral resources and are protected by mineral rights. There is also the possibility of declaring sole state ownership or establishing the source as unique. These two possibilities do not solve the problem of the relationship of geothermal rights to other rights in the same lease. Since the technology used for geothermal-energy extraction is similar to that used for oil and gas, classifying the resource as a mineral seems logical.

Some regulation is required to establish the proper siting of geothermal powerplants, well spacing, and rate of recovery. The General Land Office should issue licenses, establish the industry as a public utility, and insure protection of the environment.

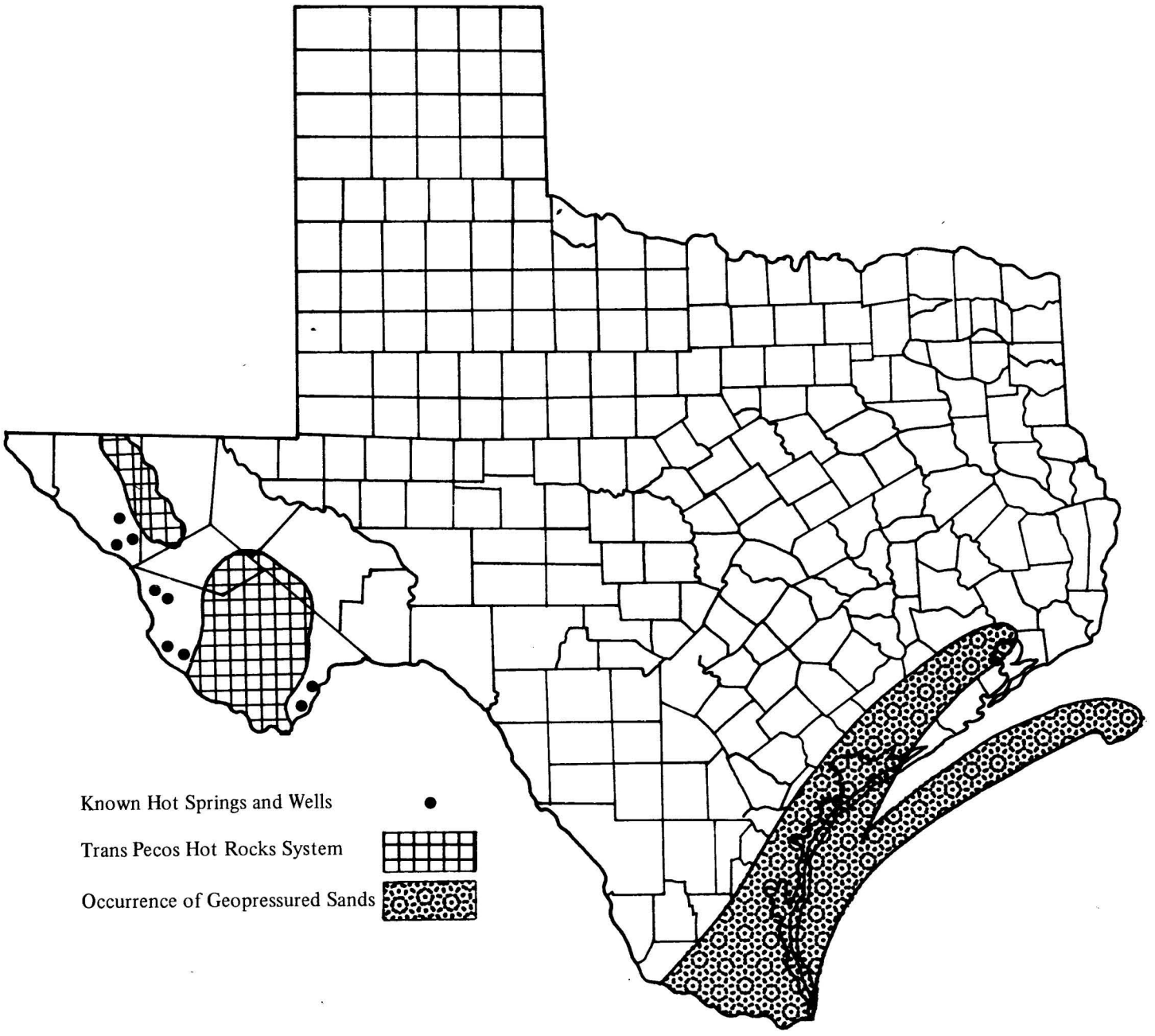
The State of Texas will hold substantial rights to geothermal resources because many of the potential producing areas are located on state lands. Thus, the state must provide a means of selling leases and establishing royalties, and it should devise a policy that would encourage the development of geothermal energy. First, the sale of leases should be conducted through the variable royalty bidding method. Second, the state should refrain from collecting royalties from the developer until the initial investment is recovered.

SOLAR ENERGY

The sun represents the largest source of energy available, but the technologies for harnessing this source efficiently

FIGURE 7-1

POTENTIAL GEOTHERMAL FIELDS IN THE STATE OF TEXAS



Source: Jones and Groat.

are not fully developed. This section reviews some of the applications of solar energy and their feasibility in Texas.

Technology

Solar energy has been used for water heating, space heating, air conditioning, and combinations of these.

1. Water Heating. Solar water heaters are manufactured and are commercially available in Australia, Israel, Japan, and the U.S.S.R., and, on a small scale, in the United States. This application was used in Florida, but the availability of "cheap" natural gas diminished solar usage. The technology, especially for collectors, is well-developed, and further product engineering and large-scale production should result in increased utilization and cost reductions.

2. Space Heating. Approximately 20 experimental solar-heated structures have been designed, built, and operated using various types of collector, storage, heat-transfer, and reserve-supply techniques. None, however, has proven to be an optimum combination of system design and cost effectiveness. Technology is available, but economic feasibility will require more research and development.

3. Air Conditioning. In the United States, Australia, and the U.S.S.R. a few experiments have been conducted using the heat from solar collectors to create refrigeration storage, jet compression, and dehumidifying systems for air cooling. No major technical barriers are seen. The problem again lies in the long-term question of cost and efficiency.

4. Combined Systems. Homes have been constructed in several countries using solar energy to perform all energy-related tasks. On a large scale, however, the size of the required collector has prevented development.

Research

In 1973 only $10 million was appropriated by Congress for solar research. Much higher appropriations are certain for the future, owing to the need to develop new, abundant energy sources. Solar energy must be developed on a larger scale before it will have a significant impact on the energy situation of the United States. Texas can help in this endeavor by encouraging demonstration projects using solar energy. More specifically, certain state buildings might be experimentally heated and cooled by solar energy.

ORGANIC WASTES

The use of organic wastes for energy production is not only possible, but is already being applied in some commercial plants.

Technology

There are several possible ways of using organic wastes in the production of energy. One is the combustion of waste to produce steam either to generate electricity or to provide steam for the heating and cooling of buildings. Another way is to convert wastes into synthetic natural gas (SNG). A third method involves the production of methane gas from sewage solids.

1. Combustion. The Nashville Thermal Corporation is operating a 200,000 pounds/hour steam plant fed by 700 tons/day of urban wastes. The plant heats and cools buildings by using steam, thereby reducing the demand for electricity. In St. Louis, urban wastes are burned to power electrical generators. This facility, using conventional equipment, processes 150 tons of urban wastes per day to produce about 1,000 kilowatts per ton. Another but as yet commercially untested means of deriving electrical power from urban wastes is the CPU-400. It is a non-polluting unit which separates metals and glass from the burnable wastes. Using a high-pressure, low-temperature boiler, it can produce 12,000 kilowatts of power from 600 tons per day of waste. For a city of 250,000 people, the system can produce enough power to meet from 5 to 15 percent of the city's electricity needs. Reports from the pilot plant operation of the CPU-400 in San Mateo, California, have been quite favorable.[21]

The estimated net operating costs, after sale of electricity, are from two to five dollars per ton of wastes. This compares favorably with incineration costs of eight to fourteen dollars per ton.[22] The comparative costs of this system and landfill depend upon the proximity of waste depositories. A study by the Midwest Research Institute estimates close-in sanitary landfill costs at $2.75 per ton and remote sanitary landfill costs at $5.94 per ton.[23]

2. Conversion. There are three methods of converting organic wastes into synthetic natural gas. They are hydrogenation, pyrolysis, and bioconversion.

Hydrogenation treats organic material with hydrogen at high temperatures and pressures to produce methane. The process is still being studied, but tentative results indicate that a maximum of 7,200 cubic feet of methane can be produced per ton of feed material. With a capital investment of $15 million, a plant serving a population of 500,000 could produce 10,000 MCF of SNG per day.[24]

Pyrolysis is a process of thermal decomposition of organic substances in the absence of oxygen. The process uses low temperatures and high pressures. The SNG yield by a pyrolysis system at West Virginia University is 5,000 cubic feet per ton of feed material. The Bureau of Mines estimates that the pyrolysis system will take a capital investment of $3.82 million for a 500 ton per day plant and $16 million for a 5,000 ton per day plant.[25]

Bioconversion is the natural bacterial decomposition of organic matter. An Institute of Gas Technology study of the process determined that a 571 ton/day plant would have a capital cost of $6 million and would produce 4,000 MCF of SNG daily.[26]

3. Methane Production. A gas containing methane and carbon dioxide is produced by treating primary and activated sludge by anaerobic digestion. The potential is estimated at 1.25 cubic feet per capita per day. Many sewage treatment plants use the methane to provide heat necessary to maintain the sludge digestion operation. The excess gas may be used to fuel boilers or internal combustion engines, to drive generators, or it may be bottled and sold.[27] An assessment of the feasibility of using the gas produced by sewage sludge fermentation is to be carried out by the College of Engineering at The University of Texas at Austin beginning in 1974.

State Policy

Organic wastes can be used to provide energy either as steam, SNG, or methane. Although organic wastes will not provide large quantities of energy (only about 5 to 15 percent of a city's needs), they could supply energy to meet increased demand and at the same time provide a method for the disposal of urban wastes.

The State of Connecticut has recently developed and begun implementation of a statewide, solid-waste management system. This system, designed to dispose of wastes in an efficient and productive manner, is comprised of three parts. The first is a plan for the state to follow in building new facilities for solid-waste management. Second is the establishment of the Connecticut Resources Recovery Authority, which is to carry out the implementation of the plan. The third part is the allocation of responsibilities for solid-waste management among the various levels of government in the state. This system deserves the attention of the Texas legislature. The economic effects and the costs of waste transportation to the processing centers should be closely observed.

One of the means the state has to encourage the use of organic wastes in meeting future energy needs is to make approval of future plans for powerplants contingent on the use of such wastes or on a statement of reasons why such plans are not feasible.

TAR SANDS

Tar sands are oil-impregnated rock formations in which little oil is recoverable through conventional drilling and pumping techniques. There are four major deposits of tar sands in Texas, the most important of which is located in Uvalde and Kinney counties. This reserve was estimated at 348 million tons in 1950. Since the hydrocarbon content is between 15 and 17 gallons per ton, this amounts to a reserve of 156,380,900 barrels of petroleum. Since 1950, the deposit has been mined for asphalt, but there is no estimate of the remaining reserves. The other major deposits are in Burnet, Anderson, Montague, and Cook counties. No data are available on reserves in these counties.

Technology

There are two basic tar-sand extraction techniques. One involves the reduction of tar-sand viscosity by heating, crushing, or other methods which cause the oil to move along paths into wells. The other method, now in use in the Great Canadian Oil Sands, removes the oil from the sand after it has been mined in an open pit. Other proposed methods involve the injection of hot fluids into the sands, or the burning of the tar within the deposit.

State Policy

Because so little research has been done on tar sands and on efficient recovery technologies, conclusions specific to Texas are difficult to formulate. Certainly, the state should encourage or sponsor research into commercially feasible recovery methods. If such technologies are found, the problems of land and water usage must be dealt with. Therefore, the General Land Office should regulate the mining operations to ensure the protection of the environment and the efficient recovery of the resource.

WIND

The idea of harnessing the power of the wind is not a new one. For over 800 years, wind power was used in both the Far East and Near East and in Europe to run grain mills. However, in the 1840s, it was found that water, and later, steam, could do the job more predictably and efficiently.

The rebirth of the windmill is based upon a new usage as an inexpensive, environmentally safe generator of electrical power. Experiments of this kind, begun about 80 years ago in Denmark, met with little success, but the recent energy shortages have led to new experimentation. Technological advances have permitted the harnessing of 70 percent of the wind's power. At present, a windmill system can be adapted to any environment with an annual average wind of over eight miles per hour. The entire State of Texas has average winds in excess of eight miles per hour, ranging from 9.4 mph along the Gulf Coast to 13.7 mph on the open plains of West Texas.

Several corporations and research groups have begun building windmill generating systems. For a five-family dwelling, costs range from $3,200 to $46,000. In time, mass production will lower the cost.

Wind energy is viable for Texas today as a supplemental source of power. The state should encourage demonstration projects, particularly those using state facilities.

SUMMARY

In the future, Texas will not be able to rely solely on oil and gas as energy sources and the state should begin now to aid in the development of alternative sources. Coal, nuclear power, geothermal deposits, solar energy, organic wastes, tar sands, and wind all represent possible alternative energy sources.

The mining of coal and tar sands should be closely regulated by the General Land Office to prevent environmental degradation and to promote efficient recovery of resources.

Geothermal deposits should be classified as a mineral and regulated as such by the General Land Office, which should be directed further to lease public lands for the production of geothermal energy. In order to encourage development, state leasing should be conducted by the variable royalty bidding method.

Since organic wastes must be disposed of, the use of such wastes as an energy source is ideal. Power-generation facilities should be approved by the state contingent on plans for use of organic wastes as a fuel source or on a statement of reasons why such plans are not feasible.

Finally, the state should encourage demonstration projects using solar energy and wind. Specifically, certain state buildings might be heated and cooled experimentally by solar energy and/or wind.

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CHAPTER EIGHT

TOWARD A COORDINATED ENERGY POLICY

INTRODUCTION

The term "energy crisis," although misleading, has served to underscore the widespread inadequacies of present energy policies in Texas. The information compiled in this report indicates that our "state energy authority," scattered among numerous state agencies, can be improved to meet changing conditions and provide the coordination necessary to solve problems.

There are numerous strategies for dealing with future energy difficulties, but to choose a particular combination of approaches, without much thought and analysis, would serve only to compound the difficulties. The policy themes that highlight this report are recommendations that the state should *consider* in the development of a coordinated energy policy.

The first requirement for a state energy policy is a comprehensive and coordinated information system. The system is needed not only to provide a single source of comparable data, but, more importantly, to provide a source of data for evaluation of current and proposed energy policies.

Many state agencies collect energy information. (See Figures 8-1 and 8-2.) For example, the Railroad Commission collects and uses information on exploration, production and development, recovery processes, and reserves of crude oil and natural gas. The comptroller of public accounts collects information on the sale of crude oil, natural gas, and some petroleum products. The Office of Information Services in the Office of the Governor collects data on energy use for the state input-output model, and the State Allocation Office maintains records on allocation of state set-asides. The General Land Office records information on state mineral leases and on the royalties derived from those leases. The Water Rights Commission, the Water Development Board, and the Water Quality Board all gather information related to water used in energy production.

This information must be consolidated and coordinated into a usable form. We propose that the Office of Information Services be authorized and directed to perform the following functions: to receive this scattered information from the collecting agencies; to aid each resource agency in its data-gathering procedures; to create recording standards to simplify the comparison of such information; to consolidate the data into a comprehensive, coordinated, and useful format; to transmit comprehensive reports back to the resource agencies; and to report to the legislature concerning new information necessary for a comprehensive energy-information system.

STATE CONSERVATION OF ENERGY

Conservation of energy is a necessary component of a coordinated state energy policy. Despite current concern over ways of producing enough energy to meet projected demands, relatively little attention has been accorded to methods of making existing supplies go further. Conservation measures would lessen the demand on energy resources and would reduce the state's dependence on imports for fuels. Increased independence would allow more time for the development of improved energy systems and the use of alternative fuels. Although even extreme conservation measures cannot halt the need for more energy, it is nevertheless prudent to reduce wasteful and inefficient uses of energy.

The state should undertake the task of improving energy efficiency in all economic sectors. The improvement of energy efficiency and conservation in the residential, commercial, industrial, and transportation sectors will have a significant impact. Perhaps the largest energy savings could be effected in homes and commercial buildings, where, for example, present inadequate insulation and excessive lighting increase heating and cooling costs. These problems are often aggravated in commercial buildings by excessive ventilation, inefficient heating and cooling equipment, and inadequate maintenance.

