UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
BOSTON EDISON COMPANY, et al.	)	Docket No. 50-471
(Pilgrim Nuclear Generating Station, Unit 2	)	

APPLICANTS' REVISED SUPPLEMENTAL TESTIMONY ON NEED FOR PILGRIM 2

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APPLICANTS' SUPPLEMENTAL TESTIMONY ON NEED FOR PILGRIM 2*

PANEL 1

PANELISTS:

Benjamin H. Weiner, Vice President-Power Supply Administration, Boston Edison Company

Philip A. Legrow, Generation Planning Engineer, Boston Edison Company

Donald V. Bourcier, Chief of Load Forecasting, New England Power Planning

Arthur W. Barstow, Manager of Generation Planning, New England Power Planning

PANEL 2

PANELISTS:

F. Cort Turner, Vice President, Arthur D. Little, Inc.

Nigel Godley, Manager-Energy Economics Section, Arthur D. Little, Inc.

David Hanna, Energy Economics Section, Arthur D. Little, Inc.

* Intervenors Commonwealth of Massachusetts Contention 6, Cleeton Contention H, Ford Contention M

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P A N E L 1

Q. Mr. Weiner, please state your name and business address.

A. Benjamin H. Weiner, Boston Edison Company, 800 Boylston Street, Boston, Massachusetts.

Q. What is your present position?

A. I am Vice President - Power Supply Administration.

Q. What positions have you held with Boston Edison Company?

A. I began my employment with Edison in 1953 as an Electrical Engineer. In 1957, I was assigned to the President's staff and, in 1969, I was promoted to the position of Assistant to the President. In April 1973, I was appointed Vice President - Power Supply Administration.

Q. Please describe the responsibilities and duties of these positions.

A. Since joining the President's staff, my duties have included the negotiation and preparation of bulk power purchase and sale agreements, including system and unit sale contracts and joint ownership arrangements covering various types of generation - hydroelectric, fossil and nuclear. I have also negotiated and prepared contracts dealing with transmission rights and charges. Since becoming Vice President, I have also assumed general responsibility for all of Edison's bulk power supply purchases and sales and rates for wholesale and resale sales. Additionally, I am Edison's

representative on the New England Power Pool (NEPOOL) Working Committee as well as an Alternate member of the Executive Committee. These positions require me to keep closely informed on the various activities of NEPOOL including the operation of the New England Power Exchange (NEPEX) and the New England Planning Staff (NEPLAN), as well as new generation scheduled by other New England companies and other matters relating to bulk power supply in New England.

I am a member of the Company's Rate Committee which examines all proposals relative to rate schedules. The Company's NEPEX Billing Group and its Coordinating and Expediting Division, which has the responsibility for scheduling all the Company's major construction programs, except for nuclear, report to me.

Q. Would you briefly describe your educational and professional background?

A. I received a Bachelor of Science degree in Electrical Engineering from the University of Massachusetts in 1953. I have completed the Harvard Business School Program for Management Development. I am a Registered Professional Engineer in the Commonwealth of Massachusetts.

Q. Mr. Weiner, what is the purpose of your testimony?

A. My testimony is to demonstrate that bringing Pilgrim 2 on line at its currently scheduled in-service date of 12/85 is necessary in order to assure adequate reliability levels in New England. I will also demonstrate that even at lower growth rates than those projected by NEPOOL, there are benefits to installing Pilgrim 2 in 12/85 as scheduled. These benefits include cost savings to New England electricity consumers, reduction in dependency on an expensive and potentially unreliable supply of oil, and the furtherance of national and regional energy policies and goals.

Q. Mr. Legrow, please state your full name and business address.

A. My name is Philip A. Legrow of Boston Edison Company, 800 Boylston Street, Boston, Massachusetts 02199.

Q. What is your present position and responsibilities with Boston Edison Company?

A. I am a Generation Planning Engineer in Boston Edison's Engineering, Planning and Research Department. My responsibilities include the analysis of any of the Company's generation costs, both short and long term, and the conduct of long range generation planning studies.

Q. Please describe your educational background and experience.

A. I received a Bachelor of Science degree in Electrical Engineering from Northeastern University in 1972, where I held memberships in Eta Kappa Nu, Tau Beta Pi, and Phi Kappa Phi, scholastic honor societies. I received a Master of Science degree in Electrical Engineering from Northeastern University in 1973. I have been employed in Boston Edison's Generation Expansion Group since completion of my studies in 1973.

Q. Mr. Legrow, what is the purpose of your testimony?

A. I performed the production costing and economic analyses underlying Mr. Weiner's testimony regarding the life-of-unit oil and dollar savings associated with a 12/85 Pilgrim 2 in-service date as compared with a 12/88 in-service date.

Q. Mr. Bourcier, please state your full name and business address.

A. Donald V. Bourcier, New England Power Planning (NEPLAN),. West Springfield, Massachusetts.

Q. What position do you hold at NEPLAN?

A. I am Chief of Load Forecasting, responsible for forecasting long-range electric energy and peak demands for the six state New England region; I also participate in the development of the annual New England Load and Capacity Report.

Q. Would you describe briefly your educational and professional background?

A. From 1960 to 1962, I attended the American International College in Springfield, Massachusetts, and I graduated in 1964 from the University of Connecticut in Storrs, Connecticut, with a Bachelor of Science degree in Economics. From 1964 to 1966, I studied at the University of New Hampshire in Durham, New Hampshire, and received a Master of Science degree in Resource Economics. I then worked for the United Illuminating Company in New Haven, Connecticut, as a statistical economist with responsibility for developing the long-range forecast of electric energy sales and revenue. From 1970 to 1972, I worked for the Remington Electric Shaver Division of Sperry-Rand Corporation in Bridgeport, Connecticut, as a Senior Marketing Research Analyst. At Remington, I developed sales forecasting models and conducted consumer market research studies. Since October 1972, I have worked for New England Power Planning developing and applying methodology for forecasting New England's electric energy and peak demands. I am a past member of the American Marketing Association and the American Statistical Association. I am the current chairman of the Load Forecasting Task Force of the NEPOOL Planning Committee.

Q. Have you written any articles or books in the field of economic analysis?

A. I am co-author of a United States Department of Interior Publication entitled "An Economic Analysis of Public Water Supply."

