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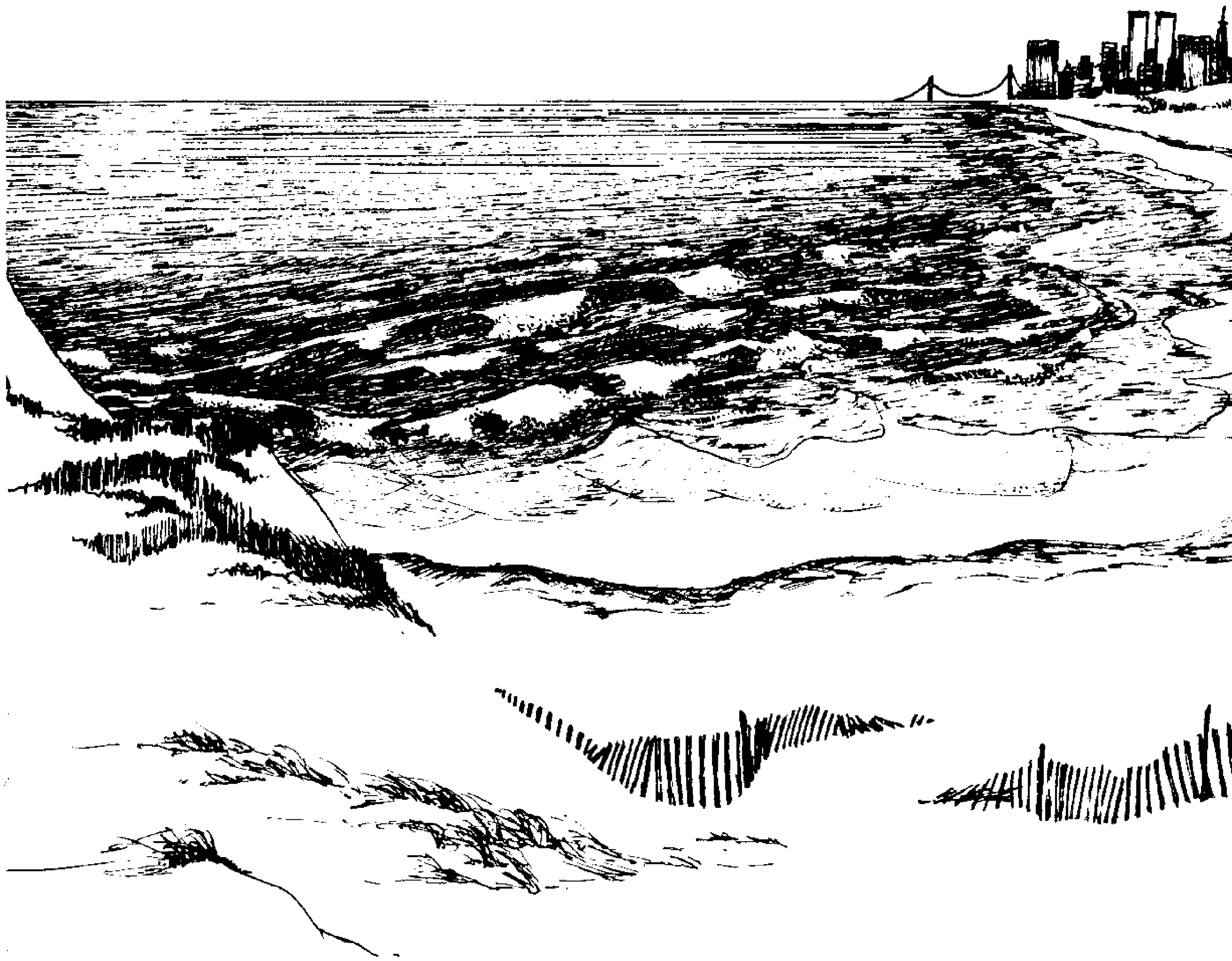
# Electricity Generation and Oil Refining

H.G. Mike Jones, Harold Bronheim, and Philip F. Palmedo



MESA NEW YORK BIGHT ATLAS MONOGRAPH 25

The offshore water in the bend of the Atlantic coastline from Long Island on one side to New Jersey on the other is known as New York Bight. This 15,000 square miles of the Atlantic coastal ocean reaches seaward to the edge of the continental shelf, 80 to 120 miles offshore. It's the front doorstep of New York City, one of the world's most intensively used coastal areas – for recreation, shipping, fishing and shellfishing, and for dumping sewage sludge, construction rubble, and industrial wastes. Its potential is being closely eyed for resources like sand and gravel – and oil and gas.

This is one of a series of technical monographs on the Bight, summarizing what is known and identifying what is unknown. Those making critical management decisions affecting the Bight region are acutely aware that they need more data than are now available on the complex interplay among processes in the Bight, and about the human impact on those processes. The monographs provide a jumping-off place for further research.

The series is a cooperative effort between the National Oceanic and Atmospheric Administration (NOAA) and the New York Sea Grant Institute. NOAA's Marine EcoSystems Analysis (MESA) program is responsible for identifying and measuring the impact of man on the marine environment and its resources. The Sea Grant Institute (of State University of New York and Cornell University, and an affiliate of NOAA's Sea Grant program) conducts a variety of research and educational activities on the sea and Great Lakes. Together, Sea Grant and MESA are preparing an atlas of New York Bight that will supply urgently needed environmental information to policy-makers, industries, educational institutions, and to interested people. The monographs, listed inside the back cover, are being integrated into this *Environmental Atlas of New York Bight.*

ATLAS MONOGRAPH 25 summarizes what we know about present energy supply and demand in the Bight region. Jones, Bronheim, and Palmedo present projections indicating that the region's electric energy needs may increase greatly in the next ten years; they emphasize that the actual growth rate is uncertain. The demand for oil refinery capacity is also increasing but oil companies are not presently planning much expansion, due to environmental and siting problems and the unsure future of the oil supply/demand situation.

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*H.G. Mike Jones*
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Atlas Monograph 25 was prepared in the context of the Brookhaven National Laboratory Regional Energy Studies Program with support from the Energy Research and Development Administration.

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Manuscript accepted January 1975.

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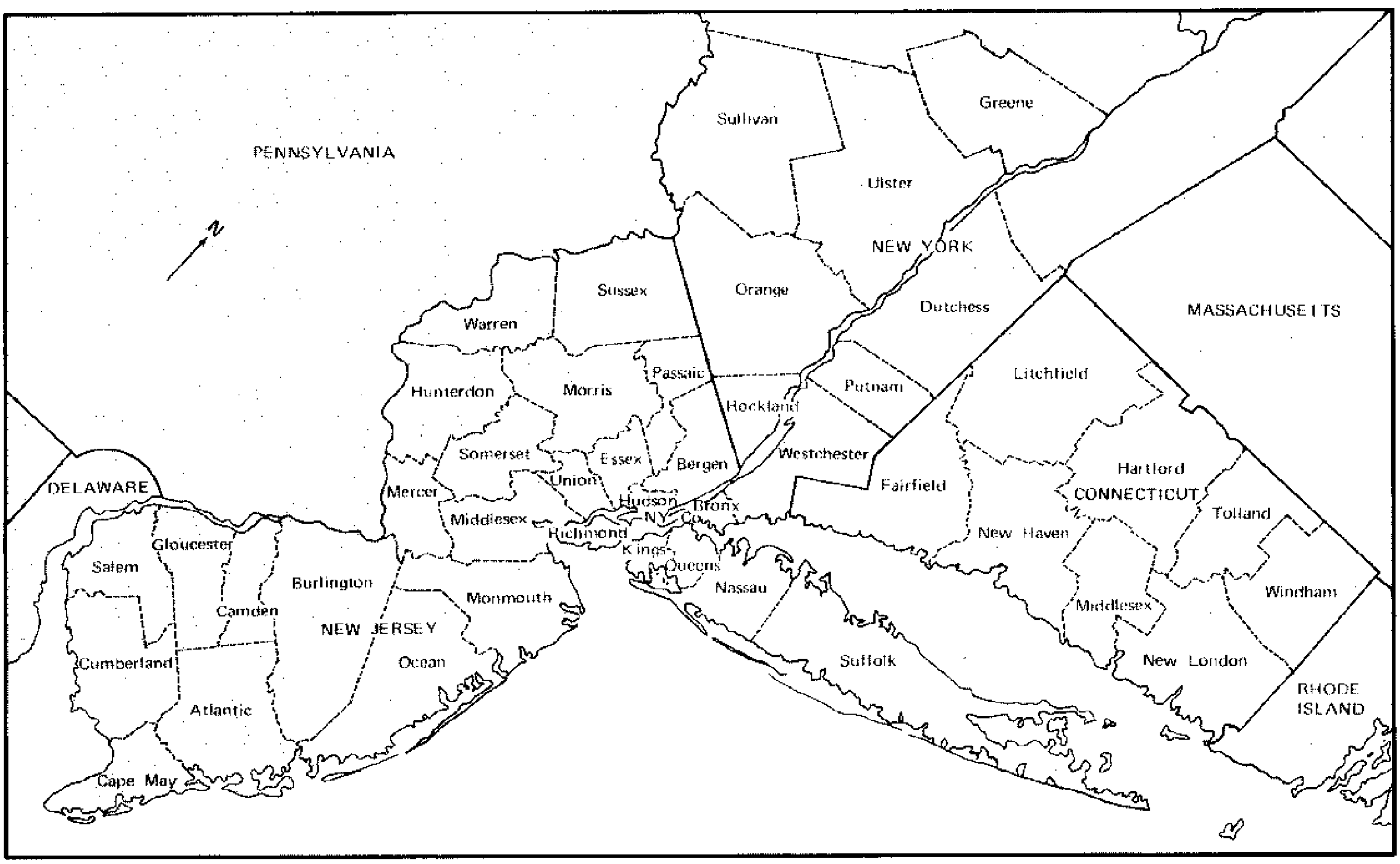


# Abstract

The New York Bight region is diverse in economic activity and energy-related services. It is dependent on oil for its energy: oil provides 76% of all energy regionally versus 44% nationally. New York City is characterized by a low average energy use in commercial and industrial activity, but on a per household basis the city used in 1970 roughly the same total energy, 148 million Btu, as the national average of 150 million Btu. In 1972 the Bight region had about 19% of its electric capacity in nuclear units versus less than 4% nationally. New Jersey, the oil refining center of the region, had a total crude handling capability of 592,000 barrels per day in 1972; 79% of this crude oil was imported.

While energy projections are today fraught with uncertainty, major increases in the demand for electricity in the Bight region clearly will occur in the future. Fuel types and sources, as well as the kind of capacity to generate this electricity, are in doubt.

# Introduction

The purpose of this monograph is to describe the electrical energy and oil refinery facilities in the New York Bight region. Although we will not examine energy supply and demand in detail, familiarity with a number of general features is essential to understanding the region's energy characteristics. Population size, economic activity, basic fuel mix, and specific energy demand requirements provide a basis for discussion. We concentrate on electrical energy and oil refineries for two reasons. First, our objective is to deal only with major energy uses and processes in central locations – activities of a reasonable minimum size for understanding and analyzing their effects. Second, the siting and environmental issues of these two categories form a well-defined but immense subgroup of all energy activity and afford a fundamental starting point for further analysis.