Our research has shown that the state should encourage energy savings. For example, minimum standards of insulation could be required by the state in the form of specific standards contained in a uniform state building code or by the establishment of energy budgets based on design of a particular structure. The setting of regressive utility rates encourages inefficient uses of energy and the state should

FIGURE 8-1

STATE ENERGY RELATED ACTIVITIES

	State Government Subdivisions and Agencies	Production and Distribution	Encouraging Production	Encouraging Importation	End Use Allocation	Encouraging New Energy Resources	Energy Use Conservation	State Agency Fuel Consumption	Revenue from Energy Resources	Related Non-Energy Resources	Management of Public Lands	Land and Water Management	Land, Water, and Air Pollution Control
		State Energy Activities											
Office of the Governor	1 Energy Advisory Council	X	X		X	X	X					X	X
	2 Energy Conservation Task Force						X	X					
	3 Division of Planning Coordination											X	
	4 Defense and Disaster Relief							X					
	5 Power Plant Siting Committee				X	X						X	X
	6 Interagency Council on Natural Resources and the Environment											X	X
	7 Interagency Transportation Council						X						
	8 Office of Information Services	X											
Executive and Administrative Agencies	9 Attorney General	X							X			X	X
	10 Bureau of Economic Geology		X									X	X
	11 Comptroller of Public Accounts								X				
	12 Texas Department of Agriculture				X							X	X
	13 State Department of Health					X						X	X
	14 Department of Public Safety							X					
	15 General Land Office	X	X						X		X	X	X
	16 Texas Industrial Commission					X	X						
	17 Interstate Oil Compact Commission		X										
	18 Texas Mass Transportation Commission						X						
	19 School Land Board										X	X	
	20 State Board of Control							X					
	21 Texas Air Control Board				X		X						X
	22 State Highway Department								X				
	23 Railroad Commission of Texas	X	X		X		X		X			X	X
	24 Board for Lease of University Lands										X	X	
	25 Texas Water Development Board											X	X
	26 Texas Water Quality Board											X	X
	27 Texas Water Rights Commission											X	X
	28 Parks and Wildlife Department										X	X	X
	29 State Soil and Water Conservation Board											X	X
	30 Southern Interstate Nuclear Board					X							
	31 Offshore Terminal Commission			X								X	X
	32 Texas Forest Service											X	
	33 Lower Colorado River Authority					X						X	X
	Legislative Committees												
Active Interim Committees, 63rd Leg.	34 Committee on Ecology Improvement											X	X
	35 Committee on the Energy Crisis	X	X	X	X	X	X	X	X		X	X	X
	36 Committee on Estuarine Inflows		X									X	X
	37 Committee on Pollution Control						X					X	X
	38 Specific Water Needs of the State											X	

FIGURE 8-2

RESOURCES AFFECTED BY STATE GOVERNMENT

	State Government Subdivisions and Agencies	Resources Affected by State Energy Activities: Oil and Petroleum Products	Natural Gas	Coal/Lignite	Nuclear Power	Hydroelectric Power	Land	Air	Water
Office of the Governor	1 Energy Advisory Council	X	X	X	X	X	X	X	X
	2 Energy Conservation Task Force	X	X						
	3 Division of Planning Coordination	X	X	X	X		X	X	X
	4 Defense and Disaster Relief	X	X						X
	5 Power Plant Siting Committee	X	X	X	X	X	X	X	X
	6 Interagency Council on Natural Resources and the Environment	X	X				X	X	X
	7 Interagency Transportation Council	X					X		
	8 Office of Information Services	X	X						
Executive and Administrative Agencies	9 Attorney General	X	X				X	X	X
	10 Bureau of Economic Geology	X	X	X	X		X		X
	11 Comptroller of Public Accounts								
	12 Texas Department of Agriculture	X	X				X		X
	13 State Department of Health				X			X	
	14 Department of Public Safety	X							
	15 General Land Office	X	X		X		X		X
	16 Texas Industrial Commission	X	X		X				
	17 Interstate Oil Compact Commission	X	X						
	18 Texas Mass Transportation Commission	X					X		
	19 School Land Board	X	X				X		X
	20 State Board of Control	X	X						
	21 Texas Air Control Board	X	X	X	X		X	X	
	22 State Highway Department	X					X		
	23 Railroad Commission of Texas	X	X				X		X
	24 Board for Lease of University Lands	X	X				X		
	25 Texas Water Development Board	X	X		X	X	X		X
	26 Texas Water Quality Board				X		X		X
	27 Texas Water Rights Commission				X	X	X		X
	28 Parks and Wildlife Department				X		X		X
	29 State Soil and Water Conservation Board						X		X
	30 Southern Interstate Nuclear Board				X				
	31 Offshore Terminal Commission	X	X				X		X
	32 Texas Forest Service						X		
	33 Lower Colorado River Authority						X		X
	Legislative Committees								
Active Interim Committees, 63rd Leg.	34 Committee on Ecology Improvement						X		X
	35 Committee on the Energy Crisis	X	X	X	X	X	X	X	X
	36 Committee on Estuarine Inflows						X		X
	37 Committee on Pollution Control							X	X
	38 Specific Water Needs of the State								X

consider establishment of a Utility Commission to set more uniform utility rates.

While the state has limited direct control over the industrial sector's energy practices, it can nevertheless promote conservation practices because, although conservation has not been a major concern of industry, there is opportunity for substantial energy savings. A coordinated state approach to the energy situation could facilitate improved conservation practices. Perhaps the most important role for the state is to encourage a statewide resource recovery, recycling, and reuse program. The state should also encourage an industrial "energy awareness" program to focus on conservation of resources.

With the occurrence of the fuel shortages and the realization that 90 percent of the fuel consumed by transportation in Texas comes from petroleum products, it is crucial that the state act now to minimize any discomforts or economic repercussions to its citizens and businesses. Texas should act to conserve energy in the transportation sector.

Currently, the primary responsibility for funding and development of transportation policies for Texas is divided among the Texas Highway Department, Texas Aeronautics Commission, Texas Railroad Commission, the Texas Turnpike Authority, the Texas Mass Transportation Commission, and the Department of Public Safety. The only state body which attempts to coordinate the activities of the various transportation agencies is the Interagency Transportation Council. Equally fragmented is the state's funding of the various transportation agencies. Therefore, a primary consideration should be the reorganization of the state's transportation agencies and its funding structure.

The creation of a State Department of Transportation could represent a means of reorganizing Texas transportation agencies. Responsibilities of the department should include the planning, design, construction, operation, and maintenance of transportation and related facilities of the state, as well as regulation of railroads, trucks, and public transportation. With the creation of a State Department of Transportation, legislation should be passed which would permit transportation funds, regardless of their source, to be expended for the mode of transportation recommended by the department.

Since the automobile consumes a larger share of the transportation budget in Texas than all other transportation modes combined, this sector is crucial to a transportation energy-conservation policy. A state task force should be created to develop a system of fuel economy, equipment, and purpose guidelines for the purchasing of state vehicles. The legislature should enact a law giving the cities of Texas the option of reserving freeway lanes for the exclusive use of public transit buses and/or multiple-occupant motor vehicles during the morning and afternoon rush hours.

Although Texas has witnessed a continual decline in the patronage of mass transportation systems, this mode of transportation, if sufficiently upgraded, could alter significantly the dimensions of the energy situation. Substantial fuel savings in the cities are possible if the state will make a positive commitment to assist in the planning and operation of efficient metropolitan mass transit systems. However, the cities will not be the only beneficiaries of state assistance to mass transportation. Fuel savings realized by better mass transit service will mean additional fuel for agricultural areas. The legislature should create a special task force to investigate the various means by which the state can financially assist urban mass transit systems.

INCREASING OIL AND GAS SUPPLIES

The development of petroleum and natural gas supplies is a major component of a comprehensive state energy policy. The urgency of the problem is illustrated by the fact that Texas exports over 60 percent of oil and natural gas resources, with no prospect of redirecting the outflow short of violating the Commerce Clause of the U.S. Constitution. The state must explore methods for increasing the in-state availability of petroleum and natural gas.

As a step in this direction, we recommend the following policies:

- majority-consent unitization
- royalty bidding for leases on state-owned land
- a publicly-owned offshore terminal
- legislative enactment of the State Allocation Office
- planning of a comprehensive intrastate natural gas allocation system.

The majority-consent unitization policy will aid secondary and tertiary recovery of oil and natural gas and will increase the recoverable reserves. Royalty bidding for leases on state-owned land will lower the initial costs of developing new oil and gas fields and will allow more small companies to explore for new oil and gas fields. Extending the policy of in-kind royalties to include past leases and relinquishment land will provide the state with more oil and gas from its lands. In addition, the state should provide an option in future leases to buy oil and gas produced from state lands. The offshore terminal will aid the Texas refining industry by providing a means of bringing more oil into the state and will provide a greater supply of oil to its citizens. A single agency should have the responsibility for allocating both state set-asides and in-kind royalties in order to avoid contradictory policies. Furthermore, a comprehensive intrastate natural gas allocation system would guarantee an equitable distribution of natural gas during fuel shortages.

POWERPLANTS: THE USE OF LAND AND WATER

A coordinated state energy policy requires not only the integration of all energy production into a common effor but must also include many non-energy factors that are related to energy production. Land and water are determining factors in energy production, with the location of powerplants dependent on the ample availability of both. Yet, any location of a powerplant will, in some manner, affect the community it is meant to serve, necessitating some form of powerplant siting requirements. Finally, land, water, or powerplant siting all require that environmental safeguards be taken into consideration. All factors must be harmonized into a total energy plan if the state is to have a coordinated energy policy.

The strong relationship between land and energy is evident in two major areas. First, a powerplant must be located on land which can meet specific requirements, such as ample water supply and proximity to the area served. The major problem is that the factors which make an ideal site for the construction of a powerplant are generally attractive for other uses as well, creating competition for land use. Second, any relationship between land and energy produces the need for environmental protection. A lack of adequate land-resource management in the energy area will lead to environmental carelessness that ultimately results in impairment of land for other purposes.

Present policy in Texas concerning land-use planning and resource management is scattered among numerous agencies. Texas has delegated most of its land-use responsibilities to lower levels of government, primarily the cities. However, the General Land Office manages all public lands and imposes environmental restrictions on the use of that land. The Texas Water Development Board, Texas Water Rights Commission, and the Texas Water Quality Board influence land decisions through their determination of water availability. Other agencies having a voice in land use are the Texas Highway Department, the Offshore Terminal Commission, the Mass Transportation Commission, and the Texas Industrial Commission.

The relationship between water and energy is inescapable. Powerplants rely upon access to adequate supplies of water for their operation. The state's utilities use surface water in the production of electric power. Water is used in the cooling process during which the steam is condensed, creating the possibility of environmental hazards. Although public health would not be affected adversely by increased temperature discharges from the steam-electric plants, ecosystems could be affected. If Texas continues the present policy of perpetual allocation of surface waters, it will not have the water necessary to produce energy for its future needs. Utilities, which are high-priority users, would not be able to obtain needed water supplies if a prior claim on water usage existed.

At present there is no agency that plans for the siting or development of electric powerplants. The state exercises control primarily through the permitting functions of the Texas Water Quality Board, the Texas Air Control Board, and the Texas Water Rights Commission. The Texas Air Control Board issues air emission permits, the Texas Water Rights Commission grants appropriative water rights to powerplants, and the Texas Water Quality Board grants a permit for thermal discharge. These functions, however, are ancillary to power-system planning and only indirectly affect siting decisions by utility companies.

The purpose of this section has been to underscore inadequacies of present state policies concerning land, water, and powerplant siting. The solution to deficiencies in present policies is the establishment of a more coordinated state siting policy. This could be done through a State Powerplant Siting Agency. It would be this agency's responsibility to study the most efficient methods of water consumption for the production of electricity, to develop a state powerplant siting policy, and to establish land-use regulation concerning transmission lines, reservoirs, and cooling ponds. This agency would also inventory potential sites for power generation and issue site certificates.

We recommend that the problems of using water in energy production be assessed within the context of the state's present practice of allocating water on a perpetual basis. During periods of critical water shortage, high-priority users must be allowed sufficient amounts of water. Furthermore, the Texas Water Development Board must submit long-range plans for meeting the water needs of electrical generation. If no powerplant siting agency is created by the legislature, the Texas Water Quality Board should encourage the use of marine water where feasible in order to increase the water supply. In the absence of a state powerplant siting agency, the Water Quality Board should consider the impact of the cooling system on the water supply when it grants a discharge permit.

FUTURE ENERGY SOURCES

A major tenet of international trade is that no nation's economy should be dependent on only one trade commodity. That is also true for a state's economy. Historically, the economy of Texas has been heavily dependent on the fossil fuels of oil and natural gas. However, as the cost of the fossil fuels increases, and their supply declines, the state's economy and public welfare will be jeopardized unless supplemental energy resources are developed.

Texas has no policy directed toward the development of coal as an additional energy resource. The mining of coal,

especially by strip mining, can have detrimental effects on the environment. There must be a policy for regulating the extraction of energy deposits, including the licensing of mine operators and the setting of reclamation standards. Control over strip mining will protect the environment, while not inhibiting the development of coal as an energy resource.

There exists no legislation for the regulation of geothermal energy. Within two or three years the exploration of geothermal fields in Texas will be well-advanced, and private industry could develop this energy resource. However, before the resource can be fully exploited, the state must define geothermal energy ownership rights. Because geothermal energy is found beneath the surface of the land and its extraction methods are similar to those of oil and gas, it is recommended that geothermal energy be defined as a mineral, thereby defining its ownership under the law of capture. Since a great portion of geothermal energy is located under state lands, the state should actively encourage its development. The same policies as applied to leasing public land for oil and gas exploration and development should be applied to leases for geothermal-energy development.

Texas does not have policies to encourage the use of organic wastes as an energy source. However, because the resource will not produce a substantial amount of energy, it is recommended that the use of organic wastes be encouraged, but not required, for electric utilities. This can be accomplished by requiring proposed electric-generating facilities to include plans that state why organic wastes should or should not be used as a supplemental fuel.

Although there are four major deposits of tar sand in the state, there has been no development of these deposits, other than mining for asphalt. This is a result of the lack of proven technology for extracting the oil locked in these deposits. Although tar sands will not be developed in the short-run, the state still must regulate strip mining for asphalt and plan for the regulation of future strip mining to recover oil. The regulations for coal should also be applied to the tar sand deposits.

Wind and solar energy share common properties in that they are ubiquitous but not constant. The lack of constancy is a major obstacle to their development as alternative energy sources, but they can be used as supplementary energy systems. The state should develop demonstration projects for using wind and solar energy. In the case of wind, one demonstration project could be the generation of electricity for rural consumers. In the case of solar energy, space heating and cooling for office buildings or residences could be a useful project.

CONCLUSION

The State of Texas currently has no comprehensive state energy policy. The uncoordinated policies of the many state agencies concerned with energy have prevented a systematic response to energy shortages. This report has tried to discuss these deficiencies and to recommend courses of action for coping with both immediate and long-range energy problems.

APPENDIX 1

SEADOCK: A Deepwater Terminal on the Texas Gulf Coast*

*Presentation by Fred Ashford, Jr., President of SEADOCK, Inc., to the Economic Development Committee, Texas Senate, February 16, 1974.

. . . the National Petroleum Council looked at domestic oil production through 1985 on the assumption that some environmental problems will be resolved and that economic incentives for domestic oil production will improve. Domestic production supplied 77 percent of U.S. needs in 1970 (see Figure App. 1-1) but proven reserves have been declining. If domestic production remains about constant through 1985 it will then meet only 48 percent of U.S. oil demand. That other 52 percent would have to come from foreign sources, primarily by ship, since half the world's oil reserves are in the area around the Persian Gulf.

By 1980 imports are projected on this basis at 10.5 million barrels per day. We are planning for 3 million barrels of that to move through SEADOCK.

But what about the Mid-East situation? And what about the U.S. goal to be energy self-sufficient by 1980? You read the same newspaper stories about the Mid-East that I do and probably have seen some predictions that the embargo will be fully or partly lifted within a week or two. No one knows that for sure, anymore than we know what the situation will be by 1977 when we hope to have SEADOCK in operation. We are moving ahead in a positive fashion, however, because we think that the United States will have to be ready to handle large amounts of imported crude oil at least until other forms of energy are ready to fill that supply-demand gap.

As for energy self-sufficiency by 1980—or by 1985, which seems to be the latest target date—there's a real question that any alternate sources of energy we've looked at can be increased dramatically by either date to substantially alter a continuous heavy reliance on oil. With things changing as they have in the oil situation in recent months, you can choose almost any forecast you prefer.

At SEADOCK at this time, however, we are continuing to plan toward the figures I have shown in this chart (Figure App. 1-1). But our design has the kind of flexibility that would permit us to build on a smaller scale or a larger one if needed.

SUPERTANKERS AND A DEEPWATER TERMINAL

The era of the supertanker or VLCC—which stands for very large crude carrier—has come about, of course, because transportation becomes a major cost item in moving large quantities of oil from distant points such as the Mid-East. These mammoth ships make low-cost oil shipments possible.

A 30,000-ton tanker has been the average on the Gulf Coast in recent years, so let's consider Persian Gulf to Gulf Coast shipping cost per barrel of crude on a 30,000-ton ship during 1980 as equal to 100 percent (see Figure App. 1-2). Use a 50,000-ton ship and you reduce that cost to about 88 percent (see Figure App. 1-2). A fully-loaded 50,000-tonner is the biggest ship that Texas ports—or most U.S. ports—can handle today. The 250,000-ton vessel, which is becoming commonplace, could cut the cost to 45 percent (see Figure App. 1-2) if we had any place to unload it. The 500,000-ton ship, the ship of tomorrow, could cut shipping cost to 38 percent (see Figure App. 1-2). Bigger ships have deeper draft and thus need deepwater terminals.

Numbers of ships would also be cut (see Figure App. 1-3). It would take thirteen 30,000-ton ships per day to supply 3 million barrels of crude or eight 50,000-ton ships but just one VLCC. Refining capacity is expected to grow, of course, so shipments *from* Texas ports could also increase. We estimate that the total load on Texas ports will double by the early 1980s without an offshore terminal. Port congestion would be staggering and would pose serious environmental problems because growing numbers of small ships could cause more accidents.

The real alternative to a deepwater port in Texas is transshipment in smaller ships from several ports in the Bahamas or Canada which can currently handle big ships. This cost is quite a bit less than direct shipment in smaller tankers but somewhat higher than direct VLCC shipment to the United States. Transshipping, however, can cost the United States jobs and investment because it encourages new refinery locations in foreign countries. And it still leaves that tremendous increase in small ships arriving in U.S. ports. About 4,000 tankers unloaded in the United States during 1970. Using 30,000-ton vessels for direct service or transshipment in 1985 would cause an increase to more than 20,000 annual arrivals. This compares with only 3,500 if 250,000-ton ships were used for Persian Gulf and African movements.

There is general agreement that we need a deepwater oil terminal. The best place to put it is near a major refining area. Here are four refining areas and locations for three proposed deepwater terminals (see Figure App. 1-4). The 3.3 million barrels per day of refining capacity located along the Texas Gulf Coast and Western Louisiana represent nearly 25 percent of total U.S. capacity. SEADOCK will serve this area. Another industry group in Louisiana—LOOP—will handle imports to another 25 percent of the U.S. refining capacity located in Louisiana and the Chicago area via Capline, one of the major U.S. petroleum pipelines. A third terminal would supply refineries in the New York-Philadelphia area. SEADOCK is not in competition with these other projects. We believe all of these terminals are needed.