Q. Have you previously testified in this proceeding?

A. Yes. In Applicants Direct Testimony on Need for Power following Transcript page 2647.

Q. Mr. Bourcier, what is the purpose of your testimony?

A. The purpose of my testimony is to identify and present the current NEPOOL load forecast. The forecast is presented and explained in three documents:

1) NEPOOL Forecast for New England, 1979-1989, NEPLAN, March 1, 1979.
2) Report of the NEPOOL Load Forecasting Task Force on the NEPOOL Model-Based Forecast of New England Electric Energy and Peak Load, 1979-1989, NEPLAN, March 1, 1979.
3) New England Load and Capacity Report, 1978-1989, NEPLAN, April 1, 1979.

Q. Mr. Barstow, please state your name and business address.

A. Arthur W. Barstow, New England Power Planning (NEPLAN), 174 Brush Hill Avenue, West Springfield, Massachusetts.

Q. What position do you hold there?

A. I am Manager of Generation Planning.

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Q. What is your educational background?

A. I received a Bachelor of Science degree in Electrical Engineering from the University of Massachusetts in 1951 and a Masters degree in Business Administration from American International College in 1964. I have also taken several courses including Power System Engineering from the General Electric Company while an employee there. I am a Registered Professional Engineer in the State of New York and a member of the Power System Engineering Committee, System Planning Subcommittee and several working groups and task forces of the Power Engineering Society of the Institute of Electrical and Electronic Engineers.

Q. Would you please describe your work experience?

A. In 1951, I went to work as an electrical engineer in the electric design department of the Kellex Corporation in New York City. From 1953 until 1958, I worked for the General Electric Company as a test engineer in various utility related equipment departments for two years, then as a design engineer in the Large Motor and Generator Department in Schenectady, New York for two years and then as a Utility Application Engineer for a year in Schenectady. In 1958, I went to work in the electrical planning department of Western Massachusetts Electric Company in Springfield, Massachusetts. I worked in distribution and transmission

planning until 1960. In 1960, the Connecticut utilities and Western Mass. Electric Company (the same companies now served by the CONVEX Satellite of NEPOOL) started generation planning as a group using Westinghouse Electric Company's computer programs entitled Power-Casting. I was appointed to be the Western Mass Electric Company (WMECO) representative in that endeavor. In 1961, while serving in that capacity, I was transferred to the Connecticut Valley Power Exchange (the dispatch center for Western Mass. Electric Company and the Hartford Electric Light Company) in North Bloomfield, Connecticut and became Systems Operations Engineer. In 1963, while still serving in the generation planning effort for WMECO with Westinghouse, I was transferred back to Western Mass. Electric Company and became Electrical Planning Engineer. In 1964, New England wide generation planning was initiated and I was asked to head it up as Chairman of the Generation Task Force. At the same time, I was made Interconnection Planning Engineer for Western Mass. Electric Company. In 1968, when NEPLAN was formed, I was one of the three engineers assigned to its startup and to be responsible for generation planning. I am currently Chairman of the Generation Task Force. In addition, I have assisted in the initiation of the load forecasting effort at Pool

level. I have co-authored IEEE papers and a number of New England Generation planning reports on the subject of generation planning and related subjects.

Q. Mr. Barstow, what is the purpose of your testimony?

A. The purpose of my testimony is to present (a)the capacity aspects of the most recent NEPOOL Load and Capacity Report, (b)NEPOOL's generation reliability criterion as it is reflected in the determination of NEPOOL's required reserves, and (c)NEPOOL's studies relating to cost vs. reliability, and planning for load growth uncertainty.

Q. Mr. Weiner, would you describe the current New England load and capacity projections?

A. The results of the most recent NEPOOL load forecast are presented in Exhibit NP-33. The NEPOOL forecast projects a 3.8% compound annual growth rate in peak load from 1979/80-1989/90. Exhibit NP-34 presents the April 1979 schedule for major generating capacity additions planned for the next decade. Exhibit NP-35 presents the total capability, peak load, and reserve percentages, assuming all of the in-service dates in Exhibit NP-34 are realized (with Pilgrim 2 in 12/85) and alternately, with the assumption that Pilgrim 2 is delayed until 12/88. With Pilgrim 2 in-service in 12/85, NP-35 shows that by 1984/85 the New England reserve margin will be at or below the minimum desired level. If Pilgrim 2 is delayed to 12/88, reserve

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margins will be inadequate and reliability impaired through 1987. Exhibit NP-36 graphically illustrates the loads and capacities planned for the next decade. If these planned units in New England are delayed, New England will not have sufficient generating capacity to maintain system reliability. The Sears Island unit has encountered opposition, particularly from the Maine Public Utilities Commission Staff, on the basis of economics and environmental considerations. The NEPCO units have been postponed and will not be built on the schedule indicated in Exhibits NP-33 - 36. Significant delays in each of these units must be considered a distinct possibility. With such potential delays it would not be prudent to delay Pilgrim 2 beyond 12/85.

Q. Mr. Barstow, please explain how NEPOOL determines how much reserve capacity is required.

A. The NEPOOL Management Committee establishes a generation reliability criterion. Given this criterion, as well as a knowledge of the pool's operating procedures, the characteristics of the units in the existing system, and a knowledge of the plans for expanding the system, it is possible, using reliability computer programs, to determine the total generating capacity reserves required.

Q. What is the NEPOOL generation reliability criterion?

A. NEPOOL has adopted a criterion which calls for the installation or purchase of sufficient capacity to assure that it will be unnecessary to physically disconnect customers (i.e., disconnect supply feeders) more frequently than once in ten years.

Q. On what basis did NEPOOL select the one day in ten years disconnecting customers' criterion?

A. In a study completed in 1974, we were able to develop risk profiles for different reliability levels by relating various criteria to the way the system is actually operated. These profiles were checked against operating experience. Specifically, in the period from January 1971 through October, 1973 there were 19 voltage reduction incidents in the pool created by insufficient available capacity whereas the reliability program estimated 13.48 to 21.84 incidents. Similarly, there were four radio and TV appeal incidents compared to a projected 1.99 to 3.19 incidents. And there were zero disconnection incidents whereas the program estimated 0.32 to 0.58 or in the zero to one incident range. Had the actual, valid pool experience been longer, there would undoubtedly have been actual disconnection incidents. The sample was terminated with October, 1973 because of the subsequent excess reserve situation brought about by the oil embargo.