No attempt is made in this monograph to evaluate related aspects of energy production in the Bight, such as proposed offshore power plants, oil drilling, and supertanker terminals. These are issues currently under intensive investigation whose impact cannot be properly assessed within the scope of this paper.

It should be stressed that the electric production and refining capacity projections presented in this paper were prepared prior to the energy disruptions of the 1973-74 winter. Nonetheless, they can be viewed as "business as usual" projections to provide conservative (i.e., high) estimates of impacts and land use requirements for the Bight region.

For our study, the New York Bight region is defined as all of New Jersey, the 10 southernmost counties of New York State plus New York City, and all of Connecticut (Map 1). This includes the entire coastline bordering the Bight as well as much of the contiguous land connected to the Bight in terms of electrical energy generation and use. Major air and water effluents creating environmental stress in the Bight usually originate inland.

# Characteristics of the Bight Region

The New York Bight region is highly diverse and densely developed, showing variation in the nature and scope of economic and energy-consumption activity. Within its boundaries is the nation's largest metropolitan area, as well as extensive light industry and non-energy-intensive commercial activities. New York City, a complex urban area, contained a 1970 population of 7,895,000 persons – a density of 26,319 persons per square mile. At that time the city had 2,000,837 households, averaging about 2.7 persons per household – 14% below the national average. The city's population level has been relatively stable over the past 10 years, growing only about 1.5% during that period. The population of the surrounding Bight region – 14,644,000 in 1970 – has grown about 1.7% per year since 1960, compared to the national growth rate average of 1.3% (Jones et al 1974).

The Bight region shows significant differences from the rest of the United States in its use of major fuels (Figure 1). In 1970 the region was more dependent on oil (including gasoline) than the nation as a whole – 76% compared to 44%. This difference was accounted for by lower regional natural gas and coal consumption than the national average.

Between New York City and the surrounding Bight region, fuel use characteristics are somewhat alike. Both use oil for electricity generation; almost 60% of this demand is met by oil. New York City and the region are also significant users of natural gas, each drawing over 15% of their overall supply from this source.

Imported crude oil is important for residential purposes and for productive activity since no fuel extraction presently occurs within the region, though it is the east coast's major oil processing and refining center. In 1970 approximately 48% of the crude and refined petroleum products imported into the region were foreign in origin. Nowhere in the United States was dependence on such imports as great (US Department of the Interior, Bureau of Mines 1971).

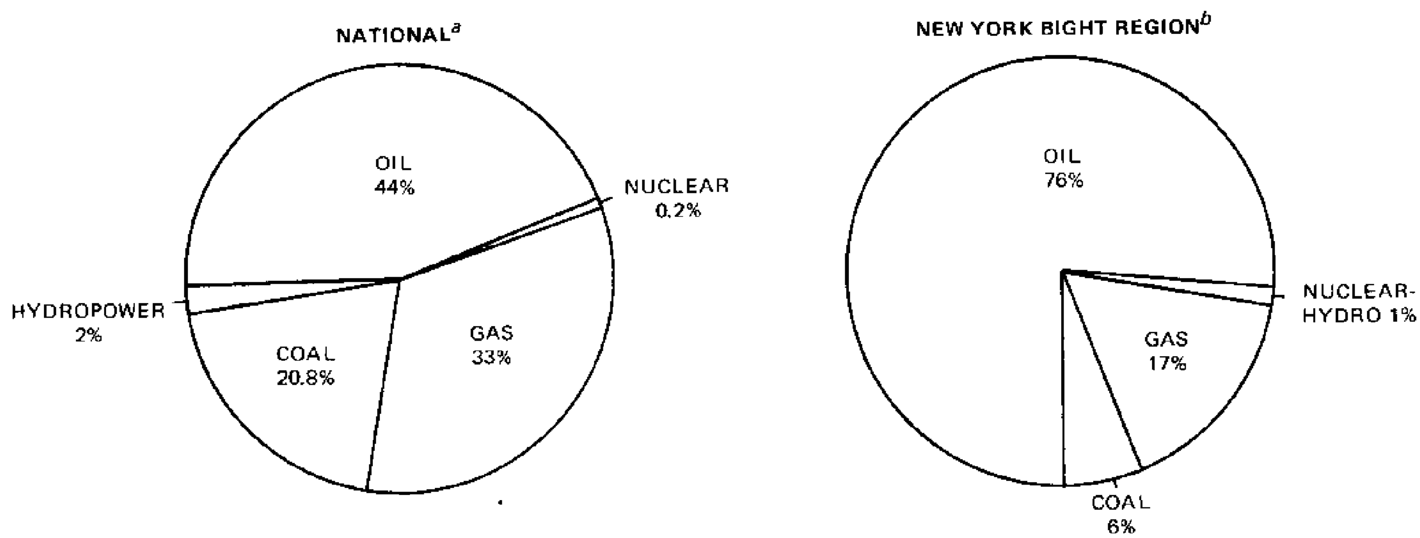
## Energy Demands

In 1970, 60% of the electricity and 30% of the fossil fuels delivered to consumers in New York City went to commercial and industrial establishments. In the surrounding Bight region approximately 65% of the electricity and 35% of the fossil fuels were consumed by these establishments.

The largest commercial energy demands are for space and water heating and for lighting and miscellaneous uses. The magnitude of these demands does not depend on the type of commercial activity but is correlated to floor space and number of persons employed.

In New York City the two largest energy-consuming industry groups – food and kindred products and chemicals and allied products – together

**Figure 1.** Energy use by fuel type




[a]Based on 1969 consumption from Associated Universities Incorporated 1972
[b]Based on 1970 consumption from Jones et al 1974

consume 34% of the energy used by industry but employ only 8% of all industrial workers. On the other hand, apparel and other textile products and printing and publishing employ over 41% of all industrial employees but account for only 9% of the industrial energy consumption. Table 1, a breakdown of fuels used for heat and power in industry, shows this kind of distinction between energy-intensive and non-energy-intensive industry. In the New York Standard Metropolitan Statistical Area (SMSA)*, for example, six of the 16 major industrial sectors use

*New York SMSA contains New York City (Bronx, Kings, Queens, Richmond, and New York counties) plus Nassau, Rockland, Suffolk, and Westchester counties.

**Table 1.** Fuels used for heat and power by areas and industry group, 1971

| Code | Area and Industry Group | Kilowatt Hours (billion) | Fuel oil: Distillate (thousand bbls) | Fuel oil: Residential (thousand bbls) | Coal (thousand tons) | Coke (thousand tons) | Natural Gas (billion $ft^3$) |
|---|---|---|---|---|---|---|---|
| | **Connecticut total** | **28.4** | **2,731.0** | **7,297.5** | **5.3** | **NA** | **14.9** |
| 20 | Food and kindred products | 0.9 | 58.6 | 112.3 | | | 0.3 |
| 22 | Textile mill products | 2.2 | 223.6 | 649.1 | | | 1.0 |
| 27 | Printing and publishing | 0.3 | 37.7 | 29.8 | | | NA |
| 28 | Chemicals and allied products | 4.0 | 120.7 | 1,511.6 | 1.5 | | 0.9 |
| 32 | Stone, clay, and glass products | 1.7 | 120.4 | 336.0 | | | 1.0 |
| 33 | Primary metal industries | 5.1 | 338.0 | 895.6 | | NA | 4.7 |
| 34 | Fabricated metal products | 2.0 | 179.6 | 330.3 | | | 1.5 |
| 35 | Machinery, except electrical | 2.1 | 277.9 | 292.7 | | NA | 2.1 |
| 36 | Electrical equipment and supplies | 0.9 | 171.8 | 136.8 | | | 0.5 |
| 37 | Transportation equipment | 2.6 | 276.3 | 749.8 | | NA | 1.4 |
| 38 | Instruments and related products | 0.6 | 73.5 | 200.0 | | | 0.4 |
| 39 | Miscellaneous manufacturing industries | 1.7 | 176.5 | 553.0 | | | 0.4 |
| | **New York SMSA total** | **32.5** | **2,775.0** | **1,767.2** | **20.2** | **NA** | **25.1** |
| 20 | Food and kindred products | 6.5 | 351.0 | 576.1 | 2.6 | | 8.4 |
| 22 | Textile mill products | 1.1 | 115.7 | 39.5 | | | 0.4 |
| 23 | Apparel, other textile products | 1.8 | 57.8 | 22.9 | 1.7 | | 0.4 |
| 25 | Furniture and fixtures | 0.5 | 64.5 | 8.0 | | | 0.1 |
| 26 | Paper and allied products | 2.5 | 291.2 | 20.7 | 0.1 | | 1.1 |
| 27 | Printing and publishing | 1.5 | 41.9 | 25.0 | | | 0.8 |
| 28 | Chemicals and allied products | 2.9 | 351.1 | 110.4 | | | 3.4 |
| 30 | Rubber and plastics products, n.e.c.* | 1.0 | 63.8 | 8.0 | | | 0.2 |
| 32 | Stone, clay, and glass products | 2.5 | 317.8 | 35.8 | 0.9 | | 2.8 |
| 33 | Primary metal industries | 1.9 | 229.2 | 359.0 | | | 1.3 |
| 34 | Fabricated metal products | 2.9 | 131.2 | 71.2 | 0.7 | | 1.6 |
| 35 | Machinery, except electrical | 1.3 | 71.3 | 22.3 | 9.0 | | 0.7 |
| 36 | Electrical equipment and supplies | 1.5 | 180.5 | 63.8 | | | 1.4 |
| 37 | Transportation equipment | 1.8 | 333.2 | 289.1 | 4.7 | NA | 1.3 |
| 38 | Instruments and related products | 0.5 | 46.7 | 55.4 | | | 0.3 |
| 39 | Miscellaneous manufacturing industries | 1.3 | 96.9 | 54.8 | 0.6 | | 0.6 |
| | **New Jersey total** | **103.7** | **15,085.5** | **13,765.5** | **355.8** | **276.8** | **84.2** |
| 20 | Food and kindred products | 8.7 | 1,784.6 | 957.7 | 28.3 | NA | 7.3 |
| 22 | Textile mill products | 3.5 | 247.3 | 430.0 | 1.8 | | 1.2 |
| 23 | Apparel, other textile products | 0.5 | 73.6 | 9.9 | | | 0.2 |
| 24 | Lumber and wood products | 0.2 | 12.9 | 6.2 | | | 0.3 |
| 26 | Paper and allied products | 9.5 | 1,587.5 | 2,431.0 | | | 2.7 |
| 27 | Printing and publishing | 0.8 | 148.5 | 29.2 | | | 1.4 |
| 28 | Chemicals and allied products | 31.3 | 5,412.6 | 3,307.4 | 281.6 | NA | 15.6 |
| 29 | Petroleum and coal products | 9.2 | 579.1 | 2,659.7 | | | 7.1 |
| 30 | Rubber and plastics products, n.e.c.* | 2.3 | 317.9 | 229.8 | 10.6 | | 3.1 |
| 31 | Leather and leather products | 0.4 | 112.3 | 14.4 | | | 0.1 |
| 33 | Primary metal industries | 8.3 | 558.8 | 1,437.0 | 33.6 | 227.2 | 5.6 |
| 34 | Fabricated metal products | 4.2 | 375.3 | 270.1 | | NA | 4.7 |
| 35 | Machinery, except electrical | 2.9 | 318.9 | 251.6 | | NA | 3.6 |
| 36 | Electrical equipment and supplies | 3.2 | 258.8 | 481.8 | | NA | 3.0 |
| 37 | Transportation equipment | 1.7 | 294.1 | 174.0 | | NA | 2.2 |
| 38 | Instruments and related products | 0.6 | 37.5 | 45.4 | | | 0.5 |
| 39 | Miscellaneous manufacturing industries | 0.8 | 96.8 | 68.3 | | | 0.7 |