THE SEADOCK TERMINAL

The SEADOCK terminal will be a single-point mooring system or SPM (see Figure App. 1-5). The tanker moors at the SPM or monobuoy and oil is pumped from the tanker through a floating hose to the SPM and from there into an

FIGURE APP. 1-1

U.S. OIL REQUIREMENTS

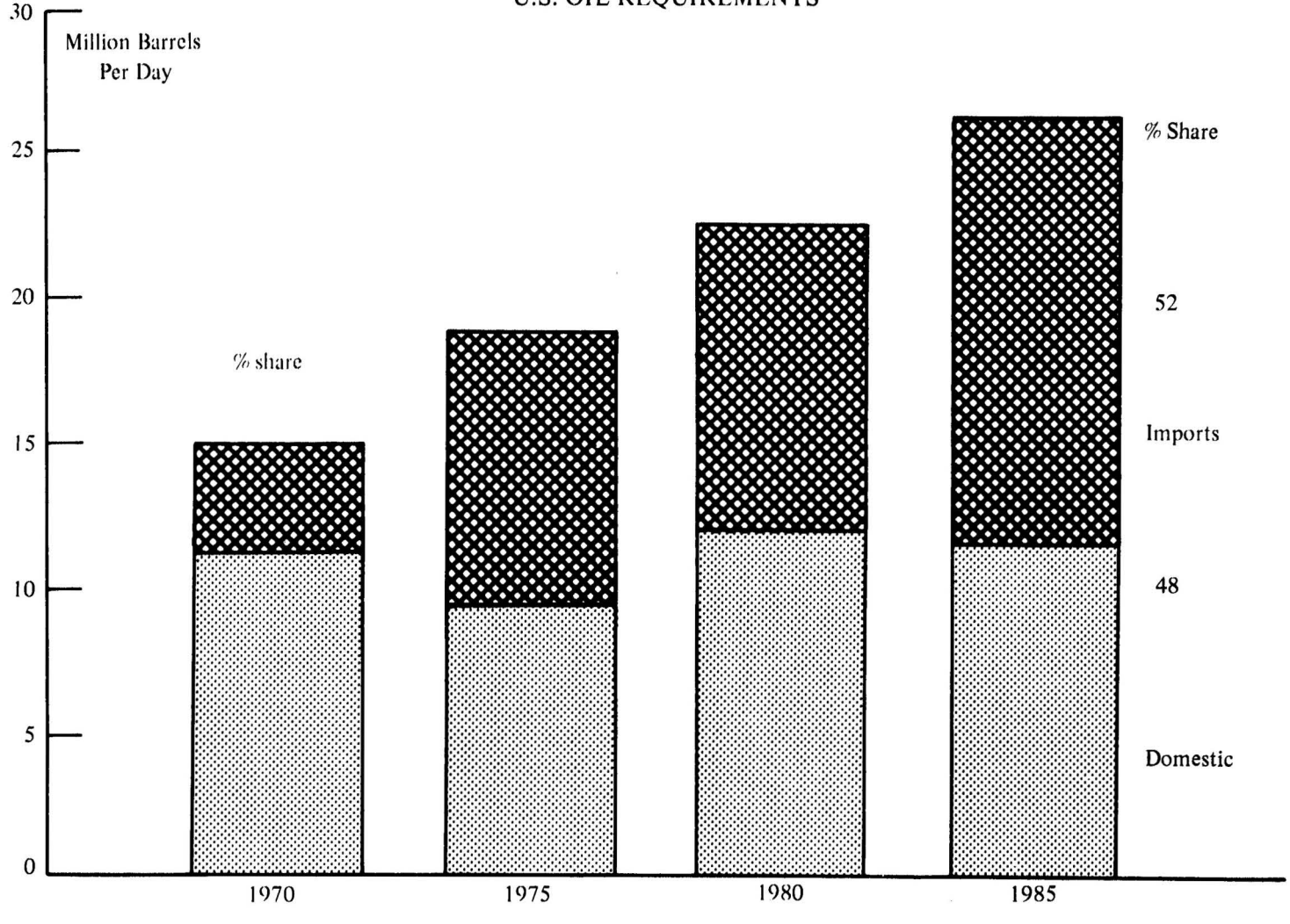


FIGURE APP. 1-2

TRANSPORT COST – NEAR EAST TO U.S. – 1980

	Ship Length	Draft	Cargo	Relative Cost/BBL.
1950	650'	35'	30,000 DWT	100%
1960	750'	38'	50,000 DWT	88%
1970	1150'	65'	250,000 DWT	45%
1975	1300'	95'	500,000 DWT	38%

FIGURE APP. 1-3

BIGGER SHIPS MEAN FEWER PORT CALLS

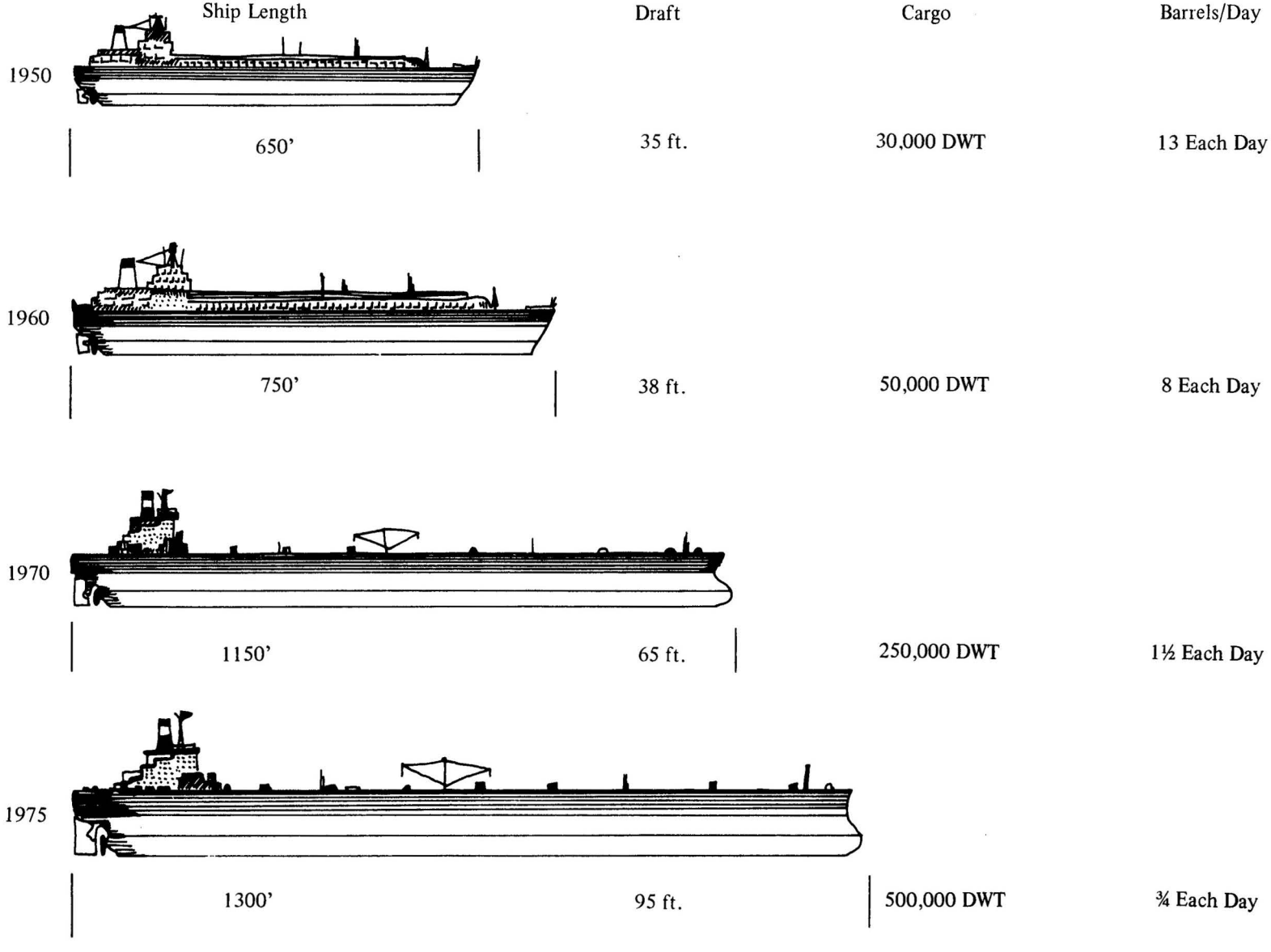


FIGURE APP. 1-4

LOCATIONS WHERE DEEPWATER TERMINALS ARE NEEDED

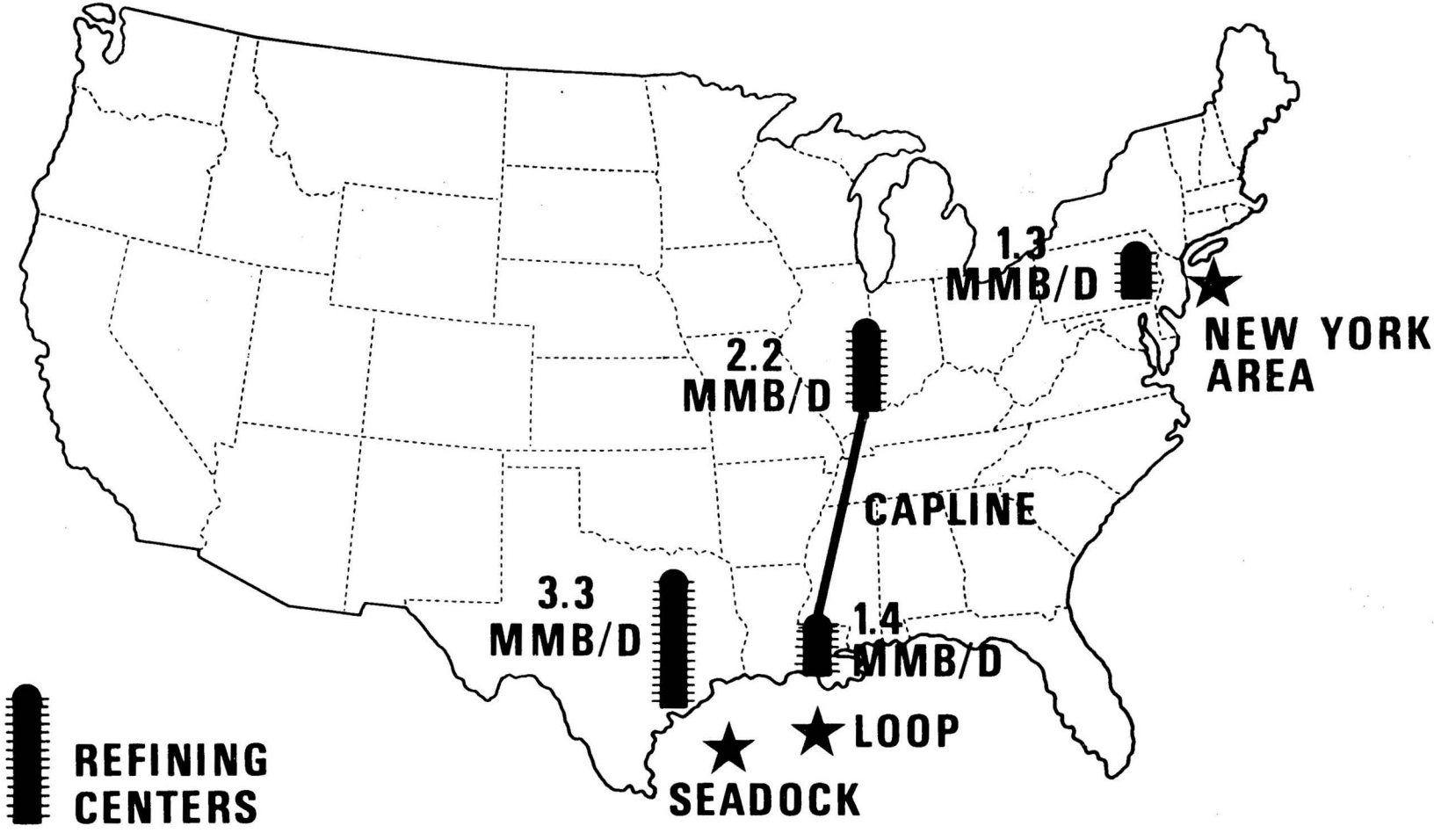
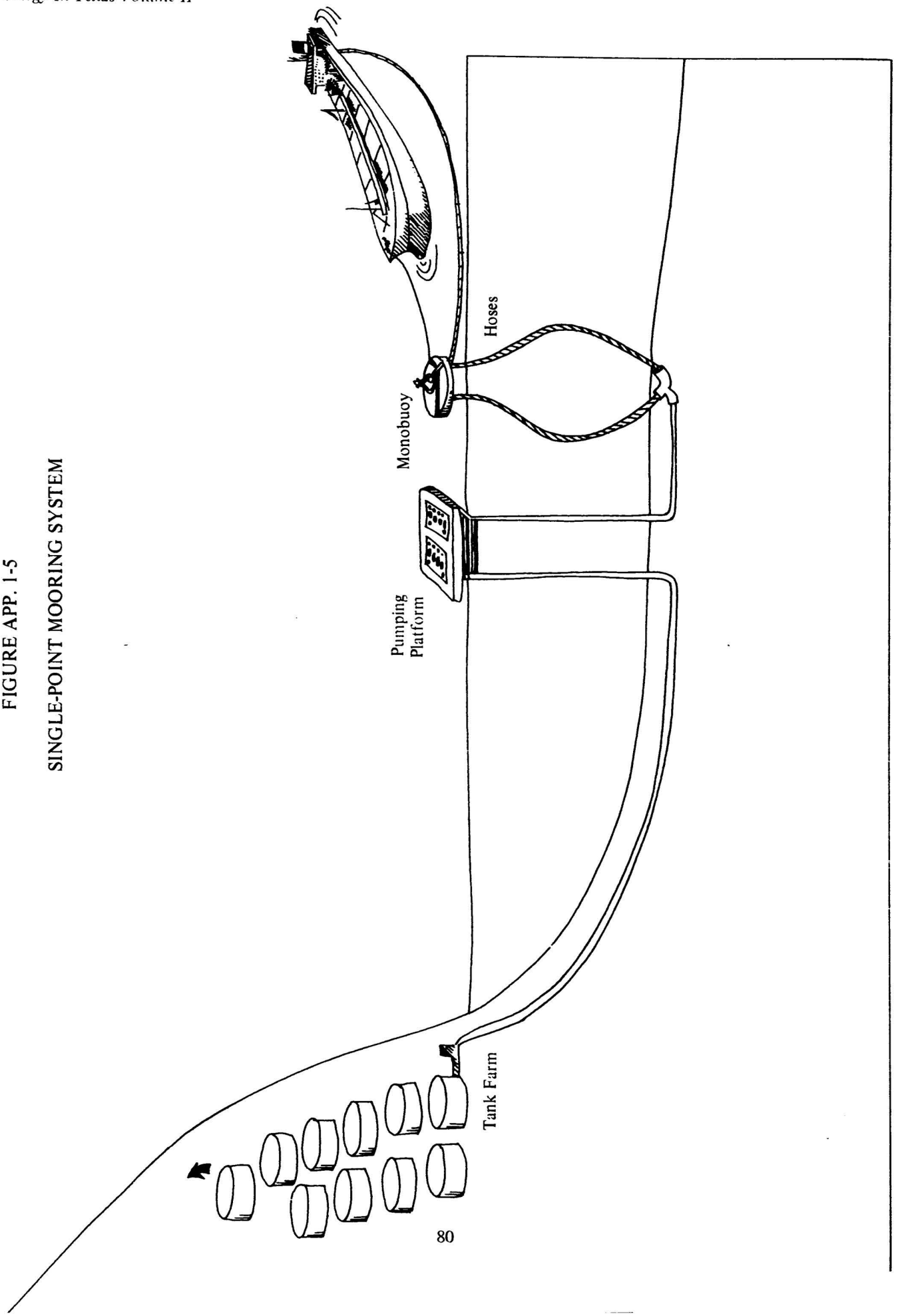


FIGURE APP. 1-5

SINGLE-POINT MOORING SYSTEM



undersea buried pipeline to a booster pump platform, then by buried pipeline to shore. The concept is proven. More than 100 SPMs have been put in successful operation worldwide over the past 15 years. The SPM can operate in weather that would put other types of terminals out of service. The tanker is free to weathervane about the buoy, facing into the wind, current, and waves to keep mooring line and other forces to a minimum. These buoys are sturdy and safe. . . . the Cantenary Anchor Leg Mooring (see Figure App. 1-6) uses a buoy which houses the oil connections on the surface and is anchored to the ocean floor by chains. Another design, the Single Anchor Leg Mooring (see Figure App. 1-7) has the oil handling connections below the surface. SEADOCK is studying advantages of both types.

Our initial marine facilities would be built 31 miles offshore from Freeport at a point where distance to existing refineries and distance from shore to deep water combine most favorably (see Figure App. 1-8). The monobuoy site is in naturally deep water and requires no dredging.

[The] schematic diagram of the SEADOCK facility (Figure App. 1-5) shows only one buoy for simplicity, though we plan at least three initially (Figure App. 1-9). All of them will be able to handle 500,000 DWT-class ships. A buried pipeline with unloading capacity of 125,000 barrels per hour or more will connect these buoys to a pumping platform. Large buried pipelines will move the oil from the platform to the onshore tank farm. At the Freeport terminal, crude oil will be metered and diverted into tanks with capacities of 500,000 barrels or more. Current plans call for more than 30 million barrels storage capacity. The primary communications and control center will also be at the onshore terminal. Oil will move by pipeline from this terminal to refineries.

We have already taken options on two tracts of land in Brazoria County. This gives us a basis to select the best possible site based on environmental studies and other considerations. We estimate that our total requirements would be approximately 1,500 acres with some 600 to 700 acres for the presently projected tankage requirements. This will provide acreage for auxiliary services and development of a liberal buffer zone.

The offshore facilities will look like this from overhead (Figure App. 1-9). There are three monobuoys visible here. SEADOCK's offshore facilities will be in approximately 110 feet of water and platform pumping capacity will be sufficient to move the crude some 37 to 38 miles to the Freeport terminal which will be inland from the coast. Modular design insures easy future expansion to accommodate deeper draft ships with additional platforms, buoys, and lines to shore as needed. The pumping and control platform complex, the three interconnected structures, will look somewhat like existing oil production platforms but will be much larger. It will house the entire offshore control operation, including living quarters for the offshore crews and a weather station and monitoring and communications facilities.

Construction of SEADOCK

Here is our schedule (Figure App. 1-10). We are now busy in the first two categories—design and engineering and environmental studies. We plan to be ready to apply for permits before mid-year. Since we still lack necessary federal legislation, it seems unlikely that permit acquisition will be complete before late this year.

Actual construction of SEADOCK could thus begin in late 1974 and would probably take at least 30 months. Operations could commence in early to mid-1977.

Environmental Concerns. For those environmental studies I mentioned, we have used Evans-Hamilton, the Institute of Storm Research at St. Thomas University in Houston, Southwest Research Institute, and numerous other consultants. Texas A&M University and Dames and Moore, a nationally recognized consultant, have a joint contract for the principal environmental work. We will spend more than $1 million on this work, now more than 90 percent completed, to discover what conditions now exist in the area affected by SEADOCK including deepwater, nearshore, and bays and estuaries as well as onshore. We will also determine how our project might affect the environment and how we can minimize undesirable effects, and determine how existing environment would affect our operations. As a result of these studies, we have already made significant design revisions.

Incidentally, we have conducted some of the most complete studies ever done on currents in the Gulf of Mexico. We have also engaged the services of a recognized expert, Dr. Dale Straughan of the University of Southern California, to do pioneer studies of Texas Gulf Coast beaches. We are told that these studies are extremely valuable contributions to scientific knowledge about these areas.