With the criterion selected, the following frequency of occurrence is expected:

Voltage Reductions	- 7-8/yr.
Radio-TV appeals	- Approx. 1/yr.
Disconnect Customers	- 0.1/yr. (or 1 every 10 years)

Lower reliability levels resulted in a greater number of expected occurrences in each category with only limited savings in cost of electricity to the customer. (Costs of outages to the customer were not considered). Accordingly, the one day in ten years customer disconnection was considered to be a reasonable pool generation planning criterion which effectively balance system cost in the form of reserve requirements with reliability expressed in terms of the expected need for voltage reductions, radio and TV appeals and actual customer disconnection by rotation of feeders. Thus, the NEPOOL Executive Committee decided that this was the reliability criterion to which the system should be designed.

Q. Having established the reliability criterion, would you please describe the procedure used to determine the NEPOOL capacity requirements?

A. Required reserve margins are based on calculations of the probability of occurrence of insufficient generating

capacity to meet the anticipated loads. These calculations are performed by NEPLAN for the pool. Once the reliability calculations have been completed and the results reviewed by the NEPOOL Planning and Executive Committees, the NEPOOL Objective Capability is established. The Objective Capability is the amount of capacity (load plus required reserves) deemed necessary by the Executive Committee to meet the Pool's reliability criterion.

Q. Has the Executive Committee established the NEPOOL Objective Capabilities for the power years 85/86, 86/87, 87/88, 88/89 and beyond?

A. No, but this is expected to occur this year. However, reasonable preliminary estimates are available for the reserve level required to meet the pool reliability criterion in that period.

Q. What is your estimate of the reserve level required to meet the reliability criterion in the period 85/86 to 88/89 and beyond?

A. On the basis of expanding under the Pool's generation mix guidelines, recent reliability studies indicate, at this point in time, that required reserves in the order of 23% to 28% of peak load will be recommended to the Planning and Management Committees. These reserves vary from

year to year depending on unit commitment and their maturity trends.

Q. Mr. Barstow, what are the economic implications of installation of nuclear capacity before it is required to meet the NEPOOL reliability criterion?

A. The NEPOOL Generation Task Force and the NEPLAN Staff report "Cost Versus Reliability Study For The Years 1983/84-2000/01," November, 1978, (an update of the 1974 reliability study) concludes that when the system is far from its economic generation mix, such as is the present case for New England, capacity installed to improve the mix which results in more than the minimum required to meet the reliability criterion can be economically justified. The higher the reliability level, the lower the overall costs due to the early installation of nuclear capacity. Considerable amounts of oil are saved in the higher reliability cases as nuclear units are installed earlier than in the other cases. For example, a 10 years/day LOLP reliability level saves 207 million barrels of oil compared to 1.0 year/day LOLP level (which approximates the present NEPOOL criterion) resulting in a reduction of 13.5% of the oil used in the 1.0 year/day LOLP case.

In addition, the February 1978 NEPOOL Generation Task Force and the NEPLAN Staff report "Planning for Load Growth

Uncertainty (Recognizing Unit Lead Times)" demonstrated that there is a considerable economic penalty associated with planning to a particular load growth rate and having to install short lead-time capacity if the system experiences a higher load growth rate than that on which the expansion was based. In addition, there is an economic <u>benefit</u> associated with planning to a high load growth rate and actually experiencing a lower growth rate. Those savings are attributable to the early installation of nuclear capacity which enables the substitution of nuclear supplied energy for the more costly fossil supplied energy. The early installation of these nuclear units also results in considerable oil savings when compared to the generation expansion pattern designed just to meet the actual load growth rate.

Q. Mr. Weiner, what are the economics of delaying Pilgrim 2's in-service date?

A. The present worth of the cost differences due to delay in the in-service date for Pilgrim 2 favor installation at the earliest possible time independent of reliability requirements. For example, for a 3 year delay, assuming that all other planned units are brought in on schedule, 12/85 installation results in net present worth savings of $1387 million (in 1986 dollars) to New England consumers over the life of the project. In spite of higher costs

in the first several years, the oil dollars saved rapidly turn the deficiency into a savings. The break-even year for net present worth savings is 1987, only one year after installation.

In addition to the loss of savings, the delay of Pilgrim 2 will increase our dependence on oil as a source of electricity. New England will burn an additional 12 million barrels of oil for each year of delay. The outlook for future oil supply is not encouraging, and such increased oil consumption clearly contradicts national energy policy and the regional interest.

Q. Have you evaluated the sensitivity of this economic analysis to different peak-load growth rates?

A. At the request of the NRC Staff we analyzed the impact of a 12/85 installation date versus 12/88 assuming a 3.4% peak load growth. The 3.4% growth case yielded present worth savings of $1087 million (in 1986 dollars) over the life of the project. The breakeven year was 1989. We have also analyzed a 3.0% growth rate for New England, comparing a 12/85 and 12/88 in-service date. The 3.0% growth case yielded present worth savings of $1051 million (in 1986 dollars) over the life of the project. The breakeven year was also 1989. We have not explicitly analyzed the impact of a 12/85 installation date versus a 12/88 installation date assuming a peak load growth rate higher than 3.8%.

It is not unreasonable to expect that a strong economic recovery in New England might lead to load growth that would exceed our current projections. At a higher load growth rate the present worth savings accruing to the earlier in-service date would be even greater due to the increased necessity of relying on increasingly expensive oil-fired generation.