*n.e.c.—not elsewhere classified

Source: US Department of Commerce MC72(SR) 6, 1973

Table 2. Electricity consumption and price, 1973

| | 1972 Population (thousands) | Sales (million kwh) Residential | Commercial-Industrial | Other | Price/kwh[a] High | Low |
|---|---|---|---|---|---|---|
| Connecticut | 3,082 | 7,256 | 10,887 | 1,152 | $3.15 | $2.82 |
| New Jersey | 7,367 | 14,236 | 29,203 | 640 | 3.42 | 2.94 |
| New York[b] | 12,422 | 16,384 | 27,957 | 9,882 | 5.18 | 2.64 |
| Region | 22,891 | 37,876 | 68,047 | 11,674 | | |

[a] Comparison for residential sector only, in cents/kwh

[b] Area in New York Bight region only

Source: Moody's Investors Service, Inc. 1974

about 70% of the fuel oil in industry. A similar pattern holds for the remainder of the Bight region, although not in the same industries.

Table 2 compares average residential and commercial-industrial electricity consumption and also shows 1973 electricity prices. There is a negative correlation between population density and residential electric energy use in the region, primarily because single family homes in suburban areas use more energy than multifamily dwellings in urban centers and because electricity prices tend to be considerably lower in suburban areas than in urban centers.

On a total energy use basis, the average New York City household consumes about 148 million Btu annually, nearly equal to the national average of 150 million Btu. However, since the average New York City household size (2.7 persons per household) is smaller than the national average (3.2 persons per household), per capita residential energy use in the city is 15% greater than the national average. The area surrounding New York City has many large cities but is primarily suburban in nature and more like the nation in most energy uses than is the city. New York City households use an average of 80% of the total energy consumed in suburban residences in the surrounding Bight region (Jones et al 1974).

Per capita use of energy for transportation tends to be low because of the region's compactness – that is, its high population density – and because of its well-developed transportation system. Numerous railroads serve the area, and major subway lines in New York City carry 1.3 billion passengers annually. These plus buses accounted for roughly 18% of "person trips" in the region in 1970. Automobile transport in New York City is lower in total passenger miles traveled per year than the national average. However, the automobile accounted for about 78% of all "person trips" in the region (Regional Plan Association 1974).

# Electric Power Production and Use

In 1972 the total electric power generating capacity in the Bight region was 39,625 Mw. Of this, Connecticut's share was 5,087 Mw, New Jersey's was 14,342 Mw, and New York's was 20,196 Mw (Federal Power Commission 1973). Table 3 indicates this generating capacity by plant type, along with corresponding national figures. Map 2 shows the geographical distribution of generating capacity as well as the type and capacity by utility.

Electric generating capacity characteristics disclose several interesting facts. First, capacity type varies significantly by state: New Jersey has over 28% gas turbines and New York, 18%. In electricity production gas turbines are relatively inefficient compared to large steam turbines. Gas turbines require high-grade fuels, usually distillate fuel oil or natural gas, and have more significant emissions than steam turbines. Because of their low capital cost, gas

**Table 3.** Total installed generating capacity, 1972 (in Mw)

| | Total | Hydro-electric | Conventional Steam | Nuclear Steam | Internal Combustion | Gas Turbine |
|---|---|---|---|---|---|---|
| United States | 399,606 | 56,566 | 322,944 | 15,300 | 4,796.0 | *a* |
| Connecticut | 5,087 | 99 | 3,410 | 1,262 | 6.0 | 311 |
| New Jersey | 14,342 | 399 | 7,129 | 2,890 | – | 3,984 |
| New York | 20,196 | 33 | 13,316 | 3,263 | 8.7 | 3,575 |

[a]Gas turbine statistics included in conventional steam

Sources: Edison Electric Institute 1973; Federal Power Commission 1973

turbines are normally used by utilities only for peaking power generation. Unfortunately, gas turbines now furnish a large proportion of new capacity in the Bight region as a result of site delays and constraints on capital availability.

The issue of electricity imports and exports is a difficult one because of the interrelationship of utilities both within the Bight region and with the power pool groups covering areas outside the region. Also, electricity purchases from power pools vary with peak demands; that is, when the region's utilities have insufficient capacity to meet peak loads – on a hot summer day, for example – they draw large amounts of electricity from outside the region. This means that electricity flow is not smooth or constant but rather is based on peak demand; hence it is unpredictable over time. In this monograph, we are discussing either installed capacity or consumption (sales) in the region. We make no distinction between internally produced or imported electricity for consumption nor between capacity serving demands outside as well as inside the region.

Because of differences in capital and operating costs, various types of electric capacity are usually associated with various operating procedures. For example, modern steam electric or nuclear plants are efficient fuel converters and are used for base load purposes. On the other hand, older, less efficient steam electric plants or gas turbine generators are used primarily for peaking demand and so are used much less intensively. Table 4 shows the total electricity generated by type in 1972. It is apparent from the table that conventional steam is used most often to generate electricity in the Bight region. In Connecticut, nuclear steam provides half the number of kilowatt hours per year of conventional steam.

In 1972 electric generating capacity served an estimated 22.9 million persons in the Bight region (New York State 1974; US Department of Commerce 1973). Electric sales totaled about 117.6 billion kwh

**Table 4.** Total electricity generation, 1972 (in billion kwh)

| | Total | Hydro-electric | Conventional Steam[a] | Nuclear Steam | Internal Combustion |
|---|---|---|---|---|---|
| United States | 1,747.0 | 272.0 | 1,413.0 | 54.0 | 7.00 |
| Connecticut | 24.0 | 0.6 | 15.6 | 7.8 | 0.01 |
| New Jersey | 34.5 | (0.2)[b] | 30.3 | 4.4 | – |
| New York[c] | 51.8 | 0.4 | 49.7 | 1.1 | 0.56 |

[a]Gas turbine statistics included in conventional steam

[b]Parentheses denote negative figure, indicating that pump storage facilities use more electricity than they generate

[c]Area in New York Bight region only

Source: Edison Electric Institute 1973

## LEGEND TO MAP 2

Source: Federal Power Commission 1973

### CONNECTICUT

| | | Capacity | Type | Utility |
|---|---|---|---|---|
| 1 | Bridgeport Harbor | 661 | ST | UI |
| | | 19 | GT | UI |
| 2 | Devon | 454 | ST | CLP |
| | | 16 | GT | CLP |
| 3 | English | 146 | ST | UI |
| 4 | Middletown | 375 | ST | HE |
| | | 19 | GT | HE |
| 5 | Montville | 577 | ST | CLP |
| | | 5 | IC | CLP |
| 6 | Norwalk Harbor | 326 | ST | CLP |
| | | 16 | GT | CLP |
| 7 | Rocky River | 31 | Hydro | CLP |
| 8 | Shepang | 37 | Hydro | CLP |
| 9 | S. Meadows | 217 | ST | HE |
| | | 177 | GT | HE |
| 10 | Stamford | 53 | ST | HE |
| 11 | Steel Point | 156 | ST | UI |
| 12 | Stevenson | 31 | Hydro | CLP |
| 13 | Haddam Weck | 600 | N | CY |
| 14 | Millstone | 662 | N | HE |
| 15 | Cos. Cob | 64 | GT | CLP |
| 16 | Coke Works | 445 | ST* | UI |

UI—United Illuminating Co
CLP—Connecticut Light and Power Co
HE—Hartford Electric Light Co
CY—Connecticut Yankee Atomic Electric Co

### NEW JERSEY

| | | Capacity | Type | Utility |
|---|---|---|---|---|
| 17 | Bergen | 650 | ST | PSE |
| | | 19 | GT | PSE |
| 18 | Burlington | 47 | ST* | PSE |
| | | 521 | GT | PSE |
| 19 | Deep Water | 308 | ST | AC |
| | | 19 | GT | AC |
| 20 | Werner, E.H. | 116 | ST | JE |
| | | 212 | GT | JE |
| 21 | Essex | 185 | ST | PSE |
| | | 585 | GT | PSE |
| 22 | Gilbert | 126 | ST | NE |
| | | 95 | GT | JE |
| | | 190 | GT* | JE |
| | | 126 | ST* | JE |
| 23 | Kearney | 599 | ST | PSE |
| | | 311 | GT | PSE |
| | | 167 | GT* | PSE |
| 24 | Linden | 613 | ST | PSE |
| | | 114 | GT | PSE |
| | | 167 | GT* | PSE |
| 25 | Marion | 125 | ST | PSE |
| 26 | Mercer | 653 | ST | PSE |
| | | 115 | GT | PSE |
| 27 | Missouri Ave | 50 | ST | AC |
| | | 56 | GT | AC |
| 28 | Sayreville | 344 | ST | JE |
| | | 213 | GT* | JE |
| 29 | Sewaren | 820 | ST | PSE |
| | | 778 | ST* | PSE |
| | | 115 | GT | PSE |
| 30 | Vineland | 77 | ST | Municipal |
| | | 20 | GT* | Municipal |
| 31 | England | 299 | ST | AC |
| | | 176 | ST* | AC |
| 32 | Oyster Creek | 550 | N | JE |
| 33 | Yards Creek | 339 | Hydro | JE |
| 34 | Hudson | 1115 | ST | PSE |
| | | 115 | GT | PSE |
| 35 | Middle Station | 80 | GT | AC |
| 36 | Bayonne | 43 | GT | PSE |
| 37 | Edison | 502 | GT | PSE |
| 38 | Glen Gardner | 157 | GT | JE |
| 39 | Salem | 2340 | N* | PSE |
| | | 42 | GT | PSE |
| 40 | Cedar | 63 | GT* | AC |
| 41 | Caril's Corner | 84 | GT* | AC |
| 42 | Greenwich | 12 | ST | AC |

AC—Atlantic City Electric Co
JE—Jersey Central Power and Light
NE—New Jersey Power and Light
PSE—Public Service Electric and Gas