The facility we propose has several built-in environmental plusses. I have already mentioned that VLCCs can drastically reduce the number of ships arriving at our ports and thus lower the statistical chance of accidents. Past records show that most oil spill accidents happen where harbor congestion is great and where maneuvering of ships is restricted by narrow, winding channels (Figure App. 1-11). These accidents are rare on the open sea.

The President's Council on Environmental Quality has concluded that deepwater terminals and VLCCs would cut spills to about one-tenth of what they would be if small ships were used in direct service or transshipment.

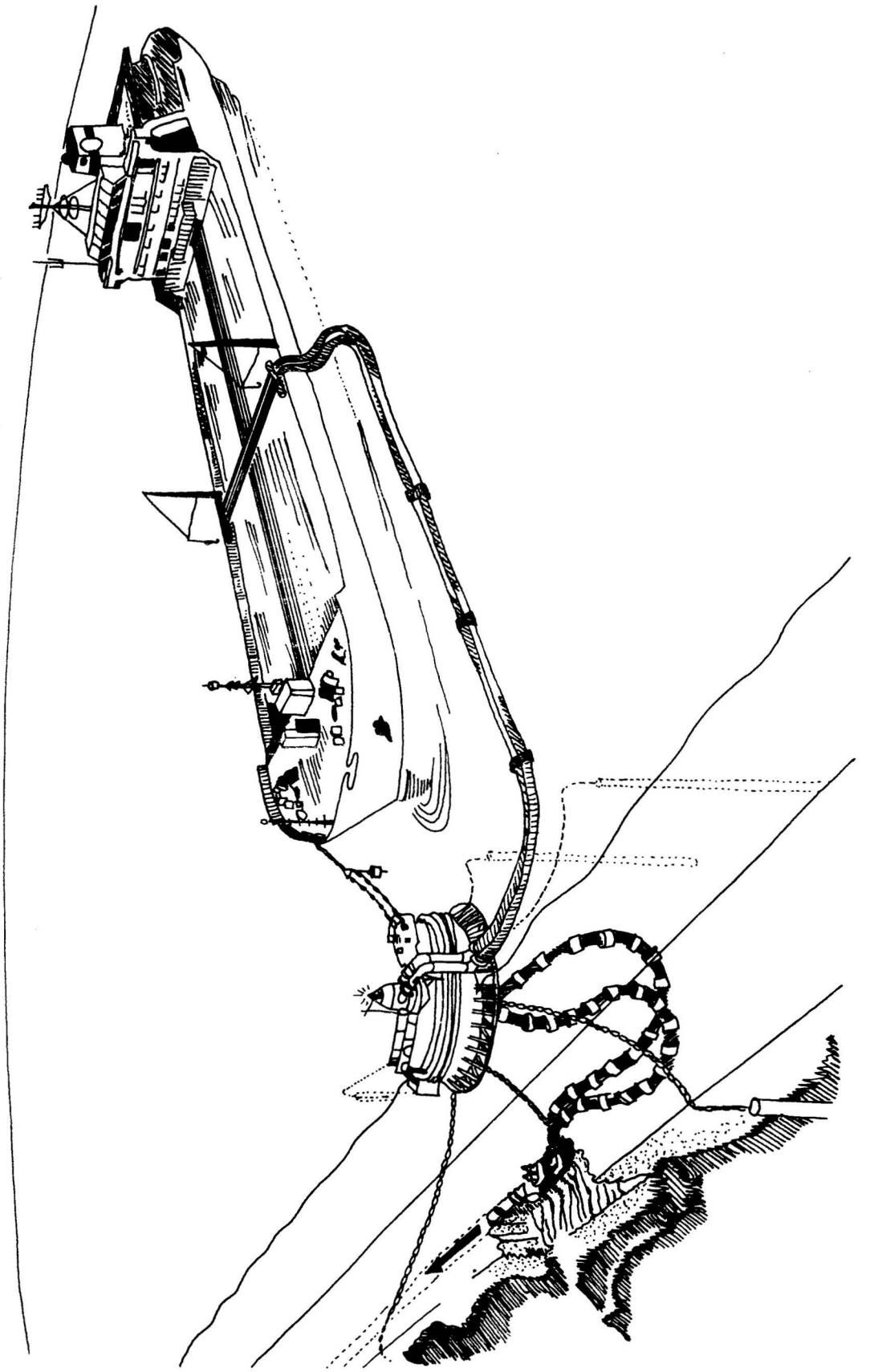


FIGURE APP. 1-6

PERSPECTIVE-CANTENARY ANCHOR LEG MOORING

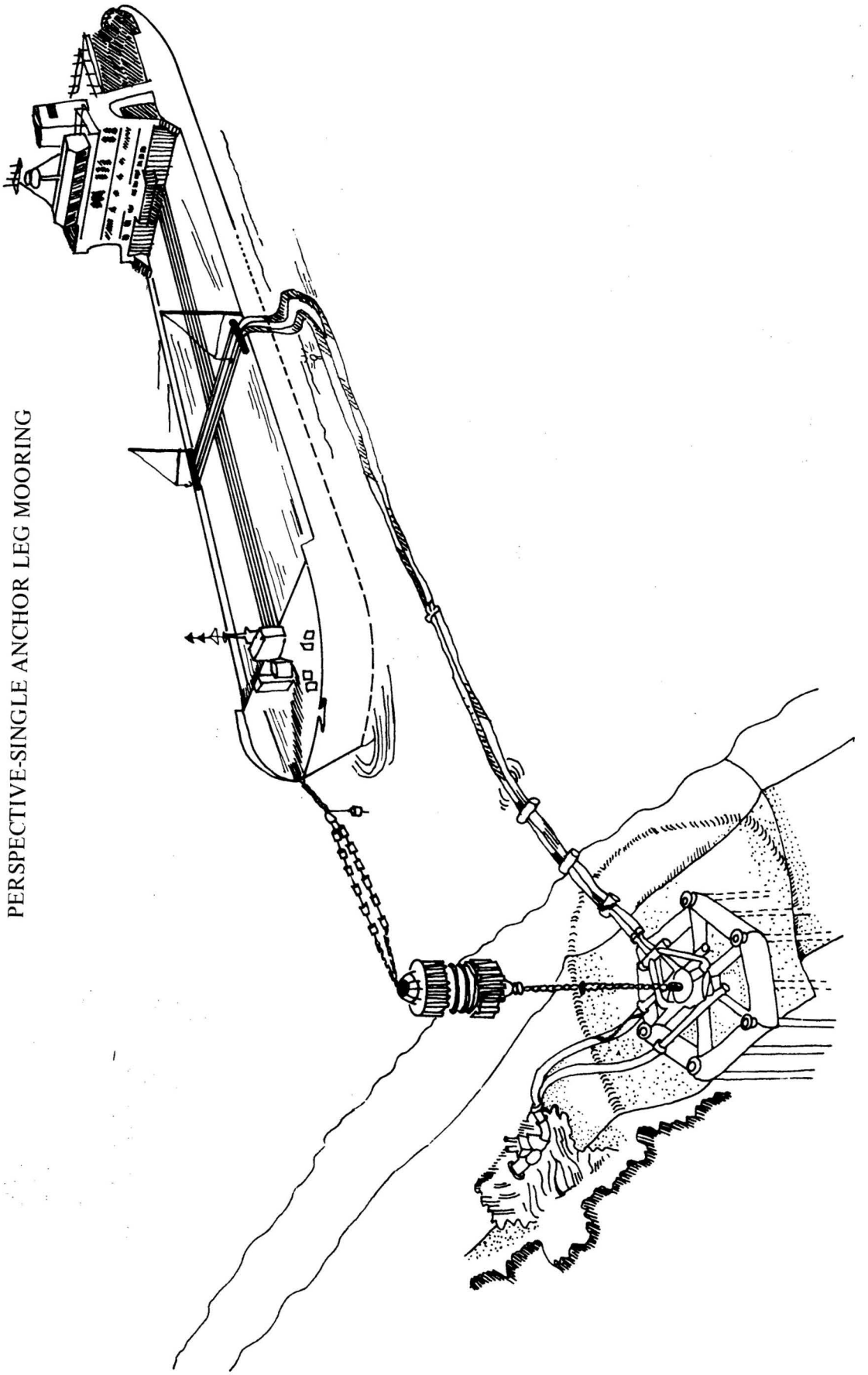
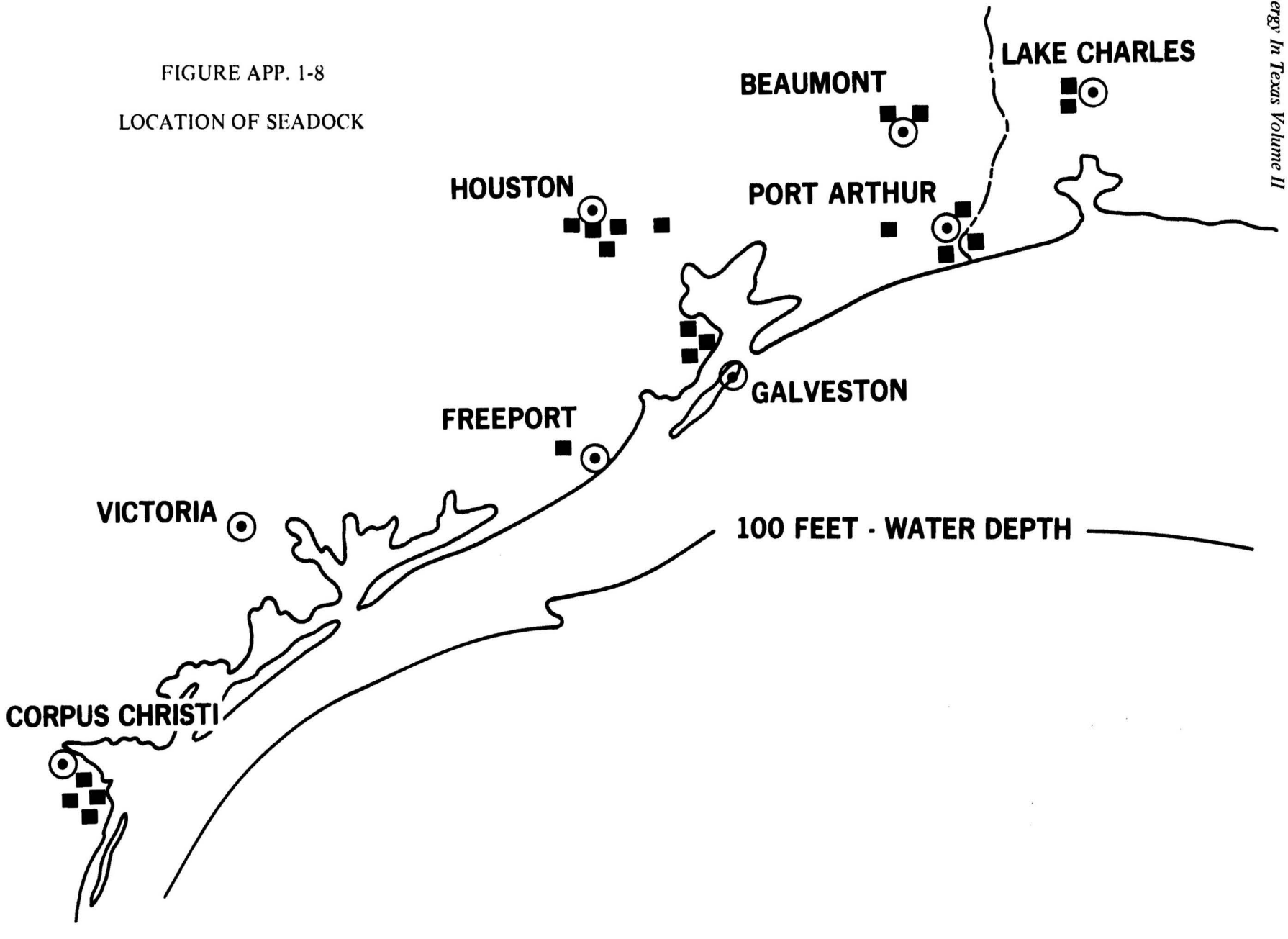


FIGURE APP. 1-7

PERSPECTIVE-SINGLE ANCHOR LEG MOORING

FIGURE APP. 1-8

LOCATION OF SEADOCK



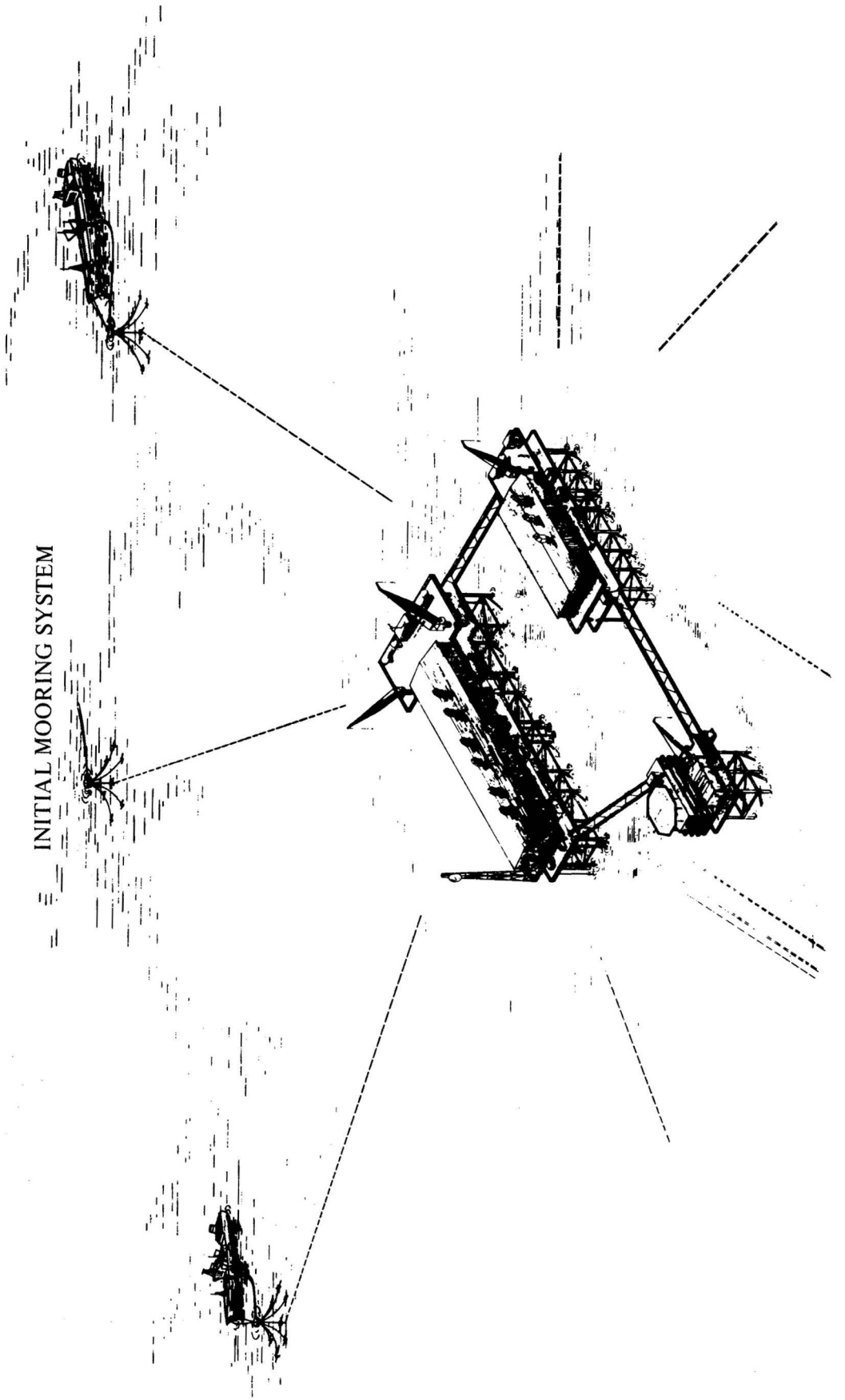
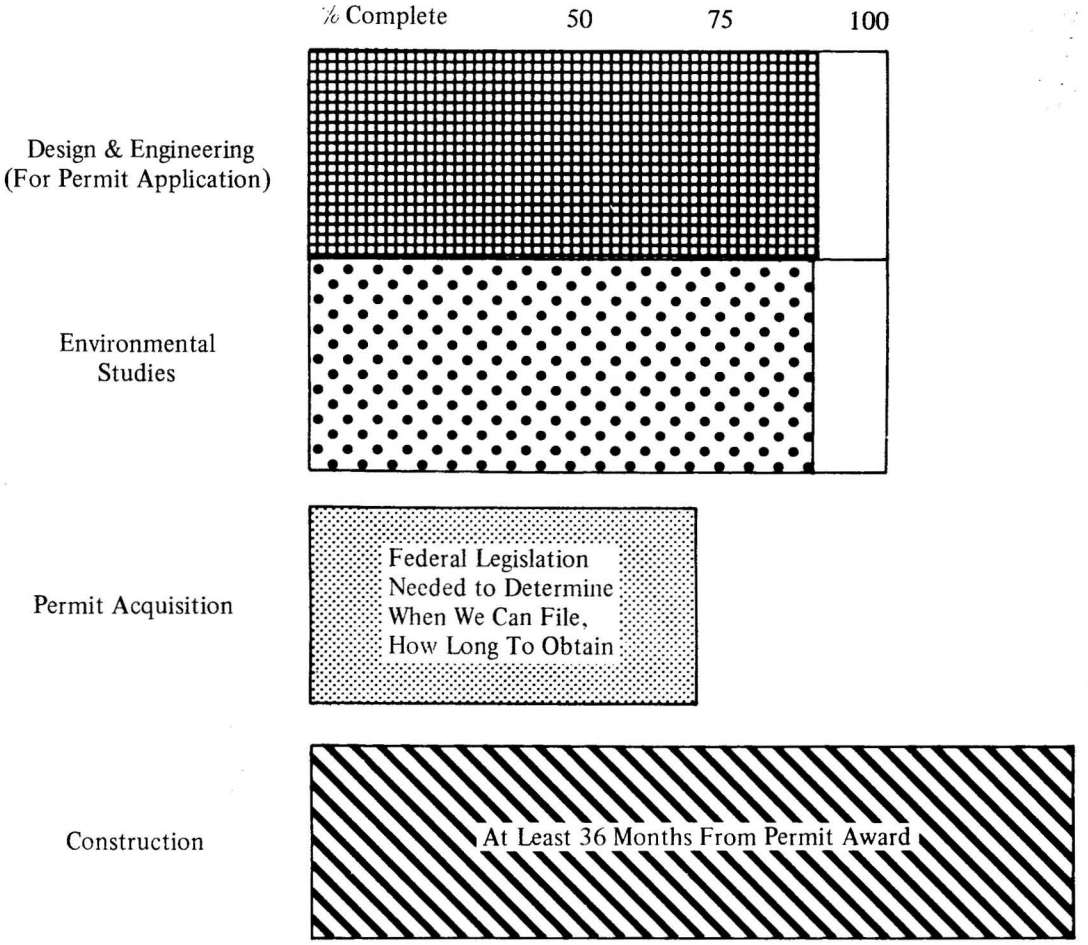


FIGURE APP. 1-9

INITIAL MOORING SYSTEM

FIGURE APP. 1-10

SEADOCK TIMETABLE



In short, environmental concern has been a basic consideration in designing SEADOCK. To sum it up quickly, SEADOCK's ability to serve VLCCs will reduce the number of tankers required for imports and will keep the ships far offshore where accidents are less likely to occur. SPM technology is proven, and SEADOCK will not utilize novel, untried concepts. In addition, spill clean-up capability is continually improving with the design of new equipment, the formation of cooperative organizations and the financial backing of insurance groups. We are convinced that SEADOCK will be beneficial to the Texas Gulf Coast environment.