Q. Mr. Legrow, would you please describe the analyses that resulted in the savings presented by Mr. Weiner?

A. The results presented by Mr. Weiner flow from year by year comparisons of the capital costs of Pilgrim 2 and New England-wide fuel costs for Pilgrim 2 in-service dates of 12/31/85 and 12/31/88, and for New England forecasted load growth rates of 3.8% (the current NEPOOL forecast), 3.4% and 3.0%. These annual differences in capital charges and fuel costs were summed, and the accumulative present worth at Boston Edison's projected marginal cost of money was taken to yield the life-of-unit savings associated with the 1985 in-service date. These annual differences, totals, and accumulative present worths are set out in Exhibits NP-37, NP-39, and NP-41 for the 3.8%, 3.4% and 3.0% growth rates, respectively. Also estimated were the barrels of fuel oil displaced due to 1985 as

opposed to 1988 installation of Pilgrim 2; these estimates are shown as Exhibits NP-38, NP-40 and NP-42 for the 3.8%, 3.4% and 3.0% growth rates, respectively. The major assumptions inherent in the development of Exhibits NP-37 through NP-42 are listed in Exhibit NP-43.

Q. Would you describe in more detail the derivation of your "Capital" and "Fuel" cost columns of Exhibits NP-37, NP-39 and NP-41?

A. To generate the "Capital" column, which is common to all three exhibits, annual capital recovery, income tax, and investment tax credit charges were added to annual projections of property taxes and nuclear fuel carrying charges for the 28-year book life of the unit for each in-service date, and the differences taken. The negative entries for years 1986-1988 reflect the absence of capital charges for the 1988 in-service case, while the 1989-2013 entries reflect the higher capital costs of the delayed (1988) unit. It is assumed that, under current Massachusetts law, property taxes end with the end of book life (2013 and 2016 for the respective in-service dates).

The "Fuel" savings for the various load growths were calculated by modeling the NEPEX system on the Company's production costing program over the years 1986-199[illegible].

The program was run twice for each load growth - once with a 1/1/86 Pilgrim 2 in-service date, and once with a 1/1/89 in-service date. The in-service dates of all other NEPOOL units were fixed at those published in the New England Load and Capacity Report of April 1, 1979. The entries in the "Fuel" column are the annual differences in the fuel costs of the entire New England system: for 1986 through 1988, with and without Pilgrim 2; from 1989 to 1993 reflecting the differential in maturity of Pilgrim 2. The absence of entries after 1993 reflects the fact that, given either in-service date, Pilgrim 2 will have reached a mature capacity factor by 1994, and no basis exists for the projection of production cost differences from that point on.

Q. Mr. Weiner, you made earlier reference to the outlook for future oil supply. Could you elaborate further on this point?

A. Recent international events have had dramatic repercussions on the world oil markets. Consequently supplies of imported oil, upon which New England must depend, cannot be regarded as secure. The lesson of the 1973-74 Arab oil embargo was reinforced dramatically this winter by the

total cutoff of Iranian oil from the world market for several months. The degree of overall U.S. dependence on petroleum imports has increased to over 40%, and the source of most of these imports has shifted geographically, from the Western Hemisphere to the Arab Middle East and Africa, so that the security of oil supplies is considerably lower than it was 5 years ago. Since 1970, the world price of crude oil has risen from approximately $1 per barrel to about $15 currently, and the continuing ability of OPEC to impose its will on the market has produced an increase of approximately 25% in the past few months alone. As a consequence of the tightness of the market brought about by the temporary Iranian cutoff, the March 1979 New York Harbor contract price for residual fuel oil was about 45% higher than the March 1978 price. While such variations in spot prices may magnify the effect of temporary shortages, the actual OPEC floor price for Saudi Arabian marker crude now stands at $14.55, while other OPEC nations have generally set their prices significantly higher. Oil burned in May by Boston Edison had an average price of $17.56/barrel, $5/barrel or 40% higher than the 1978 average cost of $12.60/barrel. In

addition, our principal suppliers, Asiatic Petroleum Company and Texaco have formally put us on notice that fuel shortages are possible in the future. While we have not as yet been denied delivery, we are on notice that supply problems exist. Uncertainty over the longer term is compounded, both as to price and assurance of supply. While it is impossible for an electric utility to significantly displace its reliance on oil in the near term, we believe that the public interest demands that we take all steps possible to reduce our oil dependency over the longer term. Bringing Pilgrim 2 in service on the earliest possible schedule will make a significant contribution to that goal.

Q. You also mentioned consistency with National energy policy. What specific policies were you referring to?

A. When President Carter announced the first comprehensive National Energy Plan in 1977, he articulated Administration policy that dependence on fossil fuel imports be reduced through a large-scale conservation effort that would check the trend of increasing reliance on petroleum and natural gas while providing time for the nation to develop alternative energy supplies.

In response, Congress passed a series of Acts [referred to as the National Energy Act (NEA)] aimed at addressing our nation's energy problems. One of these was the Powerplant and Industrial Fuel Use Act of 1978 (FUA). In passing the FUA, the Congress made the following Findings:

> (1) the protection of public health and welfare, the preservation of national security, and the regulation of interstate commerce require the establishment of a program for the expanded use, consistent with applicable environmental requirements, of coal and other alternate fuels as primary energy sources for existing and new electric powerplants and major fuel-burning installations; and
>
> (2) the purposes of this Act are furthered in cases in which coal or other altervate fuels are used by electric powerplants and major fuel-burning installations, consistent with applicable environmental requirements, as primary energy sources in lieu of natural gas or petroleum.

In the definitions, Congress included uranium as an alternate fuel. Congress included in the Statement of Purposes of the Act:

> (1) to reduce the importation of petroleum and increase the Nation's capability to use indigenous energy resources of the United States to the extent such reduction and use further the goal of national energy self-suffiency and otherwise are in the best interests of the United States;
>
> (2) to conserve natural gas and petroleum for uses, other than electric utility or other industrial or commercial generation of steam or electricity, for which there are no feasible alternative fuels or raw material substitutes;

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> (3) to encourage and foster the greater use of coal and other alternate fuels, in lieu of natural gas and petroleum, as a primary energy source; ...
>
> (6) to prohibit or, as appropriate, minimize the use of natural gas and petroleum as a primary energy source and to conserve such gas and petroleum for the benefit of present and future generations;
>
> (7) to encourage the modernization or replacement of existing and new electric powerplants and major fuel-burning installations which utilize natural gas or petroleum as a primary energy source and which cannot utilize coal or other alternate fuels where to do so furthers the conservation of natural gas and petroleum; ...
>
> (11) to reduce the vulnerability of the United States to energy supply interruptions;

Bringing Pilgrim 2 on-line at the earliest possible date (i.e., December, 1985) would be consistent with the intent and purposes of FUA, and the National Energy Plan.