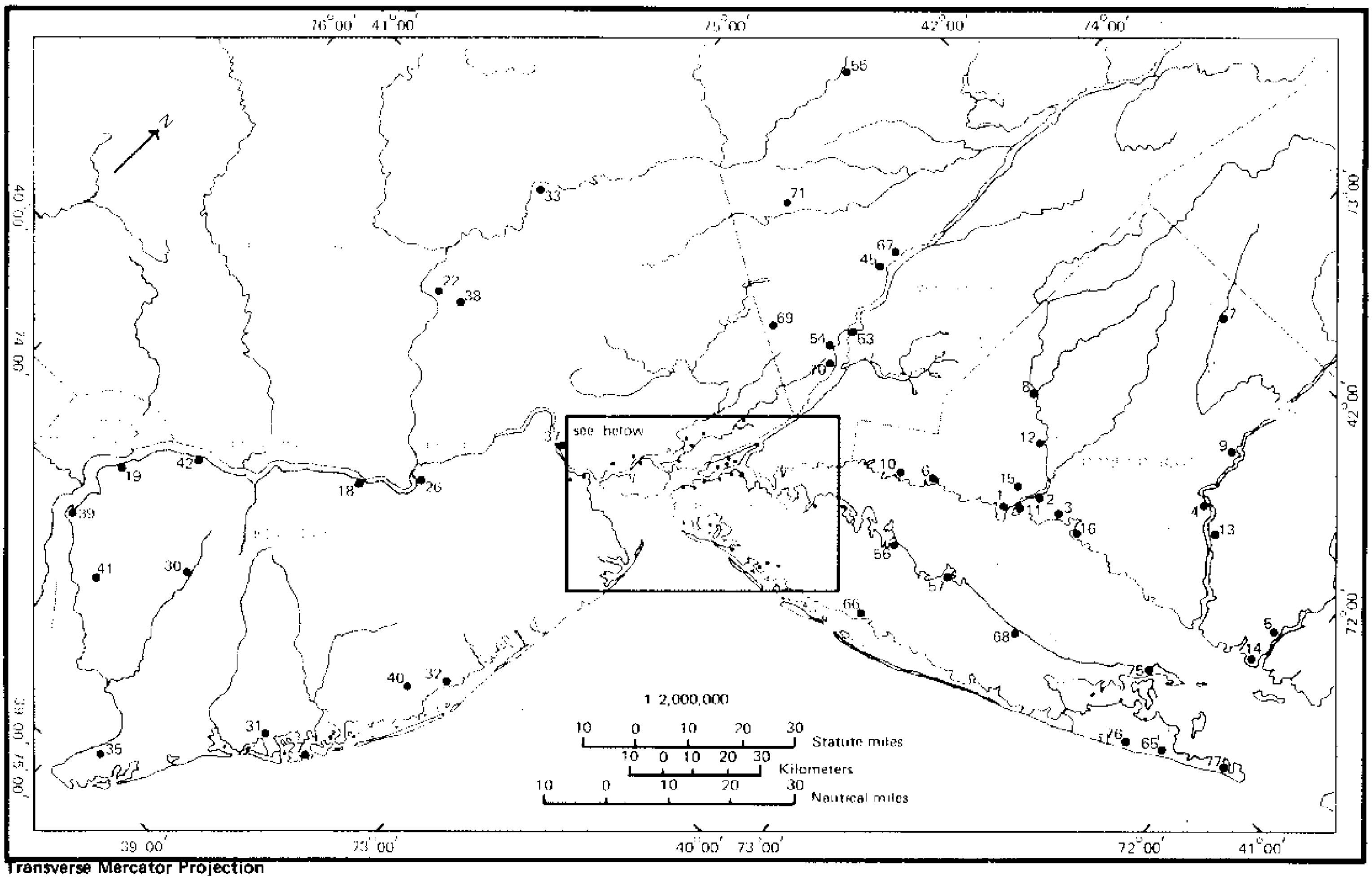
### NEW YORK

| | | Capacity | Type | Utility |
|---|---|---|---|---|
| 43 | Arthur Kill | 912 | ST | CE |
| | | 18 | GT | CE |
| 44 | Astoria | 1551 | ST | CE |
| | | 700 | GT | CE |
| 45 | Danskammer | 532 | ST | CH |
| 46 | East River | 734 | ST | CE |
| | | 60 | ST | CE |
| 47 | Barrett | 375 | ST | LILCO |
| | | 330 | GT | LILCO |
| 48 | Far Rockaway | 114 | ST | LILCO |
| 49 | Freeport | 34 | IC | Municipal |
| 50 | Glenwood Landing | 377 | ST | LILCO |
| | | 16 | GT | LILCO |
| | | 100 | GT* | LILCO |
| 51 | Hell Gate | 70 | ST | CE |
| | | 401 | ST | CE |
| 52 | Hudson Ave | 715 | ST | CE |
| | | 90 | ST | CE |
| 53 | Indian Point | 275 | N | CE |
| | | 2138 | N* | CE |
| | | 60 | GT | CE |
| 54 | Lovett | 495 | ST | OR |
| 55 | Neversink | 25 | Hydro | CH |
| 56 | Northport | 774 | ST | LILCO |
| | | 387 | ST* | LILCO |
| | | 16 | GT | LILCO |
| 57 | Port Jefferson | 467 | ST | LILCO |
| | | 16 | GT | LILCO |
| 58 | Rockville Centre | 27 | IC | Municipal |
| | | 6 | IC* | Municipal |
| 59 | Sherman Creek | 217 | ST | CE |
| 60 | Waterside | 140 | ST | CE |
| | | 572 | ST | CE |
| | | 14 | GT | CE |
| 61 | Kent Ave | 108 | ST | CE |
| | | 28 | GT | CE |
| 62 | 59th Street | 185 | ST | CE |
| | | 35 | GT | CE |
| 63 | 74th Street | 65 | ST | CE |
| | | 144 | ST | CE |
| | | 37 | GT | CE |
| 64 | Ravenswood | 1828 | ST | CE |
| | | 471 | GT | CE |
| 65 | East Hampton | 6 | IC | LILCO |
| | | 22 | GT* | LILCO |
| 66 | West Babylon | 109 | GT | LILCO |
| 67 | Roseton | 1153 | ST | CH |
| 68 | Shoreham | 850 | N* | LILCO |
| | | 53 | GT | LILCO |
| | | 3 | IC* | LILCO |
| 69 | Hillburn | 42 | GT | OR |
| 70 | Bowline | 1246 | ST | CE & OR |
| 71 | Shoemaker | 42 | GT | OR |
| 72 | Gowanus | 344 | GT | CE |
| | | 344 | GT* | CE |
| 73 | Hudson Ave | 28 | ST | CE |
| | | 8 | Hydro | CE |
| 74 | Narrows | 348 | GT* | CE |
| 75 | Southold | 14 | GT | LILCO |
| 76 | South Hampton | 11 | GT | LILCO |
| 77 | Montauk | 6 | GT | LILCO |

CH—Central Hudson Gas and Electric Corporation
CE—Consolidated Edison Co
LILCO—Long Island Lighting Co
OR—Orange and Rockland Utilities

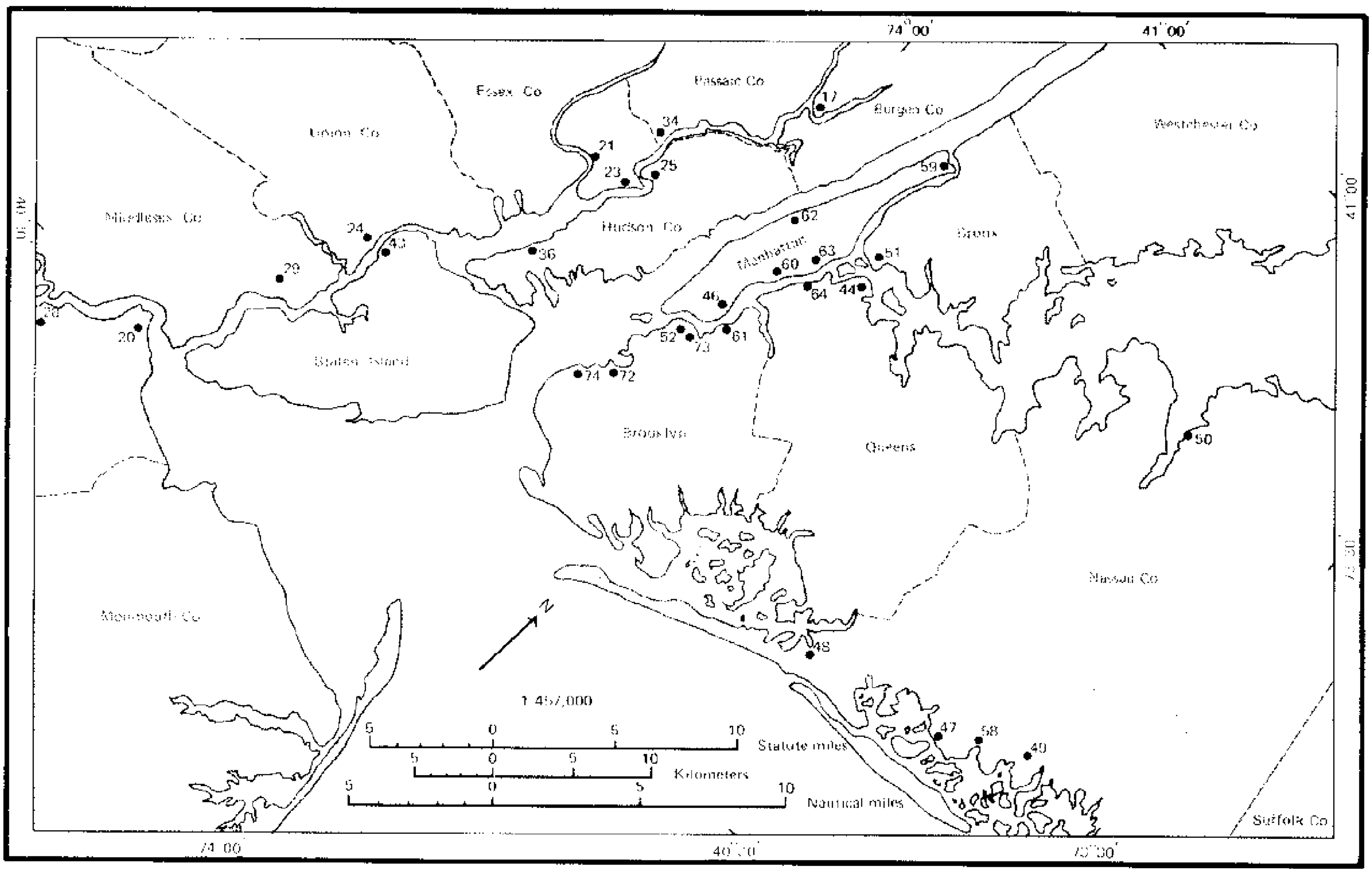
*Under construction
ST—Conventional steam
GT—Gas turbine
IC—Internal combustion
N—Nuclear
Hydro—Hydro-electric