STATE VS. PRIVATE OWNERSHIP

As you are aware, a major objection that SEADOCK has to the report of the Offshore Terminal Commission, which your are now considering, deals with the question of whether this deepwater terminal will be in the private sector or will be state owned.

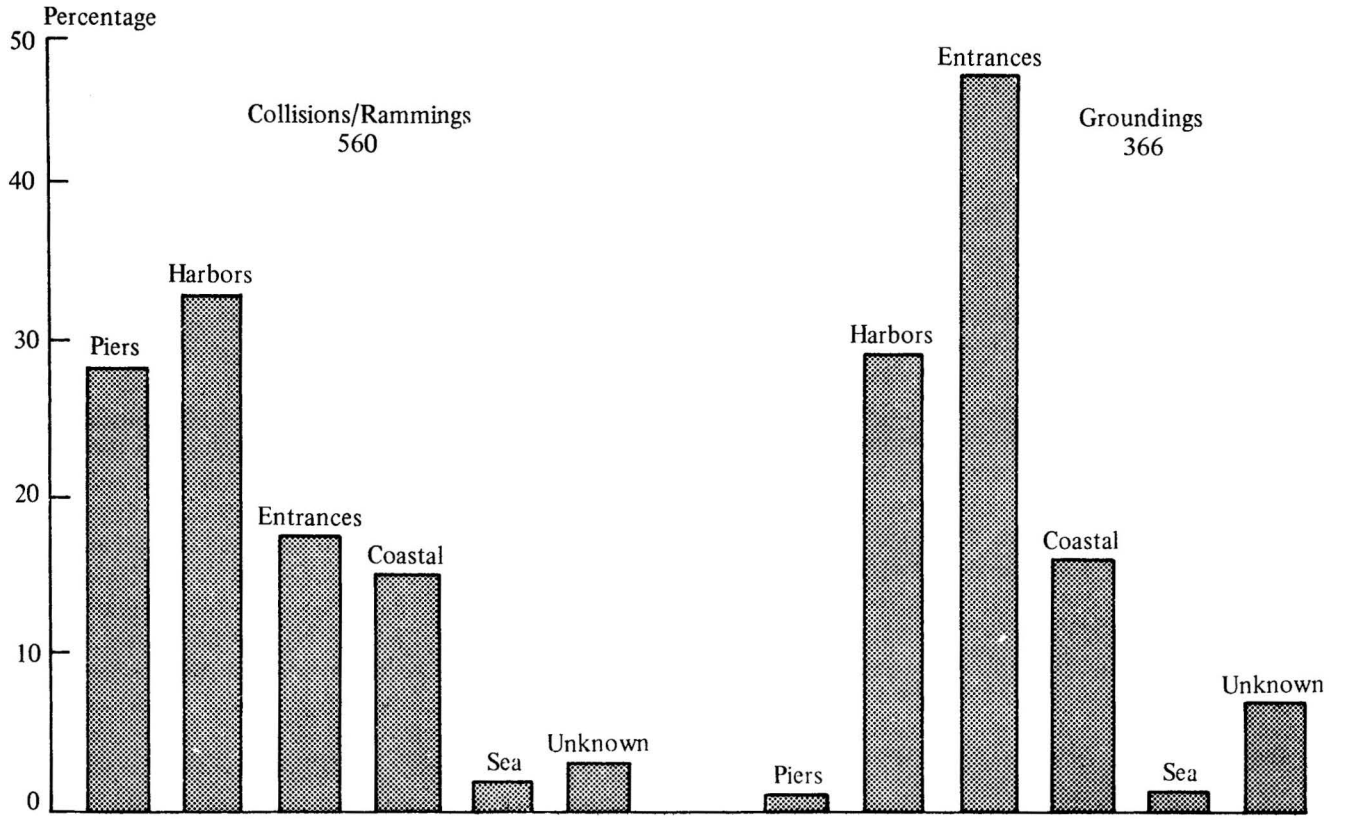
Certainly the Texas Offshore Terminal Commission itself was sharplv divided on this one point. It was exactly divided, in fact, with four commissioners for state ownership and four favoring private ownership when the issue was put to a showdown vote at the final hearing by the commission on January 24. It took a tie-breaking vote by Chairman Allbritton to swing the commission recommendation to the side of state ownership.

Private Ownership

This is an area where honest differences of opinion exist, but we believe that there are compelling arguments in favor of private ownership. The question of providing proper

FIGURE APP. 1-11

LOCATION OF TANKER ACCIDENTS



regulatory safeguards is consistent with private ownership and financing. The state's legitimate interests can and will be protected through appropriate regulatory safeguards and as long as private industry is ready, willing, and able to undertake the risk inherent in this project, we believe that any reasons for state funding disappear.

In arriving at its conclusion favoring state ownership and financing, the commission in the financing section of its report considered three distinct areas of interest. These were:

- the price to the Texas consumer at the pump;
- the economic interest of the state; and
- the environmental aspects of the project.

I have already described the sincerity of our commitment in the environmental area. It should also be clear from the efforts we have expended thus far that SEADOCK agrees wholeheartedly with the commission on the urgent need for the proposed facility. We both recognize the vital role it will play in ensuring the continued preeminence of Texas as a petroleum-refining and petrochemical center. In fact, because of the time and money we have already invested in the project, we believe we are in the best position to get on with the job as soon as the required legislation is enacted.

Consumers Interest. Let's now explore the question of consumers interest, for it is in this area that the basic differences between SEADOCK and the commission over financing and ownership are most apparent. The commission has argued that consumers would benefit from state ownership because of lower costs due to interest savings and elimination of profits.

First, the interest question. Using the commission's data, the total difference in interest costs between Alternative C—state financing using tax-exempt revenue bonds—and Alternative A—SEADOCK's approach—amounts to $14 million over the assumed 20-year life of the project. However, the state would borrow 100 percent of the capital cost while SEADOCK would borrow 90 percent. The total debt service on the additional 10 percent borrowing under state ownership more than offsets the lower interest rate.

Moreover, the cost saving attributed to tax-exempt financing is, in fact, illusory, because the real beneficiaries are the bondholders rather than consumers who, in the final analysis, will have to make up for the exemption through higher taxes.

Now let's address ourselves directly to the question of profits. It may be that tariffs are higher under the private ownership case because of the profit element. Elimination

of profits would save about two cents a barrel or about 1/20 of a cent per gallon to costs. However, the profit motive performs vital functions in our economy, as profits associated with this facility would do.

One of these vital functions is to encourage risk-taking by investors. The return on investment is the fair payment to the investor for taking risk—and there is significant risk associated with the proposed terminal. Mr. Dellinger of the commission recently pointed out that, if the state decides to own the facility and be responsible for the debt repayment, it does so after having already been put on notice that the federal government has a goal of energy self-sufficiency by 1980. Regardless of how realistic you may consider that self-sufficiency goal to be, you must surely concede that there will be great dedication devoted to eliminating the need for this facility. The commission's report itself mentions construction delays, uneconomic operations, acts of God, supply interruptions, and the possibility of oil spills. SEADOCK's shareholders are all in the risk-taking business; current events have only served to underscore this fact. As long as private enterprise will assume these risks, the state need not do so.

Everyone should understand that this risk is always there no matter who finances the project. You cannot escape the cost of this risk whether the project succeeds or fails. So it makes no difference whether the state passes along the cost of this risk to the petroleum consumer directly. This becomes another mortgage on the state and thus on the taxpayer and affects the future ability of the state to provide finances for other services in the future throughout the entire life of the project. Somehow this risk cost must be paid, either as a straightforward cost of the product or as a hidden tax.

One further point. As a practical matter, government restrictions limit distributable earnings to 7 percent of the facility's valuation. Thus there are definite, visible ways already existing to protect the consumer interest when we do treat this risk cost directly. Let me quickly add that these governmental limitations on return do nothing to guarantee a fair rate of return. No one guarantees us a profit.

Legislation. Now, in looking at the economic interest of the state, it might be appropriate to mention that the legislation which established the Texas Offshore Terminal Commission gives support to the private sector and places the burden of proof upon any agency seeking to go beyond reasonable regulatory and environmental controls. H.B. 52, passed on October 11, 1972, states: "... design and construction of the offshore port would reside within the private sector. This philosophy is in keeping with the legislative intent expressed in HCR 138 ...." House Concurrent Resolution 138, in turn, states in part: "Resolved, That the House of Representatives, the Senate concurring, finds and declares that it is the proper function of the government of this state, at all levels, to foster and aid the private sector of our economy and to prevent governmental competition in areas where the private sector has the capacity to provide the goods and services required by such bodies and agencies."

Taxpayers' Interest

Thus far, we have spoken of the citizens of Texas in their role as consumers. Let us now change our perspective somewhat and look at the question of ownership and financing through the eyes of Texans as *taxpayers*. From this viewpoint, we believe the case for private ownership becomes even more persuasive.

Under Financing Alternative C—that favored by the commission—the bonds would be secured solely by a pledge of revenues from the facility. However, the commission recognized that the relatively high risks associated with the project might well require a resolution of moral obligation by the Texas legislature in order to market the bonds. While the term "moral obligation" sounds fairly innocuous, we feel it deserves some discussion, particularly in light of the sale last month of a $302 million revenue bond issue by the New Jersey Sports and Exposition Authority. As you probably know, a statement of moral obligation by the New Jersey Legislature was required to sell these bonds. Even with this additional security, and despite the tax exempt feature, the interest rate of 7.5 percent was less than .5 percent below the rate at which a double-A rated industrial bond could have been placed on the same day. This interest-rate differential is quite a bit narrower than the 1 percent difference which the commission assumed in its report. Further, as a result of the controversy surrounding the sale of these bonds, the interpretation of a "moral obligation" has moved much closer to that of a legal obligation. For example, the controller of the currency ruled that the Sports Authority bonds are backed by the "full faith and credit" of the state. At the same time, in assigning a rating to the bonds, Moody's took the position that "the State is chipping away at its own financial structure." A lawsuit is still pending which charges that New Jersey's moral pledge commits the state's credit to the bond issue without a referendum as required by law. Whatever the merits of the suit, it is clear that neither New Jersey's image nor its credit rating has been enhanced by the whole episode. Should the State of Texas be subjected to this same kind of dilemma?

Let me re-emphasize at this point the urgency of the need for this deepwater terminal. Throughout the plan submitted by the Texas Offshore Terminal Commission and in statements by virtually everyone who has studied our present energy situation, this sense of urgency has been underlined. We agree wholeheartedly. But we do not agree with statements which the commission has made—most recently in an "Information Sheet" from the commission staff—that the time schedule for this facility will be the same regardless of public or corporate ownership.

The type of confusion I have just been discussing is just one of many ways in which we feel that state ownership could delay and jeopardize this project.

Tax-free Bonds

Finally, we are somewhat less confident than the commission that interest payments to the holders of bonds sold by the state would be exempt from federal income taxes. In order for the bonds to qualify for tax exemption under Section 103(c) of the Internal Revenue Code, the facilities must satisfy certain public use requirements and, given the significant loss of federal tax revenue involved, there continues to be room for question as to how the IRS would eventually rule in this case. At stake would be not only income taxes on the bondholders, which could be well in excess of $100 million, but also some $450 million in taxes that SEADOCK as a private owner would pay on its earnings. In this connection, a portion of the testimony given last fall by Mr. Jared G. Carter, Deputy Undersecretary of the Interior Department, before a House committee considering federal Deepwater Port Legislation is relevant. Addressing himself to the question of tax exemption, Mr. Carter said: "My . . . last specific point is that we see no reason to provide a Federal subsidy, in the form of tax free bonds, to deepwater port licenses . . . . Industry has given every indication of its willingness to finance the construction of these facilities without Federal assistance and will undoubtedly do so absent the threat of heavy charges from the adjacent state."

SUMMARY

Let me point out in closing that we have provided to each of you a copy of my formal remarks as well as some related material you may find of interest. Included in the binder you will find copies of the charts to which I have referred, a copy of previous statements by SEADOCK before the recent public hearings of the Texas Offshore Terminal Commission, a copy of a statement by the Mid-Continent Oil and Gas Association before the Dallas public hearing on the commission plan, and copies of some recent editorials on this subject which have appeared in leading Texas newspapers.

To sum up SEADOCK's position, we agree with the Texas Offshore Terminal Commission on the need for the best location for, and the best type of, an offshore terminal for Texas. SEADOCK does not agree, however, that state financing is necessary or proper.

We would point out that interest-rate savings for state as opposed to private financing would probably be only one-third to one-half of those claimed by the Terminal Commission. What interest-rate savings would be possible would eventually all come out of the taxpayer's pocket. And someone must assume the financial risks for this project, risks that inherently carry a cost that must be paid.

As long as industry stands ready, willing, and able to take these risks, in return for a hope of fair reward, it is both unnecessary and highly inappropriate for the state to own and finance the terminal.

APPENDIX 2

THE QUESTION OF PUBLIC OR PRIVATE OWNERSHIP OF A DEEPWATER TERMINAL IN TEXAS*

*Statement by Dr. W. Philip Gramm, Professor of Economics, Texas A&M University, before the Economic Development Committee of the Texas Senate, March 4, 1974.

Chairman Creighton, members of the Senate Economic Development Committee, ladies and gentlemen, the central issue before us today is whether or not a public project should be undertaken to build and operate a Texas deepwater terminal. It is the contention of the *Texas Offshore Terminal Commission Report* that "... public ownership provides the least costly financing alternative and thus provides the least cost to the ultimate user—the consumer—of the products resulting from the crude petroleum transported through the facility" (p. 2).

PUBLIC OWNERSHIP

In Section VII of the commission report the "justification" for public ownership is presented. The report assumes that the construction and operating costs of the terminal will be identical under public or private ownership, except that under public ownership the rate of interest on bonds sold to finance the terminal will be lower due to the tax-exempt status of state bonds. As a result of the lower financing cost, it is asserted that the user cost will be lower and the consumer of petroleum products will therefore pay a lower price. From these assertions, the conclusion is reached that the interest of the people of Texas is therefore served by public ownership and operation of a deepwater terminal.

I will address my remarks today to the central issue of public ownership and operation of the deepwater facility. In this respect I contend that *every* major facet of the argument in the commission report offered in support of public ownership and operation is either invalid or exists as an assertion which is presented with a clear absence of any justification.

Tax-exempt Bonds

I begin with what is the main error in the report, namely, a failure to understand, or at least a failure to present, all the ramifications of tax-exempt bonds. Tax-exempt bonds can, in general, be sold at a lower effective interest rate per face value than non-tax exempt bonds simply because people in this country who earn very high incomes can earn more after taxes by buying tax-exempt bonds paying a lower interest rate than by buying non-tax-exempt bonds which yield a higher interest rate. Higher-income people are willing to buy tax-exempt bonds at a lower rate of yield *only* if they save more taxes than they give up by accepting the lower interest rate. What the commission report has neglected is that tax receipts must fall *more* than the interest savings on the tax-exempt bonds. The savings gained by the issue of tax-exempt bonds to build a publicly-owned deepwater terminal are simply borne by the lower-income taxpayer who is too poor to take advantage of tax-exempt bonds as a tax dodge and must pay more taxes to make up for the lower taxes paid by the higher-income purchasers of the tax-exempt bonds.

The use of tax-exempt bonds to finance the deepwater terminal will therefore produce three effects. (1) If the tax-exempt bonds are guaranteed by the taxpayer or the terminal users, who would then bear the costs should the venture fail economically, the effective financing cost of the project will be lower. Then, if all the presumed cost savings are passed on, the consumer *may* save a small amount in his consumption of petroleum products. (2) Buyers of tax-exempt bonds will benefit to the extent that the increased sale of bonds drives up the interest rate on such bonds. (3) The taxpayer will pay more in taxes than he saves on petroleum products even if all savings from the lower financing cost are passed on to him. Such a program thereby transfers wealth from the tax-burdened middle classes to higher income taxpayers and from all taxpayers to all petroleum users. The important point here is that there is no net saving whatsoever. The cost of financing is the *same* under tax-exempt financing and private financing—just different people are paying the freight. Like so many other government programs which are supposed to benefit "the people," public financing with tax-exempt bonds would simply transfer costs from the user to the general taxpayer. The only possible gain from the use of tax-exempt bonds is that to the extent that people in other states will have to pay some of the higher income taxes saved by those who buy tax-exempt bonds, we might beggar our neighbors.

Production and Operating Costs

A second major error of the report I challenge is the assertion that production and operating costs will be the same under either public or private ownership. I think the people of Texas are going to find this assertion difficult to believe, given the poor record of government in operating facilities that are best left to private enterprise. The plain truth is that under public ownership and operation there is simply no reward to the operator for being efficient, and efficiency cannot even be measured without free market criteria, such as free market price and profits. In any case the burden of proof seems to rest with those who would advocate public ownership and no evidence is presented in the report.

Plan C

A third major error I would call to your attention is that there is no evidence to substantiate the fact that under the advocated Plan C, where the taxpayer is not liable for the bonds if the venture should prove to be an economic failure, a lower rate of interest could be obtained even with the tax-exempt status of the bonds. In fact, such a system

could easily produce higher financing cost if investors think the project relatively risky. In fact, the report recognizes this possibility and notes that Plan C may be impossible to implement. In any case, the assumption of a lower financing cost becomes highly questionable without obligating either the taxpayers of Texas or the users of the terminal to pay off the bonds if the project is a failure. By the logic of the report, which has oil companies passing along all costs to the consumers, *even if* the oil companies are liable, the consumer will ultimately suffer through higher fuel bills if the project fails.