The early installation of Pilgrim 2 is also most important from the standpoint of reducing our regional dependence on imported residual fuel oil. Of the five contiguous DOE Petroleum Administration for Defense (PAD) districts, the most vulnerable to interruption of imported oil supply is District I, which is comprised of all of New England, New York, Pennsylvania, New Jersey, Maryland, Delaware, West Virginia, Virginia, North and South Carolina, Georgia and Florida. In 1977, the total imports of all petroleum products to this East Coast region was equal to more than

15 times the total amount of imported petroleum products of the next largest importing PAD district. When considering only residual oil, PAD District I imports were almost thirty times the amount imported by the next highest district.[1] Because District I receives over 79% of its residual oil from foreign sources, it is critical that this region's dependency on residual fuel imports be reduced, if the goals of FUA/NEA are to be met.

As discussed, these goals are to reduce our nation's dependency on foreign petroleum imports for <u>non-essential</u> uses, while continuing to ensure an adequate reliability of service for electric generation. If Pilgrim 2 is delayed, not only are we needlessly consuming millions of additional barrels of oil, at higher and higher prices, but we are also exposing ourselves to extreme political, economic and social risks. Bringing Pilgrim 2 on-line as scheduled in 1985 will contribute to the resolution of problems associated with our regional vulnerability, and ensure reliability of service to the consumer while contributing to our national goal of energy independence.

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(1) Energy Information Administration, Department of Energy, Energy Data Reports, Year 1977.

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NEW ENGLAND
FORECAST SUMMARY 1979-1989

	Actual 1977	Actual 1978	Forecast 1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1979-89 Compound Annual Growth Rate (%)
Coincident Peak Load (MW)														
Recorded . Winter (Dec./Jan.)	14846	15100P												
. Summer	14234	14458												
Weather (a)														
Corrected . Winter (Dec./Jan.)	15363	15500P	16595	17266	18036	18822	19755	20668	21502	22267	22989	2359[illegible]	24120	3.81
. Summer	13712	14954	15569	16108	16714	17409	18113	18958	19784	20552	21275	21933	22495	3.75
Energy Sales to Ultimate Customers (GWH)														
. Total	72751	n/a	84276	87590	91249	95241	99318	104148	108843	113217	117285	120980	124144	3.95
. Residential	28222	n/a	31631	32248	33260	34543	35721	37113	38450	39577	40572	41371	42007	2.88
. Industrial	n/a	n/a	22786	24143	25446	26397	27433	28670	29841	31035	32120	33220	34123	4.12
. Commercial	n/a	n/a	28655	30006	31341	33072	34904	37066	39217	41234	43191	44962	46569	4.98
. Miscellaneous	n/a	n/a	1205	1194	1203	1228	1259	1299	1336	1371	1403	1427	1445	1.84
Net Energy for Load (GWH) (b)	79781	82800P	91861	95473	99462	103812	103256	113521	118639	123407	127840	131868	135317	3.95
Annual Load Factor (%)	61.3	62.6P	63.2	63.1	63.0	63.0	62.6	62.7	63.0	63.3	63.5	63.8	64.0	
Economic/Demographic														
. Population (000's)	12238	12256P	12337	12404	12491	12569	12654	12745	12839	12937	13029	13117	13206	0.68
. Households (000's)	4141	n/a	4301	4379	4467	4552	4637	4723	4810	4892	4972	5050	5129	1.78
. Employment (000's) (c)	5377	n/a	5692	5844	5923	5988	6066	6150	62[illegible]0	6300	6361	6423	6475	1.30
. Manufacturing (000's)	n/a	n/a	1469	1499	1513	1514	1525	1539	1543	1559	1563	1569	1565	0.64
. Nonmanufacturing (000's)	n/a	n/a	4202	4323	4389	4453	4520	4595	4661	4720	4777	4833	4889	1.53
. Unemployment Rate (%)	7.5	n/a	6.4	5.8	5.9	5.8	5.6	5.4	5.3	5.3	5.4	5.4	5.4	-
. Net Migration (000's)	n/a	n/a	27	41	31	35	36	37	38	32	29	30	30	-
. Personal Income (mil$69)	53195	n/a	56514	58947	61058	63010	65109	67299	69497	71754	73961	76196	78364	3.32

n/a - not available
P - Preliminary

(a) Correction based on long-term historical peak weather conditions.
(b) Based on energy sales to ultimate customers and nine percent transmission and distribution line losses.
(c) Total employment includes approximately 21 thousand jobs outside New England (i.e., New York and Canada).

EXHIBIT NP-33

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EXHIBIT NP-34

MAJOR NEW ENGLAND GENERATING CAPACITY ADDITIONS (THROUGH DECEMBER 1989)

COMPANY	STATION	FUEL	CAPACITY MW	SCHEDULED IN-SERVICE AS OF 4/79
MASS. MUNICIPALS	STONY BROOK	OIL	340	NOV 1981
MASS. MUNICIPALS	STONY BROOK	OIL	170	NOV 1982
PUBLIC SERVICE CO. OF N. H.	SEABROOK 1	NUC	1150	APR 1983
PUBLIC SERVICE CO. OF N. H.	SEABROOK 2	NUC	1150	FEB 1985
BOSTON EDISON	PILGRIM 2	NUC	1150	DEC 1985
NORTHEAST UTILITIES	MILLSTONE 3	NUC	1150	MAY 1986
CENTRAL MAINE POWER	SEARS ISLAND	COAL	568	NOV 1987
NEW ENGLAND ELECTRIC SYSTEM	NEPCO 1	NUC	1150	NOV 1987
NEW ENGLAND ELECTRIC SYSTEM	NEPCO 2	NUC	1150	NOV 1989