# Map 2. Generating capacity distribution




Transverse Mercator Projection

## Inset




Transverse Mercator Projection

**Table 5.** Electric sales by customer class, 1973

| | Sales (billion kwh) | | | Number of Customers | | |
|---|---|---|---|---|---|---|
| | Residential | Commercial and Industrial | Other | Residential | Commercial and Industrial | Other |
| CONNECTICUT | | | | | | |
| Connecticut Light & Power | 3,770 | 4,618 | 1,024 | 470,574 | 54,240 | 1,726 |
| Hartford Electric Light | 1,827 | 3,371 | 72 | 254,574 | 27,300 | 236 |
| United Illuminating Co | 1,659 | 2,898 | 56 | 239,148 | 24,042 | 525 |
| NEW JERSEY | | | | | | |
| Atlantic City Electric Co | 1,899 | 2,471 | 58 | 260,035 | 40,758 | 678 |
| Jersey Central Power & Light | 4,314 | 5,961 | 333 | 545,082 | 61,743 | 909 |
| Public Service Electric & Gas | 8,023 | 20,771 | 249 | 1,425,562 | 191,789 | 4,547 |
| NEW YORK | | | | | | |
| Consolidated Edison Co | 8,917 | 19,090 | 6,725 | 2,470,403 | 372,856 | 3,750 |
| Long Island Lighting Co | 5,540 | 5,925 | 1,054 | 754,396 | 74,503 | 2,708 |
| Orange & Rockland | 751 | 1,071 | 1,587 | 116,633 | 14,922 | 297 |
| Central Hudson Gas & Electric | 1,176 | 1,871 | 516 | 163,181 | 22,545 | 2,079 |

Source: Moody's Investors Service, Inc. 1974

in 1973 with 37.9 billion kwh used by residential customers, 68 billion kwh used by commercial and industrial customers, and 11.7 billion kwh used by others. Table 5 shows 1973 sales by state, utility, and customer class. The table indicates that in Connecticut residences used over 40% of the state total. In New Jersey and New York, however, the commercial-industrial sector was by far the largest, using 67% and 52%, respectively, of the total kilowatt hours sold.

## Electricity and the Environment

A complete assessment of the environmental implications of electric power production must take into account a wide range of issues: fuel extraction and transport, facility siting, power generation, plant cooling, effluents and effluent controls, waste disposal, and alternative generation and pollution control technologies. The following discussion looks briefly at the major environmental considerations bearing on electric facility operation.

Most air pollution is a result of energy conversion. In 1971 the US Environmental Protection Agency (EPA) reported that electric utilities were responsible nationwide for 62% of the sulfur oxide, 25% of the nitrogen oxide, 14% of the particulates, 0.4% of the hydrocarbon, and 0.2% of the carbon monoxide air pollution (Federal Power Commission 1971). According to the Federal Power Commission (1971), electric power production currently accounts for more than four-fifths of the total cooling water used in the United States. It also accounts for nearly one-third of the total water withdrawn for all purposes.

A fossil fuel power plant converts energy stored in coal, oil, or gas into electrical energy and emits as by-products varying amounts of particulate matter, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. A 1,000 MWe coal-fired plant with minimal environmental controls, for example, produces roughly 352,000 tons of air emissions per year, about 93% of which are sulfur oxides and particulates. If the plant were emission-controlled in 1980, annual air emissions would be: 2,000 tons of flyash, 24,000 tons of sulfur oxides, 700 tons of carbon monoxide, and 20,000 tons of nitrogen oxides (Edison Electric Institute 1973). Oil-fired plants with state-of-the-art pollution control devices can be substantially less polluting than coal-fired plants. Air emissions from an oil-fired plant in 1980 would be:

150 tons of particulates, 21,000 tons of sulfur dioxide, 8,700 tons of nitrogen oxides, and 7,500 tons of carbon monoxide.

It is difficult to compare nuclear plants to fossil fuel plants. Nuclear plant effluents dispersed into the air and water are of tremendously lower quantity but of a completely different type from fossil fuel plants. Routine radioactive releases from nuclear power plants constitute a smaller fraction of the maximum permissible release than do the emissions of sulfur oxide particulates and nitrogen oxides from fossil fuel plants; but hazards from accidental radioactive releases, while of extremely low probability, are major. Thermal effects of nuclear plants tend to be larger than those of fossil fuel plants by about 33%, if both are using direct cooling. For a complete comparative discussion of alternative electric generation types the reader is referred to Edison Electric Institute (1973).

**Power Plant Cooling.** The cooling systems used for electric power plants are, in principal, determined by examining the tradeoffs among efficiency, cost, and environmental impact. All cooling systems have significant environmental effects though varying greatly in degree and kind. Four types of cooling systems are now in use: once-through, ponds, wet towers (natural and mechanical), and dry towers. Once-through cooling is the most efficient system but usually has the most significant environmental impact. Pond cooling requires large land areas, ranging from 1 to 3 acres/Mw; cooling is achieved through evaporation. Natural draft and mechanical draft cooling towers – similar in design – cool through heat dissipation: air passes over hot water falling from the top of the tower. These require about 2 to 4 acres/1,000 Mw. Dry towers must be substantially larger than wet towers and need 3 to 8 acres/1,000 Mw. Hot water passing through metal tubes inside the tower is cooled by heat convection to air.

In terms of environmental effects, cooling options vary. Wet cooling systems, particularly those using towers or ponds, tend to produce ground fog. Also, large quantities of chemicals must be added to the cooling water to minimize corrosion and algal growth. Thus a "chemicals blowdown" problem, as it's called, exists in all wet systems. Mechanical draft towers use huge fans, which move vast quantitites of air, are noisy, and generally cause thermal updrafts. Once-through cooling systems have the greatest environmental impact and are the least expensive, the most efficient in terms of the plant's thermal effectiveness, and the most common. The major environmental consequences from this system are entrapment and entrainment of fish and larvae, dissolved oxygen release and chemical additive discharge, and thermal effects on and production of currents in receiving waters. While wet towers and ponds have less marine environmental impact than once-through cooling, they tend to affect the atmosphere and require substantial consumptive use of water. Dry towers are much higher in cost and lower in efficiency, do not influence the marine environment directly, but do cause some atmospheric effects (Federal Power Commission 1973).

**Power Plants in the Bight Region.** The environmental impact of electricity generation for any given plant type is determined by the fuels used, generation efficiency (quantity of fuel required per kilowatt hour output), air pollution control equipment in place, and method of using cooling water. Table 6 provides a comprehensive breakdown by utility and plant of the significant characteristics of steam-electric plants in the Bight region. Although this information is based on 1970 data, it is still timely because of the long life span of utility plants – 30 years plus. More current information should soon be available from the Federal Power Commission.

The data on pollutant emissions indicate the variability of environmental impact from plants of similar size. The final two columns in Table 6 demonstrate regional dependence on ocean water for condenser cooling. Although cooling towers have not been used often in the past, they will probably become increasingly common in the future.

## Projections

Electricity projections for the Bight region were prepared in two ways. First, New York State projections have been made by each Bight region utility and provided to the Public Service Commission in the *Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation* (1974). Estimates of energy production by New York utility for 1970-1985 are shown in Table 7. Unfortunately, Connecticut and New Jersey have not required that utilities provide such forecasts. For this reason, we have used Federal Power Commission (FPC) and Regional Plan Association (RPA) projections; they tend to be more generalized and less up-to-date than New York's but they do provide figures satisfactory for our purposes.

**Table 6.** Steam-electric plant air and water environmental quality control data, 1970

| | Capacity (Mw) | Fuel | | | Annual Plant[a] Emissions (thousand tons) | | |
|---|---|---|---|---|---|---|---|
| | | Coal (thousand tons) | Oil (thousand bbls) | Gas (thousand CF) | Particulates | Sulfur Dioxide | Nitrogen Oxide |
| CONNECTICUT | | | | | | | |
| United Illuminating | | | | | | | |
| Bridgeport Harbor | 660.50 | | 6,880.00 | | 0.80 | 50.55 | 15.17 |
| English | 146.30 | | 1,616.00 | | 0.21 | 13.34 | 3.56 |
| Steel | 155.50 | | 1,930.00 | | 0.25 | 14.37 | 4.26 |
| Conn. Light & Power | | | | | | | |
| Devon | 454.00 | 603.90 | 2,335.70 | | 2.20 | 42.86 | 10.59 |
| Montville | 176.00 | 351.91 | 491.16 | | 4.30 | 16.92 | 4.23 |
| Norwalk Harbor | 326.40 | 795.90 | 64.30 | | 2.02 | 36.06 | 7.30 |
| Hartford Electric Light | | | | | | | |
| Middletown | 422.00 | 407.00 | 110.28 | | 0.30 | 7.51 | 6.35 |
| South Meadow | 216.75 | 96.50 | 4,293.30 | | 0.24 | 28.95 | 10.91 |
| Stamford | 52.50 | | 2,289.40 | 0.32 | 0.30 | 15.36 | 5.05 |
| Conn. Yankee | | | | | | | |
| Atomic Power Co. | 600.30 | | Nuclear | | | | |
| NEW JERSEY | | | | | | | |
| Public Service Electric & Gas | | | | | | | |
| Bergen | 650.00 | 915.00 | | 7,171.00 | 3.05 | 38.01 | 15.12 |
| Burlington | 491.00 | | 4,990.00 | | 0.73 | 14.90 | 11.00 |
| Essex | 329.00 | 13.00 | 3,083.00 | 278.00 | 0.46 | 9.07 | 6.95 |
| Hudson | 1,114.00 | 686.00 | 2,814.00 | 9,447.00 | 1.32 | 32.62 | 14.50 |
| Kearny A | 305.00 | | 2,308.00 | | 0.39 | 6.58 | 5.09 |
| Kearny B | 294.00 | 13.60 | 3,340.00 | | 0.16 | 6.75 | 5.26 |
| Linden | 519.00 | | 7,442.00 | | 1.25 | 28.22 | 16.41 |
| Marion | 125.00 | | 1,293.00 | | 0.21 | 3.77 | 2.85 |
| Mercer | 653.00 | 1,110.00 | | 7,459.00 | 6.69 | 40.23 | 18.10 |
| Sewaren | 820.00 | | 6,792.00 | 810.00 | 0.95 | 26.21 | 15.13 |
| Atlantic City Electric Co | | | | | | | |
| England | 299.00 | 768.00 | 2.80 | | 0.54 | 34.48 | 21.13 |
| Missouri Ave | 50.00 | 151.00 | 1.60 | | 1.33 | 1.33 | 1.36 |
| Jersey Central Power & Light | | | | | | | |
| Werner | 116.00 | | 1,263.00 | | 0.11 | 3.39 | 2.78 |
| Sayreville | 347.00 | 10.00 | 3,322.00 | 4,250.00 | 0.11 | 9.07 | 8.35 |
| Oyster Creek | 560.00 | | Nuclear | | | | |
| New Jersey Power & Light | | | | | | | |
| Gilbert | 126.00 | 266.00 | 13.00 | 2,327.00 | 3.25 | 10.99 | 2.88 |
| NEW YORK[c] | | | | | | | |
| Consolidated Edison Co | | | | | | | |
| 59th Street | 185.00 | | 1,464.00 | 2.20 | 0.25 | 4.22 | 3.23 |
| 74th Street | 269.00 | | 1,426.00 | | 0.24 | 4.02 | 3.14 |
| Arthur Kill | 911.00 | 1,001.00 | 3,069.00 | | 0.44 | 26.92 | 15.78 |
| Astoria | 1,551.00 | 1,223.00 | 3,321.00 | 22,655.00 | 1.28 | 27.62 | 22.75 |
| East River | 833.00 | | 2,437.00 | 23,399.00 | 0.34 | 6.54 | 9.94 |
| Hell Gate | 611.00 | | 4,419.00 | 4,695.00 | 0.74 | 11.70 | 10.64 |
| Hudson Ave | 765.00 | | 6,162.00 | 17.00 | 1.04 | 16.54 | 13.59 |
| Indian Pt | 275.00 | | 196.00 | 3,464.00 | 0.03 | 0.53 | 0.43 |
| Kent Ave | 108.00 | | | | | | 0.67 |
| Ravenswood | 1,828.00 | 360.00 | 8,386.00 | 8,217.00 | 1.33 | 29.61 | 23.32 |
| Sherman Crk | 216.00 | | 1,450.00 | 153.00 | 0.24 | 3.60 | 3.23 |
| Waterside | 712.00 | | 3,712.00 | 13,642.00 | 0.62 | 9.71 | 10.84 |
| Long Island Lighting Co | | | | | | | |
| Barrett | 375.00 | | 2,314.00 | 4,559.00 | 0.34 | 7.92 | 6.00 |
| Far Rockaway | 114.00 | | 713.00 | 729.00 | 0.09 | 2.15 | 1.71 |
| Glenwood | 380.00 | | 1,807.00 | 3,378.00 | 0.24 | 5.40 | 4.64 |
| Northport | 774.00 | | 7,574.00 | | 0.19 | 63.02 | 16.70 |
| Port Jefferson | 467.00 | | 4,021.00 | | 0.36 | 32.38 | 8.87 |
| Orange and Rockland | | | | | | | |
| Lovett | 495.00 | 124.00 | 2,235.00 | 12,057.00 | 0.87 | 10.53 | 8.39 |
| Central Hudson Gas & Electric | | | | | | | |
| Danskammer | 532.00 | 767.00 | 1,059.00 | 3,439.00 | 2.43 | 39.01 | 9.91 |