Risk

As the report recognizes, the construction and operation of a deepwater terminal is a risky business. This is especially true given the fact that the federal government has stated a policy of attaining self-sufficiency in energy sources by 1980, a mere three years after the terminal would be completed. If the goal of self-sufficiency is achieved, the terminal will be useless for its stated purpose of providing for the efficient and economical import of foreign-produced crude oil. But even if the goal of self-sufficiency turns out to be unrealistic, the presence of such a stated objective greatly adds to the riskiness of the project. The presence of such risk will place the taxpayers' resources in jeopardy if the bonds are guaranteed and produce an interest rate as high or higher than the non-tax-exempt private bond rate if the bonds are not guaranteed.

The great bulk of the report deals with the benefits in production and employment from the construction and operation of the terminal. Yet all of the benefits will be attained if the terminal is privately built and operated. Additionally, SEADOCK or any other private operator will be forced to bear the risk involved in its construction and will have a self-interest to see that the facility is built and operated in the most efficient manner. Does anyone seriously doubt that businessmen who deal with risk every day are in a better position to make the decision about whether to build such a project than is the government? Further, to the extent that the members of SEADOCK (12 oil companies and one petrochemical company) are selling transportation and storage services to themselves, the profit margin is irrelevant. For if prices for transporting and storing petroleum are set at a high level, each participating company will pay a high price, but the excess above cost will accrue to it in profits. Therefore, to the extent that the users own the terminal, they cannot earn a net gain by selling to themselves unless the transportation and storage costs are lower than alternatives, and only the costs of production and operation are relevant since any charge above or below that rate will be reimbursed or charged to the owner-user in his profits or losses. The whole discussion of saving the consumer a 7 percent profit rate in the commission report is therefore irrelevant.

The People's Interest

We come now to the final argument for public ownership: the people's interest is served through a publicly-owned facility because the citizens of Texas have a strong interest as consumers. I ask you as members of the Senate Economic Development Committee if this same logic could not be used to argue for public ownership of all of our factories, our farms, and even our homes? What tyrant has not claimed to promote "the people's interest" when he took away his people's freedom and their property?

We have built America into the greatest industrial and agricultural nation on earth by relying on private industry to produce and distribute our goods. The only legitimate case which could be made for public ownership would be if all the citizens of Texas would benefit from the terminal and private firms could not or would not build it. The high risk involved makes the assertion of benefit questionable, and in any case, private firms are ready, willing, and able to build the terminal.

I am sure that you as members of so important a committee must make many difficult decisions in performing your duty to the people of Texas, but this report is so clearly flawed in its economic analysis and so alien in its philosophy as to make your duty clear. I urge you to reject this proposal in the name of economy, social justice, and freedom. Thank you.

APPENDIX 3

TEXAS OFFSHORE TERMINAL COMMISSION

Financing A Texas Deepwater Terminal*

*The following analysis is taken from section VII of the Texas Offshore Terminal Commission's report, *Plan for Development of a Texas Deepwater Terminal*, January 24, 1974.

A. SCOPE

The Commission's plan is legislatively required to "... contain specific means by which the terminals may be financed. . . ." The Commission finds that there are several viable financing alternatives. Hence, this part of the Commission's plan presents those alternatives. The descriptions, advantages, and disadvantages of these alternatives are described below. At the end of this part of the Commission plan, pages 103 to 119 are cash flow charts reflecting these basic alternatives and variations thereof. Further elaboration upon the financing alternatives discussed below is presented through the detailed data in these charts.

The Commission recommends that legislation be enacted which would provide for implementation of any one, or a combination of these alternatives. Proposed federal legislation regarding deepwater ports (H. R. 10701) is now pending before the national Congress, and is supported by resolution of this Commission. Passage of both the federal and complementing state legislation will permit the Commission to develop the financing alternative in the best interests of the citizens of the state, and in the economic interests of all citizens impacted by the actions of the State government of Texas.

B. GENERAL DESCRIPTION OF FINANCING

1. Method

The financing of revenue producing facilities of the type and magnitude of a deepwater port is often accomplished through the sale of bonds to the extent necessary to obtain sufficient funds to pay for construction of the facility. Once the facility is completed, those who utilize it pay fees for that use. The revenues from those fees are utilized to repay, with interest, those investors who purchased the bonds, and also to pay for the costs of operation and maintenance of the facility. Those who would use a deepwater port facility are firms bringing imported crude petroleum into Texas. The fees they would pay would be for docking at the facility, for pumping the oil from the ship to the on land storage facility, and for storage of the oil at the storage facility.

Financing of the deepwater port, as recommended herein is no exception to this usual method.

The variations of this usual method are whether the financing is to be public or private, and what security is utilized to ensure full repayment of the bonds.

2. Common Factors

There are common factors to all the financing alternatives presented by the Commission. They are:

(a) The facility includes all components, as described in Part V. ENGINEERING, up to the petroleum departure point from the on land storage facility.

(b) The magnitude of the cost of constructing this facility is $400 million during 1975-76, plus $20 million for facility expansion in 1979, including eight percent (8%) interest cost for the interim construction finances. In the cash flow charts, two specific estimates made by other entities and of the magnitude of the above figures were utilized.

(c) There are, for financial calculations, two sets of charts reflecting and comparing alternatives for two different circumstances: The first for a facility life of twenty (20) years, and the second for a thirty (30) year facility.

(d) For the various alternatives, principal payments vary but interest is calculated on the declining principal balance.

(e) The charge or tariff per barrel moved through the facility is equal to:

$$\frac{\text{(Operation \& Maintenance)} + \text{(Principal \& Interest)}}{\text{Estimated Number of Barrels per Year}}$$

(Additionally, several variations of the alternatives add a profit factor to the numerator.)

(f) Future dollars are converted to present value to establish comparable figures for all alternatives. A 10% discount rate was utilized for this conversion. A change in the discount rate used does not affect the relative dollar positions of the alternatives.

C. SPECIFIC ALTERNATIVES

The three most viable alternatives, and appropriate variations of each, are presented in this section. They are:

1. Alternative A

Alternative A is the basic corporate financing plan. Chart A_1 reflects the cash flow of that plan. The main points of Alternative A are:

a. The companies which would be the prime users of the facility would make an initial cash investment of 10% of the construction costs; the remaining 90% debt would be financed by these companies over twenty (20) years at approximately eight percent (8%) interest.

b. The oil companies would execute "take or pay" throughput contracts, with the corporate entity established by them to develop, operate, and own the facility. In these contracts, each company would guarantee to pay for the throughput of a minimum number of barrels per year, even if the company did not actually import that number of barrels during the

year. The sum of these "take or pay" contracts would be sufficient to cover all costs, including debt service of the facility for that year.

c. Book depreciation is straight line, and equal to principal reduction; tax depreciation would be on the basis of accelerated or declining balance methods.

d. The tariff per barrel would be sufficient to cover operations and maintenance (O&M) + Principal and Interest (P&I) + Return on Base (ROB). Return (ROB) is the Interstate Commerce Commission allowed seven percent (7%) of rate base. The rate base is calculated, per ICC, as capital investment less straight line depreciation at 1.5% of capital investment per year.

Under Alternative A, the estimated average present value tariff for a twenty year operation would be 4.58c per barrel. With Alternative A the corporate entity would own the facility. With the companies assuming such a liability for signing take or pay contracts, their present value interest for such obligation would come to approximately $188 million which is comprised of:

Book income after tax:	$190 million (Present Value)
Plus The	
Depreciated asset:	$ 38 million (Present Value of ICC rate base with future value, after 20 years depreciation, of $260 million)
Less	$ 40 million initial cash investment.

2. Alternative B

Alternative B represents traditional governmental financing of a revenue producing facility: the use of tax-exempt revenue bonds which fund construction. Tax-exempt bonds are bonds issued by State and local governments for constructing public purpose facilities. As such, the interest paid to purchasers of these bonds is not taxable income to them. Because of this tax-exempt factor, these bonds would probably be salable at a lower interest rate than corporate bonds.

Costs to users of the facility are set at the level necessary to generate sufficient revenues to repay the bonds plus pay operational and maintenance costs. Security for the bonds are "take or pay" contracts between the oil companies and the governmental entity issuing the bonds.

This alternative would provide the lowest tariffs–an estimated average present value of 2.91¢ per barrel over the twenty years–due to the lower interest rate (tax-exempt and secured) and exclusion of the seven percent (7%) Return on Base (ROB) of Alternative A.

Chart B_3 reflects the cash flow of this plan. The facility would be owned by the governmental entity.

The other main points of Alternative B are:

a. No "up front" cash would be necessary. The 100% debt would be financed for twenty (20) years at an assumed 6% interest.

b. Contracts would be prepared in a form in which the oil companies could receive depreciation and investment tax credit, in addition to expensing the tariffs paid.

ALTERNATIVE	PROBABLE INTEREST RATE	FINANCING METHOD	SECURITY
A	8%	Taxable corporate bonds	"take or pay" contracts, oil companies with a corporate entity
B	6%	Tax-exempt revenue bonds	"take or pay" contracts, oil companies with State
C	7%	"	Revenues

3. Alternative C

This alternative is the same as Alternative B, but without the security of the "take or pay" contracts. Without this security, it is probable that the interest rate on the bonds would be higher than the six percent (6%) of Alternative B, but lower than the taxable interest of eight percent (8%) of Alternative A.

For the development of cash flow charts a seven percent (7%) rate is therefore shown as probable. Chart C_2 reflects that cash flow. The present value estimated average tariff, over twenty (20) years, would be 3.01¢ per barrel.

More so than the other alternatives, Alternative C would require a particularly strong financial feasibility report which would have to be fully acceptable by potential purchasers of bonds. The source of such a report must be a nationally recognized authority, with oil, transportation, and financial expertise.

Absent such a feasibility report a low interest rate could be enhanced and a successful bond sale could be assured if the Texas Legislature resolved that the State had a "moral obligation" to ensure bond repayment. If deemed appropriate by the Legislature, this statement would be in the form of a concurrent resolution that the Legislature would exercise its powers as necessary to ensure payment of debt service and operation and maintenance costs, should some unpredictable action temporarily reduce revenues below those necessary to meet costs of the facility.

As there are no contracts with the users in this alternative, the oil companies would not have the tax advantages of depreciation and investment tax credits. Concurrently, they would not have the contractual liabilities of Alternatives A and B, nor would they be required to provide the $40 million "up front" cash of Alternative A. Ownership of the facility would reside in the government entity issuing the bonds.

D. COMPARISONS OF ALTERNATIVES

Selected overall observations of the alternatives, additional comparisons, and conclusions are contained in this section of the report. The Commission is persuaded that three separate but related interests must be equated in this summary of conclusions.

The first: The *citizens of Texas* have a strong interest as consumers. This interest, stated simply, is that the lower the tariff for using the facility, the lower the cost passed on to the consumer.

The second: The *government of the State of Texas*, representing its citizens, has two interests in the facility in addition to consumer advocacy. Therefore, the Commission finds:

> That the facility must be constructed because of its necessity to the State's economy, and to the general economic well-being of a large segment of the U.S. economy and;
>
> That the construction and operation of the facility must meet the highest environmental requirements. (It is presumed that the more involved the State is in financing, the more flexibility and control the State may exercise in preserving its interest.)

The third: *The oil companies must be in general agreement with the recommendation if an unscathed conversion of the Commission's recommendations into legislation is to occur. For the oil companies to be in agreement, the recommendation must therefore serve at least some interests of the oil companies.*

The chart on page 100 presents a brief comparison of the financing alternatives.

The chart on the following page indicates that, in an overall sense, Alternative C is the most attractive. However, the Commission is cognizant that there are conditions and variables which may detract from Alternative C and/or which may cause Alternatives A or B to be compromisingly attractive. The most significant of these matters are described in the following paragraphs.

The question of bond marketability exists in all alternatives, particularly Alternative C. If the economic feasibility document assigns a high probability of frequent interruption of the flow of imported crude petroleum due to unstable international conditions, and/or if the Legislature believes a resolution of moral obligation not appropriate, then the bonds may not be marketable. In that case, Alternative C becomes impossible to implement.

The oil industry has specific financial inducements in the development of an oil importation facility in addition to the industry's prime interest of continued feed for refineries for the purpose of providing petroleum products. The facility may represent, if financed through Alternative A, a very attractive return to those companies who assume the liability in that corporate financing method. Additionally, those companies may view the deepwater facility as but one component in the production and transportation system from oil well to consumer. In that case, the companies may believe that ownership of this component should be private. Since there can be a significant return to be realized by the companies from the facility, and/or if the companies are strongly of the opinion that the facility would not be an integral part of the industry's system if publicly owned, then the oil industry would strongly resist implementation of any alternative other than Alternative A. On the other hand, it must be remembered that it is still to the primary interest of the oil companies that the product of their industry be marketable at the lowest cost at the retail level. There would be no profit or loss to the oil companies in this segment of the production chain if publicly financed. Thus, this segment should be of no

COMPARISON OF FINANCING ALTERNATIVES

ALTERNATIVE	VARIATION	INTEREST RATE	AVERAGE TARIFF*	CONSUMER INTEREST**	STATE INTEREST	OIL COMPANIES INTEREST
A–Corporate Proposal	A	8	4.58	$973 million	least involvement	$188 million (PV) for liability
B–Tax-Exempt Financing with take or pay contracts	B***	6	2.91	$620 million	average involvement	0 Return for Liability
C–Tax-Exempt Financing without take or pay contracts	C	7	3.01	$641 million	highest involvement	no liability

* In ¢/barrel, the estimated average, in present value, for twenty years of operation.

** Present value of cost of facility ((principal and interest) + (operation and maintenance) +, in Alternative A, (Return on Base)). The higher this amount, the higher the cost-of-goods passed on to the consumer. These amounts provide a quantified measure of those costs which may be passed on.

*** In this alternative, the companies assume the liability of take or pay contracts. For this liability, the companies have the use of the facility, and can receive the advantages of tax depreciation and investment tax credit. However, they do not receive the 7% return on base described on p. 98. Two cash flow charts–B_1 on p. 105 and B_2 on p. 106–reflect the costs of providing this return in Alternative B at the rates of 7% and 3.5%, respectively. In these cases, the estimated average, present value of the tariff over twenty years operation would be 3.67¢/barrel and 3.22¢/barrel, respectively; and the consumer interest figure would be $825 million and $722 million respectively.

consequence to the companies so long as they can still sell and make a profit at retail. Public financing will aid in providing lowest cost at the final destination of the product.

The development of any large facility carries with it a certain degree of risk. This risk may take several forms: delays in construction, uneconomic operation, acts of God, significant interruptions of oil flow into the facility, a severe oil spill, and other similar possibilities.

If these risks become realities to the worst extent possible, the facility's cost per time period would exceed its revenues for the same time period. And should this worst situation eventuate, the owner of the facility must initiate actions to pay the difference of costs less revenue during those adverse time periods. The question exists of whether the oil industry is of such importance to the State of Texas as to cause it to be mandatory that the State assume this risk. Concurrently, regarding some of these risks, the question exists whether the State would be better able to prevent or rectify the results of these risks. It should be understood that the oil and chemical companies who have or may join SEADOCK as proposed participants have repeatedly expressed their readiness to assume the risks inherent in the financing and operation of an offshore facility of the magnitude suggested by this plan. For assuming such risks they would be fully entitled to a fair return on their investment.

There is the question of the extent of State desirability to become involved in the facility. If the State is of the opinion that its interests can be sufficiently protected without there being public ownership, or if the State is of the opinion that it does not have sufficient interest in the facility and its function to warrant public ownership, then public ownership becomes an unnecessary requirement.

In the public ownership alternatives, the total costs of the facility are reduced due to lower bond interest rates and due to exclusion of profit. Costs are covered by the tariffs paid by the companies importing oil through the facility. These costs thus become a component of the cost-of-goods-sold of the resulting petroleum products and are ultimately

paid by the consumers of these products. Although in the total price of a gallon of gasoline, costs for this segment of the production of that petroleum unit are of a very small magnitude, the cumulative total amount paid by consumers could be nearly one billion dollars during a projected 30 year facility life. The consumer benefit is thus best served by keeping the unit segment costs as low as possible.

There are several additional matters, hereinafter discussed, which have been considered in the Commission's deliberations. However, they are not believed to have significant impact upon the facility's financing.

"Control," as applied to the facility, has been a term often utilized but without clear definition. There may be concern in the oil industry that if the facility is financed by the State, control of the setting of tariffs would be out of the hands of the known and established tariff setting provisions of the ICC, and that tariffs would be set at extremely high levels. However, for the State to do so would be contrary to its interest. If necessary, this concern may be assuaged by appropriate provisions in bond documents, if the facility is to be publicly owned.

Another possible definition of control of the facility has been that it would be analogous to the "State controlling" to the same extent as has been threatened by the oil producing and exporting countries. In this context, "control" is the capability of shutting off the flow of oil through the facility. This control, even if possible, would also be contrary to the State's interest. This concern may also be rectified, if necessary, in the bond documents.

The oil industry has emphasized the financial liability the oil companies would assume if the facility is privately owned. It should be noted that this liability would be spread, albeit unevenly, among a number of companies, each of some magnitude. However, due to the industry's emphasis upon the liability, this "spread" aspect has not been included in the considerations upon which the Commission's plan is based.

Considerable discussion and difference of opinion exists regarding whether the liability of the "take or pay" contracts, in tax-exempt or taxable bond financing, can be treated on- or off-balance sheet. The Commission is of the opinion that if Alternative C is implemented, which is without "take or pay" contracts, the matter becomes moot. Conversely, if "take or pay" contracts are utilized, it is highly probable that they can be treated off-balance sheet in any alternative if the bond documents are properly formulated.

An observation has been made that financing by the State will probably be unacceptable and crude importation will be via Bahamas transshipment or by importation of crude supplies through another state(s). These are, of course, possible alternatives. It has, however, been conservatively calculated that there is a transportation savings of 20 to 30 cents per barrel through a Texas deepwater terminal versus the transshipment alternative. A State proposed financing and ownership plan would have to be extremely unacceptable to the oil companies to forego such savings. More importantly, any unacceptable financing proposed by the State would not be in the State's interest. Additionally, all states have common interests in deepwater facilities which would strongly resist one state being placed in opposition to or in competition with another. In fact, all the Gulf Coast states favor federal deepwater port legislation which contains language making State consent a necessary prerequisite to the granting of a license before facilities are built off the State's coast.

E. CONCLUSIONS

From the previous information, Alternative C (tax-exempt financing without "take or pay" contacts) is the most attractive in the sum of the interests of all parties.