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NEW ENGLAND SYSTEM CAPABILITIES
AND
ESTIMATED PEAK LOADS
1979-1989

POWER YEAR	TOTAL CAPABILITY	PEAK LOAD	% RESERVE AFTER MAINTENANCE	% RESERVE AFTER MAINTENANCE WITH PILGRIM 2 INSTALLED IN 12/88
1979/80	21,980	16,595	30.0	-
1980/81	21,982	17,266	26.8	-
1981/82	22,301	18,036	20.0	-
1982/83	22,626	18,822	19.5	-
1983/84	23,773	19,755	20.3	-
1984/85	23,768	20,668	15.0	-
1985/86	25,869	21,502	20.3	15.0
1986/87	26,804	22,267	20.4	15.2
1987/88	28,421	22,989	23.6	18.6
1988/89	28,422	23,595	20.5	-
1989/90	29,574	24,120	22.6	-

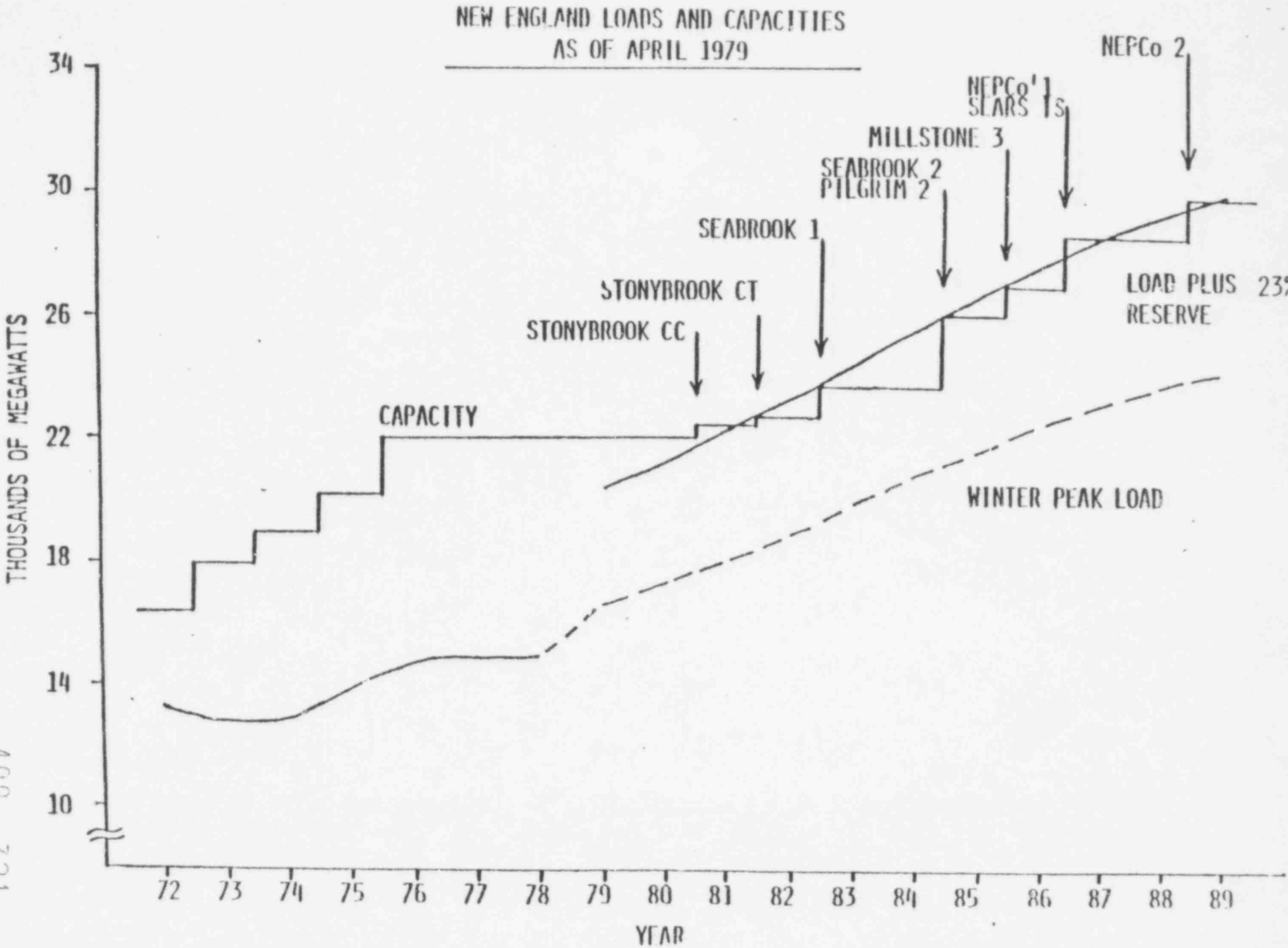

EXHIBIT NP-36

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Exhibit NP-37
Revised 6/29/79

3.8% GROWTH CASE
SAVINGS ASSOCIATED WITH INSTALLING PILGRIM 2 IN 1985 VS. 1988
($000)

Year	Capital Savings	Fuel Savings	Total Savings	Acc. P.W. Savings At 10.83%
1986	(408,754)	403,363	(5,391)	(5,391
1987	(397,061)	492,479	95,418	80,702
1988	(381,362)	501,458	120,096	178,474
1989	176,428	81,297	257,725	367,789
1990	179,332	48,342	227,674	518,686
1991	172,870	60,419	233,289	658,198
1992	168,609	11,354	179,963	755,302
1993	161,256	43,742	204,998	855,106
1994	154,631	-	154,631	923,032
1995	149,317	-	149,317	982,214
1996	145,196	-	145,196	1,034,139
1997	143,046	-	143,046	1,080,297
1998	140,720	-	140,720	1,121,267
1999	138,002	-	138,002	1,157,520
2000	135,192	-	135,192	1,189,565
2001	133,399	-	133,399	1,218,095
2002	130,678	-	130,678	1,243,312
2003	123,591	-	123,591	1,264,830
2004	116,972	-	116,972	1,283,207
2005	108,938	-	108,938	1,298,649
2006	107,159	-	107,159	1,312,353
2007	103,829	-	103,829	1,324,335
2008	100,826	-	100,826	1,334,833
2009	97,163	-	97,163	1,343,962
2010	93,733	-	93,733	1,351,907
2011	90,500	-	90,500	1,358,829
2012	86,505	-	86,505	1,364,799
2013	82,638	-	82,638	1,369,944
2014	126,981	-	126,981	1,377,078
2015	109,209	-	109,209	1,382,614
2016	92,377	-	92,377	1,386,839