[a]Steam electric plants only, excludes gas turbine and hydro-electric

[b]R–River, B–Bay, H-Harbor

[c]Area in New York Bight region only

Source: Federal Power Commission 1973

| | Cooling Water ($ft^3/sec$) | | | Chemical Additives (tons) | | | | | Type of Cooling (Mw) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Source | Rate of Withdrawal | Rate of Discharge | Rate of Consumption | Phosphate | Caustic Soda | Lime | Aluminum | Chlorine | Once Thru Saline | Once Thru Fresh |
| Bridgeport H[b] | 687.72 | 687.72 | 5.91 | 0.50 | | | | | 399.50 | |
| Mill R | 330.41 | 330.41 | 2.84 | 8.70 | 10.40 | | | | 146.25 | |
| Bridgeport H | 248.79 | 248.79 | 2.14 | 8.85 | 15.80 | | | | 155.50 | |
| | | | | | | | | | | |
| Housatonic R | 625.50 | 625.50 | 5.58 | 3.50 | 2.40 | | | 44.00 | 454.00 | |
| Thames R | 238.00 | 238.00 | 2.05 | 0.32 | 0.21 | | | | 176.00 | |
| LI Sound | 470.00 | 470.00 | 4.04 | 0.60 | 2.70 | | | 82.25 | 366.40 | |
| | | | | | | | | | | |
| Detroit R | 152.20 | 112.90 | 1.31 | 7.10 | 0.55 | 269.81 | | 27.00 | | 54.00 |
| Connecticut R | 340.50 | 340.50 | 2.93 | 0.02 | 0.01 | | | 72.00 | | 422.00 |
| Connecticut R | 418.00 | 418.00 | 3.59 | 0.57 | 0.89 | | | 34.00 | | 222.00 |
| | | | | | | | | | | |
| Connecticut R | 870.00 | 870.00 | 7.48 | 0.90 | | | | | | 600.00 |
| | | | | | | | | | | |
| Overpeck R | 968.00 | 968.00 | 8.32 | 0.75 | 181.26 | | | 825.00 | 650.00 | |
| Delaware R | 709.00 | 709.00 | 6.10 | | 4.92 | | | 64.00 | | 491.00 |
| Passaic R | 847.00 | 847.00 | 7.28 | | 19.08 | | | 277.00 | 329.00 | |
| Hackensack R | 1,382.00 | 1,382.00 | 11.89 | | 360.93 | | | 660.00 | 1,114.00 | |
| Hackensack R | 1,081.00 | 1,081.00 | 9.30 | 0.30 | 34.50 | | | 124.00 | 304.00 | |
| Hackensack R | 440.00 | 440.00 | 3.78 | | 93.00 | | | 67.00 | 294.00 | |
| Arthur Kill | 528.00 | 528.00 | 4.54 | 11.05 | 1,631.50 | | | 715.00 | 520.00 | |
| Hackensack R | 176.00 | 176.00 | 1.51 | 12.00 | | | | 66.00 | 125.00 | |
| Delaware R | 1,056.00 | 1,056.00 | 9.08 | | 52.50 | | | 91.00 | | 652.00 |
| Arthur Kill | 1,302.00 | 1,302.00 | 11.20 | | 377.50 | | | 330.00 | 820.00 | |
| | | | | | | | | | | |
| Great Egg H | 342.00 | 342.00 | 2.94 | 2.15 | 153.52 | | | 60.00 | 299.00 | |
| Beach Thrfare | 117.00 | 117.00 | 1.00 | 0.35 | 9.75 | 2.06 | | 15.00 | 59.00 | |
| | | | | | | | | | | |
| Raritan R | 193.00 | 193.00 | 1.66 | 18.00 | 30.54 | 12.00 | 3.00 | 56.00 | 116.00 | |
| Raritan R | 430.00 | 430.00 | 3.70 | 4.50 | 112.50 | | | 75.00 | 347.00 | |
| Barnegat B | 1,094.00 | 1,094.00 | 9.41 | | 30.64 | | | 379.00 | 550.00 | |
| | | | | | | | | | | |
| Delaware R | 276.00 | 276.00 | 2.37 | 0.58 | | | 0.38 | 1.80 | | 126.00 |
| | | | | | | | | | | |
| Hudson R | 870.00 | 870.00 | 7.48 | 4.00 | 28.50 | | | 24.00 | 187.00 | |
| East R | 175.00 | 175.00 | 1.51 | 1.00 | 237.50 | | | 50.00 | 269.00 | |
| Lower NY H | 929.00 | 929.00 | 7.99 | 0.50 | 45.00 | | | 132.00 | 850.00 | |
| East R | 1,743.00 | 1,743.00 | 15.00 | 2.50 | 10.00 | | | 412.00 | 1,560.00 | |
| East R | 1,230.00 | 1,230.00 | 10.58 | 128.00 | 138.00 | | | 256.00 | 777.00 | |
| East R | 744.00 | 744.00 | 6.40 | 13.50 | 13.50 | | | 62.00 | 613.00 | |
| East R | 798.00 | 798.00 | 6.86 | 73.00 | 112.00 | | | 34.00 | 765.00 | |
| Hudson R | 345.00 | 345.00 | 2.97 | 24.00 | 19.50 | | | 5.00 | 275.00 | |
| East R | 94.00 | 94.00 | 0.81 | 12.00 | 51.00 | | | 70.00 | 108.00 | |
| East R | 1,464.00 | 1,464.00 | 12.59 | 1.00 | 77.00 | | | 338.00 | 1,720.00 | |
| Harlem R | 261.00 | 261.00 | 2.24 | 15.00 | 5.00 | | | 53.00 | 217.00 | |
| East R | 787.00 | 787.00 | 6.77 | 9.50 | 895.00 | | | 172.00 | 713.00 | |
| | | | | | | | | | | |
| Hogg Is Chan | 412.00 | 412.00 | 3.54 | 1.55 | 0.40 | | | 32.00 | 375.00 | |
| Mott Basin | 127.00 | 127.00 | 1.09 | 0.19 | | | | 24.00 | 114.00 | |
| LI Sound | 368.00 | 368.00 | 3.16 | 6.00 | 4.05 | | | | 350.00 | |
| LI Sound | 660.00 | 660.00 | 5.68 | 0.38 | 175.00 | | | | 750.00 | |
| Port Jefferson H | 600.00 | 600.00 | 5.16 | 0.42 | 0.24 | | | 40.00 | 460.00 | |
| | | | | | | | | | | |
| Hudson R | 735.00 | 735.00 | 6.32 | 0.82 | 0.25 | | | 2.00 | 482.00 | |
| | | | | | | | | | | |
| Hudson R | 500.00 | 500.00 | 4.30 | 0.80 | 57.70 | | 11.25 | | | 532.00 |

Table 7. Annual energy requirements
(millions of kwh)

| | 1970 | 1972 | Forecast 1975 | 1980 | 1985 |
|---|---|---|---|---|---|
| Central Hudson | 2,951 | 3,370 | 4,185 | 6,360 | 9,600 |
| Con Edison[a] | 34,747 | 36,810 | 37,125 | 44,300 | 50,300 |
| LILCO | 10,826 | 12,244 | 15,401 | 21,357 | 28,047 |
| NYSE&G[b] | 1,062 | 1,220 | 1,445 | 2,189 | 3,145 |
| Orange & Rockland | 2,348 | 2,804 | 3,468 | 5,454 | 8,373 |
| Total New York[c] | 51,934 | 56,448 | 61,624 | 79,660 | 99,465 |

[a] We assume that Power Authority of the State of New York (PASNY) sales are entirely outside the region; we attribute generation from Indian Point and Astoria (Con Ed plants), which are being acquired by PASNY, to Con Ed.

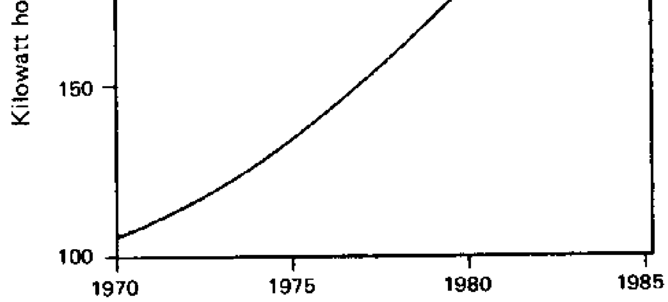
[b] We have assumed that 13% of NYSE&G sales occur in the Bight region, or 1,062 million kwh in 1970; assumption is based on Regional Plan Association estimates.

[c] Includes the Freeport and Rockville Centre in all years

Source: *Report of Member Electric Corporations*, vol. 1, 1974

The FPC projected growth rate for the northeastern United States is 6.7% to 1975 and 6.5% to 1985 for residential electric consumption. FPC growth rates for the commercial-industrial sector are 6.4% to 1975 and 5.8% to 1985. The Regional Plan Association (1974) reports that Connecticut utilities project aggregate growth at 7.4% to 1985, while RPA expects a 5.4% growth rate. New Jersey utilities report growth expectations of 6.7% to 1985, while RPA again estimates a 5.4% growth rate. We have chosen the conservative path by averaging the FPC and RPA growth rates in Connecticut and New Jersey, respectively, to obtain an average growth rate in electrical requirements of 6.4% in Connecticut and a little over 6% in New Jersey. The projections for New York State, Connecticut, and New Jersey are shown in Figure 2. Our projections indicate that electrical energy requirements will rise from about 133 billion kwh in 1975 to 228 billion kwh by 1985.