More so than Alternatives A and B, achieving a low interest rate in this alternative would be a function of the strength of the economic feasibility report. *Efforts to achieve the lowest rate would be greatly enhanced by the legislative statement of moral obligation*. Acceptance of this alternative by the oil companies depends on whether they can achieve a present value (based upon a twenty year period) in excess of $188 million for incurring the same liability through some other investment, an example being perhaps the building or expansion of refineries.

In contrast with the possible risks, this financing alternative is the one which is most in the public interest and in balance with the probability of implementation of this alternative. Accordingly, it is the Commission's finding that the facility should be publicly owned. Additionally, the Commission finds that such ends should be accomplished through government revenue bonds whose repayment will rest entirely upon the revenues generated by the deepwater port facility. *The Commission further finds that the public would be most benefited by these revenue bonds being secured by minimum throughput ("take or pay") contracts between the companies who will use the facility and the State (Alternative B)*. If that alternative cannot be implemented, the Commission finds that the public would still receive larger scale benefits if the security for these bonds is restricted to the revenues of the facility (Alternative C).

However, the Commission recognizes that each of these alternatives may become more attractive because of changed circumstances. Therefore, the Commission recommends that legislation be enacted that would permit any alternative, including private ownership, if such an alternative can be shown to be more attractive.

F. CASH FLOW CHARTS

The following pages (103 to 115) are the cash flow charts referenced on Page 97 of the Commission's plan. These charts are:

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
A_1*	Taxable	Private	8%	Take or Pay	7%	20 years
A_2	Taxable	Private	8%	Take or Pay	7%	30 years
B_1	Exempt	Public	6%	Take or Pay	7%	20 years
B_2	Exempt	Public	6%	Take or Pay	3.5%	20 years
B_3*	Exempt	Public	6%	Take or Pay	0%	20 years
C_1	Exempt	Public	6%	Revenue	0%	20 years
C_2*	Exempt	Public	7%	Revenue	0%	20 years
C_3	Exempt	Public	8%	Revenue	0%	20 years
D_1	Exempt	Public	7%	Revenue	0%	30 years
D_2	Exempt	Public	7%	Revenue	0%	30 years

(All figures on the charts, except volume and tariff, are X$1,000. Volume is barrels X1,000 per day. Tariff is $ per barrel.)

*These charts present the cash flows of the three basic alternatives, respectively, of Alternatives A, B, and C, described in the text of the plan.

Charts A_2, D_1, and D_2 reflect slightly different cost figures than those of the other charts and present a thirty (30) year facility life.

Charts D_1 and D_2 are bond amortization schedules which include, in addition to the factors of the other charts, three years capitalized interest and a 15% reserve (.15 X (capitalized interest + capital expenditures)).

In Chart D_1 it is assumed that bonds are held to a maturity of 30 years and then redeemed.

In Chart D_2 it is assumed that the bonds contain a 15-year call provision, which is exercised, after which the lowered costs are reflected in lowered tariffs.

These reductions are reflected in columns (19) and (20) of (Page 3) of Chart D_2, showing Net Tariff and Adjusted Gross Revenues.

A_1

YEAR	(1) VOLUME	(2) CAPITAL	(3) O & M	(4) PRINCIPAL	(5) 8% INTEREST	(6) BOOK DEPCN.	(7) AFTER TAX DIVDS.	(8) PV DIVIDENDS	(9) GROSS REVENUE	(10) PRESENT VALUE REVENUES	(11) CUMM. PV REVENUES	(12) TARIFF
1975	-0-	276495	-0-									
1976	1731	105910	26703	12442	19907	12442	18615	16922	81351	73956	73956	.1287
1977	2152		28327	17459	26537	17459	26062	21537	107059	88473	162429	.1362
1978	2346		29724	17459	25141	17459	24702	18558	108175	81271	243700	.1263
1979	2558	12850	31214	17459	23744	17459	23561	16092	109397	74718	318418	.1171
1980	2867		33051	18182	23272	18182	24300	15087	115312	71597	390015	.1101
1981	2991		34546	18182	21818	18182	23473	13250	116554	65794	455809	.1067
1982	3104		36089	18182	20363	18182	22809	11705	117856	60483	516292	.1040
1983	3198		37659	18182	18909	18182	22291	10398	119200	55606	571898	.1021
1984	3300		39309	18182	17454	18182	21905	9289	120638	51162	623060	.1001
1985	3391		41005	18182	16000	18182	21635	8340	122133	47082	670142	.0986
1986	3391		43055	18182	14545	18182	21063	7382	123179	43174	713316	.0995
1987	3391		45208	18182	13090	18182	20563	6551	124298	39601	752917	.1004
1988	3391		47468	18182	11636	18182	20126	5830	125494	36355	789272	.1013
1989	3391		49841	18182	10181	18182	19740	5197	126765	33377	822649	.1024
1990	3391		52333	18182	8727	18182	19396	4643	128117	30671	853320	.1035
1991	3391		54950	18182	7272	18182	19088	4153	129554	28190	881510	.1046
1992	3391		57698	18182	5818	18182	18807	3720	131078	25927	907437	.1059
1993	3391		60583	18182	4363	18182	18545	3336	132690	23870	931307	.1072
1994	3391		63612	18182	2909	18182	18300	2992	134403	21974	953281	.1085
1995	3391		66792	18180	1454	18180	18064	2684	136213	20241	973522	.1100
									2409466			
										973522		

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
A_1	Taxable	Private	8%	Take or Pay	7%	20 years

A_2

YEAR	(1) VOLUME	(2) CAPITAL	(3) O & M	(4) PRINCIPAL	(5) 8% INTEREST	(6) BOOK DEPCN.	(7) AFTER TAX DIVDS.	(8) PV DIVIDENDS	(9) GROSS REVENUE	(10) PV REVENUES	(11) CUMM. PV REVENUES	(12) TARIFF
1975	-0-	274755				-0-						-0-
1976	1731	123210	27213	8900	19782	9891	19233	17484	81351	73956	73956	12.9
1977	2152		28843	12900	27942	14327	27570	22783	107059	88473	162429	13.6
1978	2346		30246	12900	26910	14327	27156	20402	108175	81271	243700	12.6
1979	2558	19300	31743	12900	25878	14327	26748	18268	109397	74718	318418	11.7
1980	2867		34114	13500	26235	15022	27699	17198	115312	71597	390015	11.0
1981	2991		35618	13500	25155	15022	27283	15401	116554	65794	455809	10.7
1982	3104		37172	13500	24075	15022	26873	13791	117856	60483	516292	10.4
1983	3198		38752	13500	22995	15022	26470	13248	119200	55606	571898	10.2
1984	3300		40413	13500	21815	15022	26074	11057	120638	51162	623060	10.0
1985	3391		42121	13500	20835	15022	25683	9900	122133	47082	670142	9.9
1986	3391		43370	13500	19755	15022	25297	8866	123179	43174	713316	10.0
1987	3391		44679	13500	18675	15022	24917	7938	124298	39601	752917	10.0
1988	3391		46052	13500	17595	15022	24544	7110	125494	36355	789272	10.1
1989	3391		47492	13500	16515	15022	24175	6365	126765	33377	822649	10.2
1990	3391		49000	13500	15435	15022	23812	5700	128117	30671	853320	10.4
1991	3391		50580	13500	14355	15022	23456	5104	129554	28190	881510	10.5
1992	3391		52238	13500	13275	15022	23104	4569	131078	25927	907437	10.6
1993	3391		53976	13500	12195	15022	22757	4093	132690	23870	931307	10.7
1994	3391		55801	13500	11115	15022	22416	3665	134403	21974	953281	10.9
1995	3391		57714	13500	10035	15022	22080	3281	136213	20241	973522	11.0
1996	3391		59636	13500	8955	15022	21749	2938	138044	18649	992171	11.2
1997	3391		61622	13500	7875	15022	21423	2630	139946	17185	1009356	11.3
1998	3391		63675	13500	6795	15022	21101	2356	141924	15852	1025208	11.5
1999	3391		65797	13500	5715	15022	20785	2109	142897	14504	1039712	11.5
2000	3391		67990	13500	4635	15022	20473	1889	143462	13241	1052953	11.6
2001	3391		70258	13500	3555	15022	20166	1691	144113	12091	1065044	11.6
2002	3391		72602	13500	2475	15022	19864	1515	144849	11051	1076095	11.7
2003	3391		75025	13500	1395	15022	19565	1355	145594	10089	1086184	11.8
2004	3391		77528	3939	315	3865	19272	1214	124117	7819	1094003	10.0
2005	3391		80117				18983	1087	118083	6766	1100769	9.5
								294107	3792495	1100769		

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	RETURN OR SECURITY	SECURITY FEE	TIME SPAN
A_2	Taxable	Private	8%	Take or Pay	7%	30 years

B_1

YEAR	(1) VOLUME	(2) CAPITAL	(3) O & M	(4) PRINCIPAL	(5) 6% INTEREST	(6) TOTAL COST	(7) COST TARIFF	(8) SECURITY FEE	(9) SECURITY FEE (PV)	(10) PRESENT VALUE REVENUES	(11) TOTAL TARIFF
1975	-0-	276495	-0-								
1976	1731	105910	26703	19763	16589	63055	.0997	19354	17594	57323	.1304
1977	2152		28327	19763	21758	69248	.0889	27058	22360	57722	.1233
1978	2346		29724	19763	20572	70059	.0818	26657	20027	52635	.1129
1979	2558	12850	31214	19763	19386	70363	.0753	26255	17932	48057	.1034
1980	2867		33051	19763	18972	71786	.0685	26753	16610	44571	.0941
1981	2991		34546	19763	17786	72095	.0660	26338	14867	40697	.0901
1982	3104		36089	19763	16600	72452	.0639	25923	13303	37182	.0868
1983	3198		37659	19763	15414	72836	.0623	25508	11899	33977	.0842
1984	3300		39309	19763	14229	73301	.0608	25093	10641	31086	.0816
1985	3391		41005	19763	13043	73811	.0596	24678	9513	28454	.0795
1986	3391		43055	19763	11857	74675	.0603	24263	8504	26173	.0799
1987	3391		45208	19763	10671	75642	.0611	23848	7597	24099	.0803
1988	3391		47468	19763	9485	76716	.0619	23433	6788	22224	.0809
1989	3391		49841	19763	8300	77904	.0629	23018	6060	20512	.0815
1990	3391		52333	19763	7114	79210	.0639	22603	5411	18962	.0822
1991	3391		54950	19763	5928	80641	.0651	22188	4828	17547	.0830
1992	3391		57698	19763	4743	82204	.0664	21773	4306	16259	.0840
1993	3391		60583	19763	3557	83903	.0677	21358	3842	15094	.0850
1994	3391		63612	19763	2371	85746	.0692	20943	3424	14019	.0861
1995	3391		66792	19761	1185	87738	.0708	20528	3050	13037	.0874
			879167	395258	239560	1513985			205556	619630	
									825186		

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
B_1	Exempt	Public	6%	Take or Pay	7%	20 years

B_2

YEAR	(1) VOLUME	(2) CAPITAL	(3) O & M	(4) PRINCIPAL	(5) 6% INTEREST	(6) TOTAL COST	(7) COST TARIFF	(8) SECURITY FEE	(9) SECURITY FEE (PV)	(10) PRESENT VALUE REVENUES	(11) TOTAL TARIFF
1975	-0-	276495	-0-								
1976	1731	105910	26703	19763	16589	63055	.0997	9677	8797	57323	.1151
1977	2152		28327	19763	21758	69848	.0889	13529	1118	57722	.1061
1978	2346		29724	19763	20572	70059	.0818	13328	1090	52635	.0973
1979	2558	12850	31214	19763	19386	70363	.0753	13127	8965	48057	.0894
1980	2867		33051	19763	18972	71786	.0685	13376	8305	44571	.0813
1981	2991		34546	19763	17786	72095	.0660	13169	7433	40697	.0781
1982	3104		36089	19763	16600	72452	.0639	12961	6651	37182	.0753
1983	3198		37659	19763	15414	72836	.0623	12754	5949	33977	.0733
1984	3300		39309	19763	14229	73301	.0608	12546	5320	31086	.0712
1985	3391		41005	19763	13043	73811	.0596	12339	4756	28454	.0696
1986	3391		43055	19763	11857	74675	.0603	12131	4251	26173	.0701
1987	3391		45208	19763	10671	75642	.0611	11924	3798	24099	.0707
1988	3391		47468	19763	9485	76716	.0619	11716	3394	22224	.0714
1989	3391		49841	19763	8300	77904	.0629	11509	3030	20512	.0722
1990	3391		52333	19763	7114	79210	.0639	11301	2705	18962	.0731
1991	3391		54950	19763	5928	80641	.0651	11094	2414	17547	.0741
1992	3391		57698	19763	4743	82204	.0664	10886	2153	16259	.0752
1993	3391		60583	19763	3557	83903	.0677	10679	1921	15094	.0764
1994	3391		63612	19763	2371	85746	.0692	10471	1712	14019	.0777
1995	3391		66792	19761	1185	87738	.0708	10264	1525	13037	.0791
			879167	395258	239560	1513985			102778	619630	
									722408		

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
B_2	Exempt	Public	6%	Take or Pay	3.5%	20 years

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
YEAR	VOLUME	CAPITAL	O & M	PRINCIPAL	6% INTEREST	TOTAL COST	COST TARIFF	SECURITY FEE	SECURITY FEE (PV)	PRESENT VALUE REVENUES	TOTAL TARIFF
1975	-0-	276495	-0-					-0-	-0-		
1976	1731	105910	26703	19763	16589	63055	.0997			57323	.0997
1977	2152		28327	19763	21758	69848	.0889			57722	.0889
1978	2346		29724	19763	20572	70059	.0818			52635	.0818
1979	2558	12850	31214	19763	19386	70363	.0753			48057	.0753
1980	2867		33051	19763	18972	71786	.0685			44571	.0685
1981	2991		34546	19763	17786	72095	.0660			40697	.0660
1982	3104		36089	19763	16600	72452	.0639			37182	.0639
1983	3198		37659	19763	15414	72836	.0623			33977	.0623
1984	3300		39309	19763	14229	73301	.0608			31086	.0608
1985	3391		41005	19763	13043	73811	.0596			28454	.0596
1986	3391		43055	19763	11857	74675	.0603			26173	.0603
1987	3391		45208	19763	10671	75642	.0611			24099	.0611
1988	3391		47468	19763	9485	76716	.0619			22224	.0619
1989	3391		49841	19763	8300	77904	.0629			20512	.0629
1990	3391		52333	19763	7114	79210	.0639			18962	.0639
1991	3391		54950	19763	5928	80641	.0651			17547	.0651
1992	3391		57698	19763	4743	82204	.0664			16259	.0664
1993	3391		60583	19763	3557	83903	.0677			15094	.0677
1994	3391		63612	19763	2371	85746	.0692			14019	.0692
1995	3391		66792	19761	1185	87738	.0708			13037	.0708
			879167	395258	239560	1513985				619630	

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
B_3	Exempt	Public	6%	Take or Pay	0%	20 years

C_1

YEAR	(1) VOLUME	(2) CAPITAL	(3) O & M	(4) PRINCIPAL	(5) 6% INTEREST	(6) TOTAL COST	(7) PRESENT VALUE REVENUES	(8) TOTAL TARIFF
1975	-0-	276495	-0-					
1976	1731	105910	26703	19763	16589	63055	57323	.0997
1977	2152		28327	19763	21758	69848	57722	.0889
1978	2346		29724	19763	20572	70059	52635	.0818
1979	2558	12850	31214	19763	19386	70363	48057	.0753
1980	2867		33051	19763	18972	71786	44571	.0685
1981	2991		34546	19763	17786	72095	40697	.0660
1982	3104		36089	19763	16600	72452	37182	.0639
1983	3198		37659	19763	15414	72836	33977	.0623
1984	3300		39309	19763	14229	73301	31086	.0608
1985	3391		41005	19763	13043	73811	28454	.0596
1986	3391		43055	19763	11857	74675	26173	.0603
1987	3391		45208	19763	10671	75642	24099	.0611
1988	3391		47468	19763	9485	76716	22224	.0619
1989	3391		49841	19763	8300	77904	20512	.0629
1990	3391		52333	19763	7114	79210	18962	.0639
1991	3391		54950	19763	5928	80641	17547	.0651
1992	3391		57698	19763	4743	82204	16259	.0664
1993	3391		60583	19763	3557	83903	15094	.0677
1994	3391		63612	19763	2371	85746	14019	.0692
1995	3391		66792	19761	1185	87738	13037	.0708
			879167	395258	239560	1513985	619630	

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
C_1	Exempt	Public	6%	Revenue	0%	20 years

C_2

YEAR	(1) VOLUME	(2) CAPITAL	(3) O & M	(4) PRINCIPAL	(5) 7% INTEREST	(6) TOTAL COST	(7) PRESENT VALUE REVENUES	(8) TOTAL TARIFF
1975	-0-	276495	-0-					
1976	1731	105910	26703	19763	19354	65820	59846	.1041
1977	2152		28327	19763	25384	73474	60718	.0935
1978	2346		29724	19763	24001	73488	55211	.0858
1979	2558	12850	31214	19763	22618	73595	50265	.0788
1980	2867		33051	19763	22134	74948	46535	.0716
1981	2991		34546	19763	20750	75059	42370	.0687
1982	3104		36089	19763	19367	75219	38602	.0663
1983	3198		37659	19763	17983	75405	35176	.0645
1984	3300		39309	19763	16600	75672	32092	.0628
1985	3391		41005	19763	15217	75985	29292	.0613
1986	3391		43055	19763	13833	76651	26866	.0619
1987	3391		45208	19763	12450	77421	24666	.0625
1988	3391		47468	19763	11066	78297	22682	.0632
1989	3391		49841	19763	9683	79287	20876	.0640
1990	3391		52333	19763	8300	80396	19246	.0649
1991	3391		54950	19763	6916	81629	17762	.0659
1992	3391		57698	19763	5533	82994	16416	.0670
1993	3391		60583	19763	4149	84495	15200	.0682
1994	3391		63612	19763	2766	86141	14084	.0695
1995	3391		66792	19763	1383	87938	13067	.0710
			879167	395260	279487	1553914	640972	

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
C_2	Exempt	Public	7%	Revenue	0%	20 years