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Exhibit NP-38
Revised 6/2[illegible]/79

3.8% GROWTH CASE
FUEL SAVINGS ASSOCIATED WITH INSTALLING PILGRIM 2 IN 1985 VS. 1988

Year	12/85 Pilg. 2 MWHR	12/88 Pilg. 2 MWHR	MWHR	Bbl. Oil Equiv.*
1986	5,943,521	-	5,943,521	9,905,868
1987	5,940,818	-	5,940,818	9,901,363
1988	6,263,348	-	6,263,348	10,438,913
1989	6,749,019	5,942,067	806,952	1,344,920
1990	6,738,399	5,935,820	802,579	1,337,632
1991	7,047,508	6,240,489	807,019	1,345,032
1992	7,068,628	6,771,058	297,570	495,950
1993	7,047,412	6,748,850	298,562	497,603
Total Oil Savings				35,267,281

*Assumes 10,000 Btu/kWh, 6 MMBtu/bbl.

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Exhibit NP-39
Revised 6/29/79

3.4% GROWTH CASE
SAVINGS ASSOCIATED WITH INSTALLING PILGRIM 2 IN 1985 VS. 1988
($000)

Year	Capital Savings	Fuel Savings	Total Savings	Acc. P.W. Savings At 10.83%
1986	(408,754)	328,891	(79,863)	(79,863)
1987	(397,061)	363,171	(33,890)	(110,441)
1988	(381,362)	390,758	9,396	(102,792)
1989	176,428	65,029	241,457	74,573
1990	179,332	51,597	230,929	227,628
1991	172,870	55,881	228,751	364,426
1992	168,609	13,755	182,364	462,826
1993	161,256	28,616	189,872	555,265
1994	154,631	-	154,631	623,191
1995	149,317	-	149,317	682,373
1996	145,196	-	145,196	734,298
1997	143,046	-	143,046	780,456
1998	140,720	-	140,720	821,427
1999	138,002	-	138,002	857,680
2000	135,192	-	135,192	889,724
2001	133,399	-	133,399	918,254
2002	130,678	-	130,678	943,471
2003	123,591	-	123,591	964,990
2004	116,972	-	116,972	983,366
2005	108,938	-	108,938	998,808
2006	107,159	-	107,159	1,012,512
2007	103,829	-	103,829	1,024,494
2008	100,826	-	100,826	1,034,992
2009	97,163	-	97,163	1,044,121
2010	93,733	-	93,733	1,052,067
2011	90,500	-	90,500	1,058,988
2012	86,505	-	86,505	1,064,958
2013	82,638	-	82,638	1,070,104
2014	126,981	-	126,981	1,077,237
2015	109,209	-	109,209	1,082,773
2016	92,377	-	92,377	1,086,998

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Exhibit NP-40
Revised 6/29/79

3.4% GROWTH CASE
FUEL SAVINGS ASSOCIATED WITH INSTALLING PILGRIM 2 IN 1985 VS. 1988

Year	12/85 Pilg. 2 MWHR	12/88 Pilg. 2 MWHR	MWHR	Bbl. Oil Equiv.*
1986	5,941,742	-	5,941,742	9,902,903
1987	5,941,815	-	5,941,815	9,903,025
1988	6,258,429	-	6,258,429	10,430,715
1989	6,747,160	5,941,510	805,650	1,342,750
1990	6,743,522	5,935,851	807,671	1,346,118
1991	7,043,027	6,236,696	806,331	1,343,885
1992	7,067,911	6,768,166	299,745	499,575
1993	7,047,027	6,746,673	300,354	500,590
Total Oil Savings				35,269,561

*Assumes 10,000 Btu/kWh, 6 MMBtu/bbl.

Exhibit NP-41
Revised 6/29/79

3.0% GROWTH CASE
SAVINGS ASSOCIATED WITH INSTALLING PILGRIM 2 IN 1985 VS. 1988
($000)

Year	Capital Savings	Fuel Savings	Total Savings	Acc. P.W. Savings At 10.83%
1986	(408,754)	317,323	(91,431)	(91,431)
1987	(397,061)	345,210	(51,851)	(138,215)
1988	(381,362)	380,114	(1,248)	(139,231)
1989	176,428	59,224	235,652	33,869
1990	179,332	58,974	238,306	191,814
1991	172,870	47,749	220,619	323,748
1992	168,609	21,494	190,103	426,324
1993	161,256	30,116	191,372	519,494
1994	154,631	-	154,631	587,420
1995	149,317	-	149,317	646,602
1996	145,196	-	145,196	698,527
1997	143,046	-	143,046	744,685
1998	140,720	-	140,720	785,655
1999	138,002	-	138,002	821,909
2000	135,192	-	135,192	853,953
2001	133,399	-	133,399	882,483
2002	130,678	-	130,678	907,700
2003	123,591	-	123,591	929,219
2004	116,972	-	116,972	947,595
2005	108,938	-	108,938	963,037
2006	107,159	-	107,159	976,741
2007	103,829	-	103,829	988,723
2008	100,826	-	100,826	999,221
2009	97,163	-	97,163	1,008,350
2010	93,733	-	93,733	1,016,295
2011	90,500	-	90,500	1,023,217
2012	86,505	-	86,505	1,029,187
2013	82,638	-	82,638	1,034,332
2014	126,981	-	126,981	1,041,466
2015	109,209	-	109,209	1,047,002
2016	92,377	-	92,377	1,051,227

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Exhibit NP-42
Revised 6/29/79

3.0% GROWTH CASE
FUEL SAVINGS ASSOCIATED WITH INSTALLING PILGRIM 2 IN 1985 VS. 1988

Year	12/85 Pilg. 2 MWHR	12/88 Pilg. 2 MWHR	MWHR	Bbl. Oil Equiv.*
1986	5,941,743	-	5,941,743	9,902,905
1987	5,939,321	-	5,939,321	9,898,868
1988	6,257,807	-	6,257,807	10,429,678
1989	6,745,243	5,938,763	806,480	1,344,133
1990	6,743,888	5,935,851	808,037	1,346,728
1991	7,041,351	6,235,473	805,878	1,343,130
1992	7,065,725	6,765,560	300,165	500,275
1993	7,042,522	6,743,376	299,146	498,577
Total Oil Savings				35,264,294

*Assumes 10,000 Btu/kWh, 6 MMBtu/bbl.