Figure 2. Projected electric energy requirements in the Bight region




Sources: *Report of Member Electric Corporations*, vol.1, 1974; Federal Power Commission 1972

The utilities' projected New York State growth rate of about 4.5% to 1985 may be somewhat high since it was prepared prior to the Arab oil embargo. For Connecticut and New Jersey, the projected growth rate of slightly over 6% to 1985 again is probably high; it was prepared even earlier than the New York projections.

In the New York area, nuclear generation is projected to grow from 10% to 27% of total capacity between 1974 and 1985; fossil steam capacity would decrease from 55% to 44%. According to FPC forecasts for the northeastern United States, 70% of Connecticut's and New Jersey's capacity would be nuclear in 1985, with fossil steam furnishing 28% of the requirements (Federal Power Commission 1972). The substantial additional capacity in nuclear facilities is questionable at the time of this writing. Constraints on capital availability and uncertain future demands have resulted in the cancellation of many new plants, particularly nuclear ones. At present there is no certain base from which to project energy demand of any kind.

The recent dramatic changes in oil price and availability, plus the scarcity and high cost of natural gas along with changing attitudes toward energy use, lead to greater difficulties in predicting the future than we are accustomed to. The alternative national gross energy demand forecasts presented in Table 8 give a quantitative feel for the range of variation in recent energy projections. No regional disaggregation of these forecasts is presently available nor is it necessary to illustrate our point.

Growth rates in Table 8 vary by a maximum of 3.5% between the Ford Foundation low case and the National Petroleum Council high case. In 10 years this small percent variance leads to forecasts that differ by 40%. The electric energy requirement projections in this monograph have been selected as the most probable, based on the analysis of the particular forecasters at the time of preparation. The projections should be used with two qualifications: first, all forecasts contain substantial uncertainty and must be used carefully; second, as conditions change, new forecasts must be prepared to replace obsolete ones. Unfortunately it is not possible to predict when or in what direction the changes will occur.

**Table 8.** Comparative energy forecasts

| | 1985 (quadrillion Btu) | Compound Annual Growth Rate 1974-1985 |
|---|---|---|
| Project Independence (FEA) | | |
| $7/barrel | 109.1 | 3.2% |
| $11/barrel | 102.9 | 2.7% |
| Dupree and West* | 116.6 | 3.8% |
| Ford Foundation | | |
| High Case | 115.0 | 3.7% |
| Low case | 93.0 | 2.0% |
| National Petroleum Council* | | |
| High case | 144.9 | 5.5% |
| Low case | 124.9 | 4.3% |

*Projection made before October 1974 oil embargo and subsequent price increases

Source: Federal Power Commission 1973

# Oil Refining

The major oil refining center of the northeastern United States is in New Jersey; there are no refineries in Connecticut or the New York portion of the Bight region. Oil refineries are second to electric power plants as an important energy processor in the region. Map 3 shows refineries by company and Table 9 describes briefly their capacities in various processes. The total crude oil capacity in 1972 was 592,000 barrels per day. In that year 173.4 million barrels of crude oil entered the New Jersey refineries. The refinery capacities in Table 9 represent all facilities existing in the Bight region in 1972. Depending upon the respective oil companies' needs, there are often output fluctuations and shifts in mix of products. Thus from year to year, and even from month to month, the total refinery capacity and output change. An important illustration is the shutdown of the Amerada-Hess Corporation's refinery in Port Reading; it has been closed since early November 1974 and its 70,000 barrels per day crude oil capacity will remain inoperative indefinitely.

Although the Bight region contains only 4.4% of the nation's refinery capacity, it processes nearly 17% of the nation's imported foreign crude oil (US Department of the Interior, Bureau of Mines 1973). In 1972, 79% of the crude oil input into New Jersey refineries was of foreign origin. In 1970 only 40% of the crude oil for these facilities was imported; in two years the contribution of foreign sources to the total refining in the region nearly doubled with no appreciable increase in capacity (US Department of the Interior, Bureau of Mines 1973). Since the output of these facilities almost totally supplies fuel demands of the region, such supply shifts have major economic and social implications.

## Oil and the Environment

The five major areas of environmental concern with regard to oil refineries are: air pollution, waste water discharges, solid waste disposal, noise abatement, and aesthetics. In recent years government regulations involving each of these have become increasingly stringent. Rough estimates of the cost of the required controls indicate a 10% to 20% initial additional

**Table 9.** Oil refining in the Bight region,1972

| | Crude Capacity[a] | | Charge Capacity – b/sd[b] | | | | | | | | Production Capacity – b/sd[c] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cat Cracking | | | | | | | | | | | |
| Company and Location | b/cd | b/sd | Vacuum Distillation | Thermal Oper. | Fresh Feed | Recycle | Cat Reforming | Cat Hydro-cracking | Cat Hydro-refining | Cat Hydro-treating | Alkyla-tion | Aromatics-Isomerization | Lubes | Asphalt | Coke (t/d) | Gasoline |
| 1 Amerada–Hess Corp Port Reading | 70,000 | 75,000 | 30,000 | – | 30,000 | 15,000 | 6,500 | – | – | 6,500 | 4,200 | – | – | – | – | 32,000 |
| 2 Chevron Oil Co Perth Amboy | NR | 80,000 | 50,000 | – | 30,000 | 2,000 | 14,000 | – | – | 14,500<br>18,000 | 2,500 | – | – | 12,000 | – | 21,500 |
| 3 Exxon Co Linden | 255,000 | 268,000 | 140,000 | – | 125,000 | 45,000 | 46,000 | – | 50,000 | 46,000<br>14,000<br>37,000 | 10,700 | – | – | 46,000 | – | 115,900 |
| 4 Mobil Oil Corp Paulsboro | 100,000 | 102,000 | 50,000 | 23,700 | 32,000 | 5,000 | 23,500 | – | – | 23,500<br>33,000 | 2,300 | – | 7,920 | – | 975 | 35,570 |
| 5 Texaco Inc Westville | 91,000 | NR | 29,500 | 13,000 | 40,000 | NR | 13,000 | – | – | 13,000<br>10,000 | 3,000 | – | – | – | – | 33,000 |
| Total | 592,000 | 620,800 | 301,100 | 38,100 | 261,400 | 80,300 | 104,400 | – | 50,000 | 216,400 | 23,000 | – | 7,920 | 58,000 | 975 | 237,970 |

[a] The processes listed are either in barrels per calendar day (b/cd) or barrels per stream or operating day (b/sd).

[b] Vacuum distillation is a primary process to separate crude oil into its various fractions. Cracking and refining involve breaking and switching chains of molecules; they are mainly associated with making gasoline. Thermal operations involve using high temperatures for changing molecular structures, making ethylene and propylene.

[c] Alkylation and aromatics-isomerization are processes for making high octane fuels. Lubes, asphalt, and coke are residues of the various processes.

Source: *Oil & Gas Journal* 1972

capital cost for new refineries (Associated Universities Incorporated 1972).

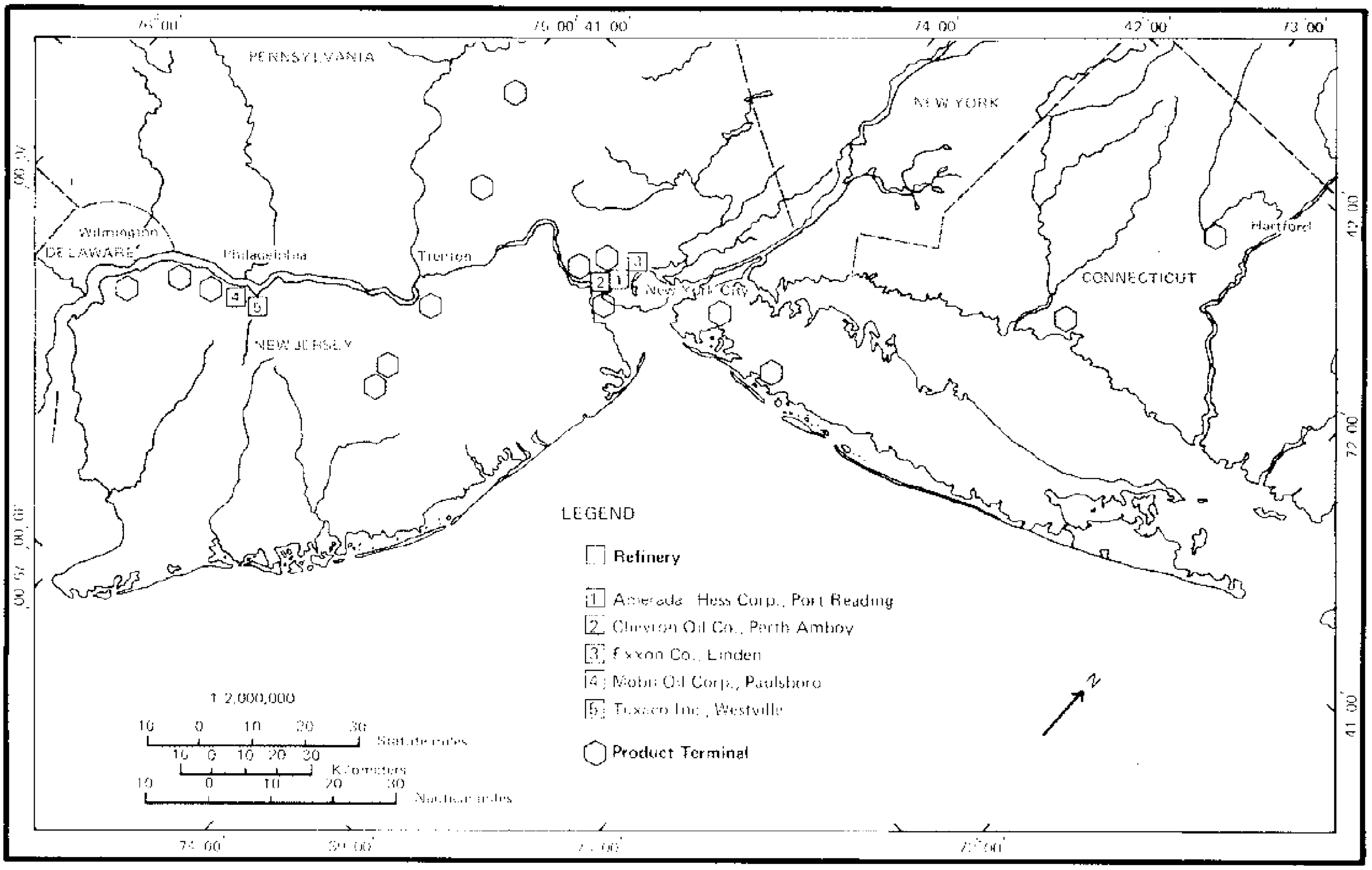
Air pollution standards that must be met by refineries are complex, varying by region and locality, and therefore will not be presented here. The major potential air emissions from refineries are particulates, sulfur dioxide, carbon monoxide, hydrocarbons, nitrogen dioxide, aldehydes, ammonia, and miscellaneous oderous pollutants. Water pollution comes from a variety of sources in refineries; the major water use, however, is for cooling and boiler makeup purposes. Since chemicals must be added to these waters, complicated and expensive fluid segregation, neutralization, biological treatment, filtration, and chemical treatment are necessary.