C_3

YEAR	(1) VOLUME	(2) CAPITAL	(3) O & M	(4) PRINCIPAL	(5) 8% INTEREST	(6) TOTAL COST	(7) PRESENT VALUE REVENUES	(8) TOTAL TARIFF
1975	-0-	276495	-0-					
1976	1731	105910	26703	19763	22119	68585	62350	.1085
1977	2152		28327	19763	29011	77101	63716	.0981
1978	2346		29724	19763	27430	76917	57787	.0898
1979	2558	12850	31214	19763	25849	76826	52472	.0822
1980	2867		33051	19763	25296	78110	48498	.0746
1981	2991		34546	19763	23715	78024	44044	.0714
1982	3104		36089	19763	22134	77986	40022	.0688
1983	3198		37659	19763	20553	77975	36375	.0668
1984	3300		39309	19763	18972	78044	33098	.0647
1985	3391		41005	19763	17391	78159	30130	.0631
1986	3391		43055	19763	15810	78628	27559	.0635
1987	3391		45208	19763	14228	79199	25232	.0639
1988	3391		47468	19763	12647	79878	23140	.0645
1989	3391		49841	19763	11066	80670	21240	.0651
1990	3391		52333	19763	9485	81581	19530	.0659
1991	3391		54950	19763	7904	82617	17977	.0667
1992	3391		57698	19763	6323	83784	16572	.0676
1993	3391		60583	19763	4742	85088	15307	.0687
1994	3391		63612	19763	3161	86536	14148	.0699
1995	3391		66792	19761	1580	88133	13096	.0712
			879167	395258	319416	1593841	662293	

CHART	TAX STATUS	OWNERSHIP	INTEREST RATE	SECURITY	RETURN OR SECURITY FEE	TIME SPAN
C_3	Exempt	Public	8%	Revenue	0%	20 years

D_1

YEAR	(1) BOND PROCEEDS	(2) CAPITAL EXPENDITURES	(3) VOLUME	(4) TARIFF	(5) GROSS REVENUES	(6) O & M	(7) NET REVENUES
1975	612144	274755	-0-	-0-	-0-	-0-	-0-
1976		123210	1731	.129	81351	27213	54138
1977			2152	.136	107059	28843	78216
1978			2346	.126	108175	30246	77929
1979		19300	2558	.117	109397	31743	77654
1980			2867	.110	115312	34114	81198
1981			2991	.107	116554	35618	80936
1982			3104	.104	117856	37172	80684
1983			3198	.102	119200	38752	80448
1984			3300	.100	120638	40413	80225
1985			3391	.099	122133	42121	80012
1986			3391	.100	123179	43370	79809
1987			3391	.100	124298	44679	79619
1988			3391	.101	125494	46052	79442
1989			3391	.102	126765	47492	79273
1990			3391	.104	128117	49000	79117
1991			3391	.105	129554	50580	78974
1992			3391	.106	131078	52238	78840
1993			3391	.107	132690	53976	78714
1994			3391	.109	134403	55801	78602
1995			3391	.110	136213	57714	78499
1996			3391	.112	138044	59636	78408
1997			3391	.113	139946	61622	78324
1998			3391	.115	141924	63675	78249
1999			3391	.115	142897	65797	77100
2000			3391	.116	143462	67990	75472
2001			3391	.116	144113	70258	73855
2002			3391	.117	144849	72602	72247
2003			3391	.118	145594	75025	70569
2004			3391	.100	124117	77528	46589
2005			3391	.095	118083	80117	37966
	612144	417265			3792495	1541387	2251108

D_1 (continued)

(7) NET REVENUES	(8) 7% DEBT SERVICE INTEREST	(9) AFTER INTEREST BALANCE	(10) RESERVE	(11) 6% INTEREST ON RESERVE	(12) NON-RESERVE BALANCE	(13) 4% INT. ON NON-RESERVE	(14) INVESTMENT INCOME	(15) TOTAL NON-RESERVE	(16) PRINCIPAL PAYMENT	(17) ENDING SURPLUS
-0-	42850	294539	91821	5509	202717	8108	13617	216334		
54138	42850	182617	91821	5509	90796	3631	9140	99936		
78216	42850	217983	91821	5509	126162	5046	10555	136717		
77929	42850	253062	91821	5509	161241	6449	11958	173199		
77654	42850	268566	91821	5509	176745	7069	12578	189323		
81198	42850	306914	91821	5509	215093	8603	14112	229205		
80936	42850	345000	91821	5509	253179	10127	15636	268815		
80684	42850	382834	91821	5509	291013	11640	17149	308162		
80448	42850	420432	91821	5509	328611	13144	18653	347264		
80225	42850	457807	91821	5509	365986	14639	20148	386134		
80012	42850	494969	91821	5509	403148	16125	21634	424782		
79809	42850	531928	91821	5509	440107	17604	23113	463220		
79619	42850	568697	91821	5509	476876	19075	24584	501460		
79442	42850	605289	91821	5509	513468	20538	26047	539515		
79273	42850	641712	91821	5509	549891	21995	27504	577395		
79117	42850	677974	91821	5509	586158	23446	28955	615113		
78974	42850	714103	91821	5509	622282	24891	30400	652682		
78840	42850	750093	91821	5509	658272	26330	31839	690111		
78714	42850	785957	91821	5509	694136	27765	33274	727410		
78602	42850	821709	91821	5509	729888	29195	34704	764592		
78499	42850	857358	91821	5509	765537	30621	36130	801667		
78408	42850	892916	91821	5509	801095	32043	37552	838647		
78324	42850	928390	91821	5509	836569	33462	38971	875540		
78249	42850	963789	91821	5509	871968	34878	40387	912355		
77100	42850	998039	91821	5509	906218	36248	41757	947975		
75472	42850	1030661	91821	5509	938840	37553	43062	981902		
73855	42850	1061666	91821	5509	969845	38793	44302	1014147		
72247	42850	1091063	91821	5509	999242	39969	45478	1044720		
70569	42850	1118782	91821	5509	1026961	41078	46587	1073548		
46589	42850	1122521	91821	5509	1030700	41228	46737	1077437		
37966	42850	1117637	91821	5509	1025816	41032	46541	1072357	612144	460213
2251108	1328350	2846451		170779		722325	893104			

D_2

YEAR	(1) BOND PROCEEDS	(2) RESERVE FUND (15%)	(3) CAPITAL REQUIREMENTS	(4) VOLUME	(5) GROSS TARIFF	(6) GROSS REVENUES	(7) O & M	(8) AVAILABLE REVENUES
1975	575334	75044	275000	-0-	-0-	-0-	-0-	-0-
1976			125000	1731	.129	81351	27213	54138
1977				2152	.136	107059	28843	78216
1978				2346	.126	108175	30246	77929
1979				2558	.117	109397	31743	77654
1980				2867	.110	115312	34114	88198
1981				2991	.107	116554	35618	80936
1982				3104	.104	117856	37172	80684
1983				3198	.102	119200	38752	80448
1984				3300	.100	120638	40413	80225
1985				3391	.099	122133	42121	80012
1986				3391	.100	123179	43370	79809
1987				3391	.100	124298	44679	79619
1988				3391	.101	125494	46052	79442
1989				3391	.102	126765	47492	79273
1990				3391	.104	128117	49000	79117
1991				3391	.105	129554	50580	78974
1992				3391	.106	131078	52238	78840
1993				3391	.107	132690	53976	78714
1994				3391	.109	134403	55801	78602
1995				3391	.110	136213	57714	78499
1996				3391	.112	138044	59636	78408
1997				3391	.113	139946	61622	78324
1998				3391	.115	141924	63675	78249
1999				3391	.115	142897	65797	77100
2000				3391	.116	143462	67990	75472
2001				3391	.116	144113	70258	73855
2002				3391	.117	144849	72602	72247
2003				3391	.118	145594	75025	70569
2004				3391	.100	124117	77528	46589
2005				3391	.095	118083	80117	37966

D_2 (continued)

(8) AVAILABLE REVENUES	(14) ENDING BALANCE	(15) PRINCIPAL PAYMENT	(16) SURPLUS BALANCE (AT 6%)	(17) TARIFF REDUCTION $/BBL	(18) NET TARIFF	(19) ADJUSTED GROSS REVENUES	(20) DISCOUNTED ADJUSTED GROSS REVENUES
-0-	196919				-0-	-0-	-0-
54138	98162				.129	81351	73956
78216	144533				.136	107059	88473
77929	192472				.126	108175	81271
77654	242053				.117	109397	74718
88198	304162				.110	115312	71597
80936	361493				.107	116554	65794
80684	420865				.104	117856	60483
80448	482376				.102	119200	55606
80225	546125	575334	45835		.100	120638	51162
80012	-0-		48585	.064	.035	42121	16237
79809			51500	.064	.036	43370	15201
79619			54590	.064	.036	44679	14234
79442			57865	.064	.037	46052	13341
79273			61337	.064	.038	47492	12504
79117			65017	.063	.041	49000	11730
78974			68918	.063	.042	50580	11006
78840			73054	.063	.043	52238	10332
78714			77437	.063	.044	53976	9710
78602			82083	.063	.046	55801	9123
78499			87008	.063	.047	57714	8576
78408			92229	.063	.049	59636	8056
78324			97762	.063	.050	61622	7567
78249			103628	.063	.052	63675	7112
77100			109846	.062	.053	65797	6678
75472			116437	.060	.056	67990	6275
73855			123423	.059	.057	70258	5894
72247			130828	.058	.059	72602	5539
70569			138678	.057	.061	75025	5199
46589			146999	.037	.063	77528	4884
37966			155818	.030	.065	80117	4590
							816848

D_2 (continued)

(8) AVAILABLE REVENUES	(9) 7% DEBT SERVICE INTEREST	(10) AFTER INTEREST BALANCE	(11) 4% INTEREST ON BALANCE	(12) 6% INTEREST ON RESERVE	(13) INVESTMENT INCOME	(14) ENDING BALANCE	(15) PRINCIPAL PAYMENT	(16) SURPLUS BALANCE (AT 6%)
-0-	40273	185017	7400	4502	11902	196919		
54138	40273	85784	7876	4502	12378	98162		
78216	40273	136105	3926	4502	8428	144533		
77929	40273	182189	5781	4502	10283	192472		
77654	40273	229853	7698	5402	12200	242053		
88198	40273	289978	9682	4502	14184	304162		
80936	40273	344825	12166	4502	16668	361493		
80684	40273	401904	14459	4502	18961	420865		
80448	40273	461040	16834	4502	21336	482376		
80225	40273	522328	19295	4502	23797	546125	575334	45835
80012	-0-	-0-	-0-	-0-	-0-	-0-		48585
79809								51500
79619								54590
79442								57865
79273								61337
79117								65017
78974								68918
78840								73054
78714								77437
78602								82083
78499								87008
78408								92229
78324								97762
78249								103628
77100								109846
75472								116437
73855								123423
72247								130828
70569								138678
46589								146999
37966								155818

E_1

YEAR	BOND PROCEEDS	RESERVE FUND (15%)	CAPITAL REQUIREMENTS	VOLUME	GROSS TARIFF	GROSS REVENUES	O&M	AVAILABLE REVENUES	6% DEBT SERVICE INTEREST	AFTER INTEREST BALANCE
1975	564651	73650	275000	-0-	-0-	-0-	-0-	-0-	33879	182122
1976			125000	1731	.129	81351	27213	54138	33879	89066
1977				2152	.136	107059	28843	78216	33879	135932
1978				2346	.126	108175	30246	77929	33879	174192
1979				2558	.117	109397	31743	77654	33879	213927
1980				2867	.110	115312	34114	88198	33879	266010
1981				2991	.107	116554	35618	80936	33879	312695
1982				3104	.104	117856	37172	80684	33879	361485
1983				3198	.102	119200	38752	80448	33879	412195
1984				3300	.100	120638	40413	80225	33879	464913
1985				3391	.099	122133	42121	80012	33879	519726
1986				3391	.100	123179	43370	79809		
1987				3391	.100	124298	44679	79619		
1988				3391	.101	125494	46052	79442		
1989				3391	.102	126765	47492	79273		
1990				3391	.104	128117	49000	79117		
1991				3391	.105	129554	50580	78974		
1992				3391	.106	131078	52238	78840		
1993				3391	.107	132690	53976	78714		
1994				3391	.109	134403	55801	78602		
1995				3391	.110	136213	57714	78499		
1996				3391	.112	138044	59636	78408		
1997				3391	.113	139946	61622	78324		
1998				3391	.115	141924	63675	78249		
1999				3391	.115	142897	65797	77100		
2000				3391	.116	134462	67990	75472		
2001				3391	.116	144113	70258	73855		
2002				3391	.117	144849	72602	72247		
2003				3391	.118	145594	75025	70569		
2004				3391	.100	124117	77528	46589		
2005				3391	.095	118083	80117	37966		
						3783495		2258108	372669	

6 % Interest Rate, 3.5 % Security Fee; Tax Exempt

E_1 (continued)

4% INCOME AVAILABLE ON BALANCE	6% INCOME ON RESERVE	TOTAL INVESTMENT INCOME	ENDING BALANCE	3.5% SECURITY FEE	AVAILABLE BALANCE	PRINCIPAL PAYMENT	SURPLUS BALANCE + INCOME AT 6%	NET TARIFF	ADJUSTED GROSS REVENUES	DISCOUNTED ADJUSTED GROSS REVENUES
7284	4419	11703	193825	-0-	193825			-0-	-0-	-0-
7753	4419	12172	101238	9625	91613			.129	81351	73956
3664	4419	8083	144015	13855	130160			.136	107059	88473
5206	4419	9625	183817	13647	170170			.126	108175	81271
6806	4419	11225	225152	13443	211709			.117	109397	74718
8468	4419	12887	278897	13241	265656			.110	115312	71597
10626	4419	15045	327740	13042	314698			.107	116554	65794
12587	4419	17006	378491	12847	365644			.104	117856	60483
14625	4419	19044	431239	12654	418585			.102	119200	55606
16743	4419	21162	486075	12464	473611			.100	120638	51162
18944	4419	23363	543089	12277	530812	564651	39811	.099	122133	47080
							42199	.036	43370	15201
							44731	.036	44679	14234
							47415	.037	46052	13341
							50260	.038	47492	12504
							53276	.041	49000	11730
							56472	.042	50580	11006
							59861	.043	52238	10332
							63452	.044	53976	9710
							67259	.046	55801	9123
							71295	.047	57714	8576
							75573	.049	59636	8056
							80107	.050	61622	7567
							84914	.052	63675	7112
							90008	.053	65797	6678
							95409	.056	67990	6275
							101133	.057	70258	5894
							107201	.059	72602	5539
							113634	.061	75025	5199
		161315		127095			120452	.063	77528	4884
							127679	.065	80117	4590
									2312827	847691

E_2

YEAR	BOND PROCEEDS	RESERVE FUND (15%)	CAPITAL REQUIREMENTS	VOLUME	GROSS TARIFF	GROSS REVENUES	O&M	AVAILABLE REVENUES	6% DEBT SERVICE INTEREST	AFTER INTEREST BALANCE
1975	564651	73650	275000	-0-	.090	-0-	-0-	-0-	33879	182122
1976			125000	1731	.129	81351	27213	54138	33879	89066
1977				2152	.136	107059	28843	78216	33879	145557
1978				2346	.126	108175	30246	77929	33879	198057
1979				2558	.117	109397	31743	77654	33879	252394
1980				2867	.110	115312	34114	88198	33879	310459
1981				2991	.107	116554	35618	80936	33879	372523
1982				3104	.104	117856	37172	80684	33879	436748
1983				3198	.102	119200	38752	80448	33879	503316
1984				3300	.100	120638	40413	80225	33879	
1985				3391	.099	122133	42121	80012	33879	
1986				3391	.100	123179	43370	79809		
1987				3391	.100	124298	44679	79619		
1988				3391	.101	125494	46052	79442		
1989				3391	.102	126765	47492	79273		
1990				3391	.104	128117	49000	79117		
1991				3391	.105	129554	50580	78974		
1992				3391	.106	131078	52238	78840		
1993				3391	.107	132690	53976	78714		
1994				3391	.109	134403	55801	78602		
1995				3391	.110	136213	57714	78499		
1996				3391	.112	138044	59636	78708		
1997				3391	.113	139946	61622	78324		
1998				3391	.115	141924	63675	78249		
1999				3391	.115	142897	65797	77100		
2000				3391	.116	134462	67990	75472		
2001				3391	.116	144113	70258	73855		
2002				3391	.117	144849	72602	72247		
2003				3391	.118	145594	75025	70569		
2004				3391	.100	124117	77528	46589		
2005				3391	.095	118083	80117	37966		
						3783495		2258108	304911	

6 % Interest Rate, 0 % Security Fee; Tax Exempt

E_2 (continued)

4% INCOME AVAILABLE ON BALANCE	6% INCOME ON RESERVE	TOTAL INVESTMENT INCOME	ENDING BALANCE	0% SECURITY FEE	AVAILABLE BALANCE	PRINCIPAL PAYMENT	SURPLUS BALANCE + INCOME AT 6%	NET TARIFF	ADJUSTED GROSS REVENUES	DISCOUNTED ADJUSTED GROSS REVENUES
7284	4419	11703	193825	-0-	193825			-0-	-0-	-0-
7753	4419	12172	101238		101238			.129	81351	73956
4049	4419	8468	154025		154025			.136	107059	88473
6161	4419	10580	208637		208637			.126	108175	81271
8345	4419	12764	265158		265158			.117	109397	74718
10606	4419	15025	325484		325484			.110	115312	71597
13019	4419	17438	389961		389961			.107	116554	65794
15598	4419	20017	456765		456765			.104	117856	60483
18270	4419	22689	526005		526005	564651	35004	.102	119200	55606
							37104	.034	40413	17138
							39330	.035	42121	16237
							41690	.036	43370	15201
							44191	.036	44679	14234
							46843	.037	46052	13341
							49653	.038	47492	12504
							52633	.041	49000	11730
							55791	.042	50580	11006
							59138	.043	52238	10332
							62686	.044	53976	9710
							66448	.046	55801	9123
							70434	.047	57714	8576
							74661	.049	59636	8056
							79140	.050	61622	7567
							83889	.052	63675	7112
							88922	.053	65797	6678
							94257	.056	67990	6275
							99913	.057	70258	5894
							105908	.059	72602	5539
							112262	.061	75025	5199
							118998	.063	77528	4884
							126138	.065	80117	4590
		130856							2152590	782824

Cash flow charts E_1 and E_2 were not included in the finance section of the Commission's report. The factors inherent to these particular charts are:

- SEADOCK's ICC-allowed tariffs were utilized;
- The proceeds of these tariffs were applied to:
  (a) Principal and Interest of governmental revenue bonds, and
  (b) SEADOCK's estimates of the operation and maintenance costs of the port; and
- Bond sales well in excess of development costs were utilized to provide a reserve fund which would satisfy the most critical financial advisor.

The end result is that under these factors the excess in SEADOCK's tariffs would allow for completely repaying the bonds in only nine years.