Solid wastes are produced in refineries during normal operation (miscellaneous trash) and as residue from air pollution abatement treatment and waste water treatment (silt, lime, and alum sludge). Most wastes are contaminated with oil and may be disposed of in many different ways, including landfill, incineration, ocean dumping, or soil biodegradation. Other, more desirable, long-term approaches to solid waste disposal are still being sought. Solid waste disposal costs for a refinery of 150,000 barrels per day are estimated at about $200,000 per year (Associated Universities Incorporated 1972).

Noise and aesthetic impacts are more recently perceived problems than the environmental concerns discussed above. Noise control techniques are of three primary types: source control (redesigned motors), transmission path control (mufflers), and receiver control (ear protectors and insulated rooms). Aesthetics should be considered in the initial design and preparation of the refinery plant and site. Smoke and dust problems are partially overcome with air pollution controls. Landscaping, painting, and siting are perhaps the next most important factors to be considered in refinery development.

The refineries in the Bight region contribute to air and water pollution. Emissions from refineries are presented in Table 10. Quantities were derived from national average emission factors for uncontrolled refineries together with 1972 data for New Jersey

## Map 3. Oil refineries and product terminals




Transverse Mercator Projection

**Table 10.** Emissions due to refining, 1972

| | Tons |
|---|---|
| Water Pollutants[a] | |
| Dissolved solids | 1,408 |
| Suspended solids | 21,558 |
| Nondegradable organics | 5,827 |
| BOD | 6,726 |
| COD | 19,616 |
| Air pollutants[b] | |
| Particulates | 6,188 |
| Nitrogen oxides | 16,933 |
| Sulfur oxides | 29,285 |
| Hydrocarbons | 84,712 |
| Carbon monoxide | 192,524 |
| Aldehydes, etc. | 3,622 |

[a] Based upon emission factor for national average uncontrolled refining

[b] Air emissions for Mobil Oil and Texaco estimated from the emission rate of the other three refineries in Table 9

Sources: US Department of Interior, Bureau of Mines 1973; Hittman Associates, Inc. 1973

**Table 12.** Stocks of refineries, bulk terminals, and pipelines, 1972

| | Barrels |
|---|---|
| Motor gasoline | 20,034,000 |
| Aviation gasoline | 219,000 |
| Naptha — jet fuel | 155,000 |
| Kerosene — jet fuel | 1,404,000 |
| Kerosene | 2,769,000 |
| Distillate oil | 23,293,000 |
| Residual oil | 8,732,000 |
| Others | 9,593,000 |
| Total products | 66,199,000 |
| Crude | 6,186,000 |

NOTE: Figures are derived by assuming that stocks of products in the region are proportional to the refining capacity. New Jersey has 36% of PAD I (Petroleum Allocation for Defense district) refining capacity.

Source: US Department of the Interior, Bureau of Mines 1973

**Table 11.** Pipelines, 1972

| Name and Product | Origin — Destination |
|---|---|
| **Inbound** | |
| Oil Products | |
| Colonial Pipeline Co | Pasadena, TX — Linden, NJ |
| Sun Pipeline Co | Marcus Hook, PA — Newark, NJ |
| Harbor Pipeline Co | Philadelphia — New York Harbor |
| Natural Gas | |
| Tennessee Gas Pipeline Co | Brownsville/New Orleans — New York |
| Columbia Gas System | Brownsville/New Orleans — New York |
| Texas Eastern Transmission | McAllen, Freer, TX — New York |
| Transcontinental Gas Pipeline | Brownsville/New Orleans — New York |
| Algonquin Gas Transmission | Lambertsville, NJ — New Haven |
| **Outbound** | |
| Oil Products | |
| Buckeye Pipeline Co | Linden, NJ — Pittsburgh |
| | Macuncie, PA — Syracuse, NY |
| Tidewater Pipeline | Bayonne, NJ — Williamsport, PA |
| Jet Lines, Inc | New Haven — Springfield, MA |
| **Within** | |
| Oil Products | |
| Long Island Pipeline Corp | Linden, NJ — Long Island City/JFK |
| Northville Dock Corp | Riverhead — Brentwood, NY |
| Coastal Oil Co | Newark — South Plainfield, NJ |

Sources: Tri-State Regional Planning Commission 1967; Federal Power Commission 1971; Moody's Investors Service, Inc. 1974 refineries. Sulfur oxides, hydrocarbons, and carbon monoxide are the major air pollutants. They are emitted primarily from tall stacks; this tends to decrease their ground level or air quality impairment effect.

**Pipelines.** A major supply avenue for petroleum products and the only supplier of natural gas to the region is the network of underground pipelines listed in Table 11. Because they are underground, their environmental impact is minimal.

**Storage.** Associated with refineries, pipelines, and product terminals for receiving petroleum products are large storage facilities. These tank farms account for 90% to 95% of all storage within the region. Table 12 lists the approximate 1972 stocks and storage by petroleum product for the three main facilities described above. The ability to store essential fuel resources determines how the energy system can respond to shifts or disruptions in supply. Because the Bight region is particularly vulnerable even to slight and temporary tremors in world politics, capacity to store oil products promises to be a critical issue in the near future.

### Projections

Between now and 1985 there will be an 18.6% growth in refinery capacity in the Bight region, according to the US Bureau of Mines (1974). Chevron Oil is adding a refining capacity of 80,000 barrels per day in Perth Amboy, and Exxon Company is adding a 30,000 barrel per day capacity in Linden (US Department of the Interior 1974). Because of the problems associated with licensing and site selection, it is unlikely that any other new refinery capacity will be constructed by 1985 in the Bight region.

## Summary

The New York Bight region — diverse and complex in terms of its electricity generation, oil refining, and the market it serves — includes some of the most densely populated and economically important areas in the world. Its coastal location is an asset for electricity generation and in the refining of oil products, but its air and water sustain heavy environmental stresses. Decentralized energy-using activities — space heating and automobiles, in particular — are major pollution sources.

In 1972 the Bight region contained an electric generating capacity of 39,625 Mw, approximately 10% of the national total. A relatively high proportion of this capacity was nuclear (19%) and gas turbine (20%). The reliance on gas turbines, not only for peaking power requirements but also for intermediate supply, was due primarily to their lower capital cost and to siting delays for large base load plants. Although fossil fuel plants produce much higher emissions than nuclear plants, they have the advantage of long industrial experience and no radiation hazards or safety problems.

The latest regional projections indicate major growth in electricity and other energy needs by 1985. Growth rates for electricity in New York State, Connecticut, and New Jersey — in the 4.5% to 6% range — are expected to moderate as a result of higher electricity prices and conservation, but the final outcome is extremely uncertain. Little growth in refinery capacity is currently planned in the Bight region, but needs continue to increase. Problems here include environmental and siting issues.

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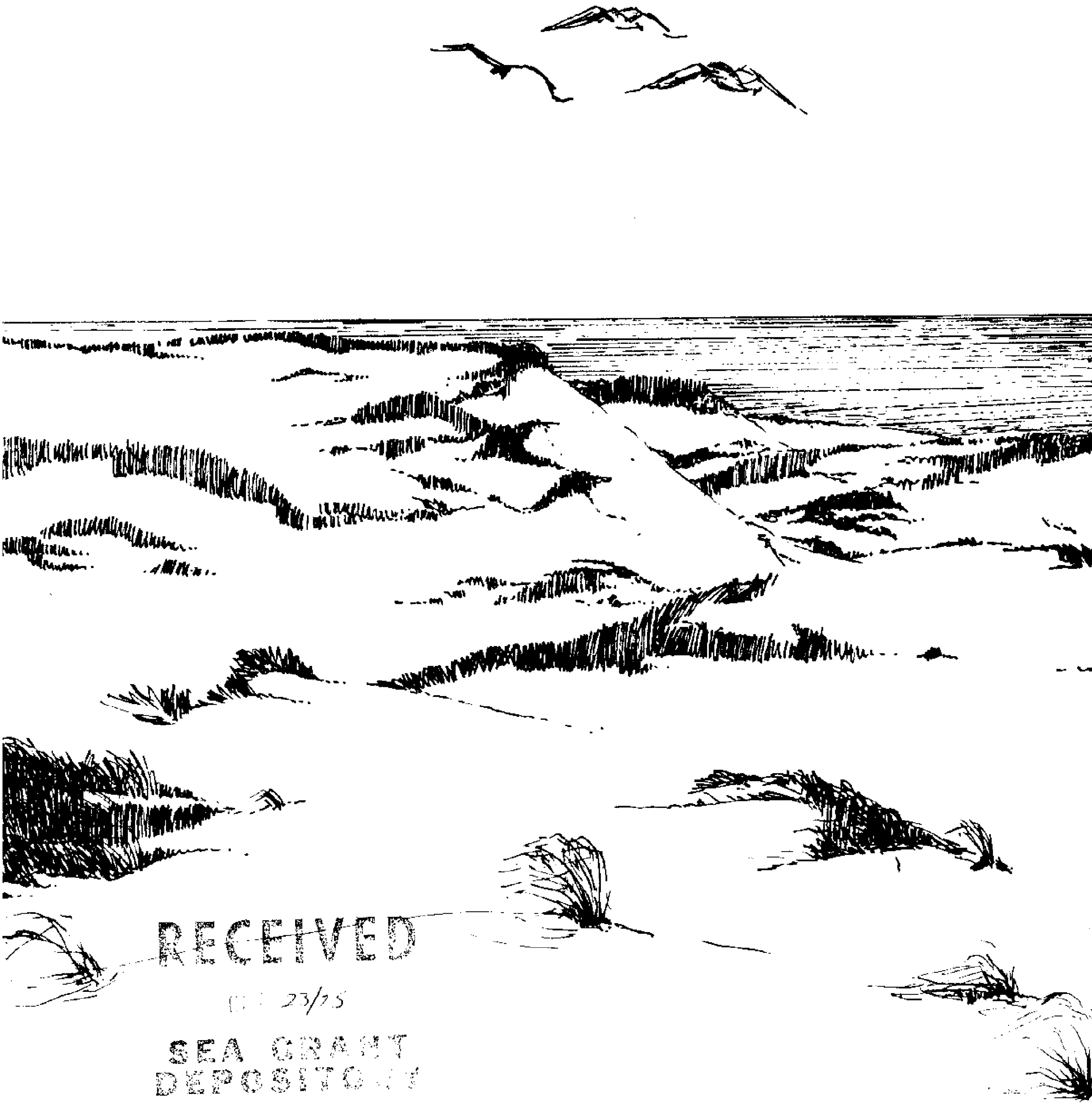

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