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Exhibit NP-43
Revised 6/29/79

MAJOR ASSUMPTIONS EMPLOYED IN ECONOMIC ANALYSIS OF DELAYED INSTALLATION

General rate of inflation: 6%/year

Boston Edison cost of money: 10.83%

Fossil Fuel price forecast: July 1978 A.D. Little report, except inflation assumed to remain constant at 6% rather than dipping to 4% after 1989.

Nuclear fuel price forecast: Internal Boston Edison forecast, consistant as to input assumptions with the July 1978 A.D. Little report.

Sample current dollar fuel prices: ($/MMBtu)

	1986	1988	1990	1992	1994
No. 6 oil, 1% S	6.659	7.974	9.548	11.169	13.064
No. 6 oil, 2.2%	6.126	7.322	8.751	10.234	11.968
No. 2 oil	7.597	9.074	10.839	12.649	14.761
Coal	-	-	-	-	-
Pilgrim 2, 12/85 C.O.	.779	.862	1.152	1.374	1.615
Pilgrim 2, 12/88 C.O.	-	-	1.057	1.291	1.606

Load Model: 59% load factor all cases; peak loads:

1. as published in the April 1, 1979 New England Load and Capacity Report and other NEPOOL documents;
2. 1985/86 winter peak of 19,510 extrapolated at 3.4%/year as specified by the NRC's Oak Ridge Model;
3. 1978/79 weather-adjusted winter peak, extrapolated at 3.0%/year.

Pilgrim 2 capital costs: $1,895 million in 1985, $2.550 billion in 1988

Pilgrim 2 book life: 28 years

Pilgrim 2 tax life: 16 years

Pilgrim 2 depreciation method: double declining balance, switching to straight line

Effective income tax rate: 49.51%

Pilgrim 2 property tax assumptions: Plymouth annual budget growth: 10%

Income tax credit: 10% for all years

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Plymouth valuation growth: 10%/year

Classification implemented in FY 1980

Nuclear capacity factor maturation:

1st year capacity factor:	59%
2nd year:	59%
3rd year:	62%
4th year:	67%
5th year:	67%
6th and following years:	70%

Future capacity additions to meet load plus 23% required reserves through 1993: nuclear, similar to Pilgrim 2. All planned units listed in the April 1, 1979 New England Load and Capacity Report installed on the schedules indicated therein.

P A N E L   2

408 330

Q. Mr. Turner, will you please state your name and place of residence?

A. My name is F. Cort Turner and I reside in Cambridge, Massachusetts.

Q. By whom are you employed?

A. I am employed by Arthur D. Little, Inc., Cambridge, Massachusetts.

Q. What is your educational background?

A. I received undergraduate and graduate degrees in chemical engineering and in management from the Massachusetts Institute of Technology.

Q. Please describe your experience with Arthur D. Little, Inc.

A. I have been employed by Arthur D. Little, Inc. since 1952. My current position is Vice President responsible for the overall coordination of the company's international energy consulting work. Prior to this, I was manager of Arthur D. Little's Energy Economics Section in Cambridge. Throughout my career at Arthur D. Little I have specialized in oil and gas consulting on behalf of such diverse clients as large energy users (utilities and chemical companies), oil companies (major and independent), governments of producing and consuming countries, the U.S. Environmental Protection Agency, etc. This work has included strategic planning, crude oil and product marketing, refinery feasibility studies, energy forecasting, design of taxation terms for oil and gas exploration, and the development of a linear programming refinery model to test the impact of change on the cost of producing individual crudes.

Q. Mr. Godley, will you please state your name and place of residence?

A. My name is Nigel Godley and I reside in Acton, Massachusetts.

Q. By whom are you employed?

A. I am employed by Arthur D. Little, Inc., Cambridge, Massachusetts.

Q. What is your educational background?

A. I hold a diploma in Business Administration from the Portsmouth College of Technology and I attended a special course dealing with decision-making in the marine industries at the Massachusetts Institute of Technology.

Q. Please describe your experience with Arthur D. Little, Inc.

A. I have been employed by Arthur D. Little, Inc. since 1969. I am currently manager of the Company's Energy Economics Section. My areas of specialization include crude oil and petroleum product pricing, oil taxation, concession analysis, petroleum transportation, energy forecasting and the financial analysis of the hydrocarbon industry including exploration production, refining, and marketing activities.

Q. Mr. Hanna, will you please state your name and place of residence?

A. My name is David Hanna, and I reside in Arlington, Massachusetts.

Q. By whom are you employed?

A. I am employed by Arthur D. Little, Inc., Cambridge, Massachusetts.

Q. What is your educational background?

A. I received an undergraduate degree in physical sciences from Oxford University and a graduate degree in business management from the London Business School.

Q. Please describe your experience with Arthur D. Little, Inc.

A. I have been employed by Arthur D. Little, Inc., since 1972. I am a member of the Energy Economics Section in Cambridge and specialize in oil and gas consulting for U.S. and international clients. My work has included strategic planning, oil supply/demand forecasting and crude oil and petroleum products pricing.

Q. What work has Arthur D. Little, Inc., recently performed for Boston Edison related to fuel oil price forecasts?

Q. What work has Arthur D. Little, Inc. recently performed for Boston Edison related to fuel oil price forecasts?

A. Arthur D. Little, Inc. (ADL) was commissioned by Boston Edison in July, 1977 to prepare a report on the outlook for coal and residual fuel oil prices for Boston Edison. Our final report on this assignment was submitted in July, 1978. In August, 1978 we prepared written testimony for the hearings in Massachusetts DPU 19494 which was presented by us in April, 1979. In May, 1979 Boston Edison commissioned Arthur D. Little, Inc., to update our oil price forecasts, the results of which are incorporated in this testimony.

Q. What cost elements enter into the price of petroleum products?

A. The chain of costs starts with the acquisition of crude oil and includes the transportation of crude oil to refineries by pipelines and tankers, the refining of crude oil into the different petroleum products, and the delivery and distribution of these products to the ultimate consumer. In addition, governments (including state and local) may impose taxes and/or fees/duties on individual products. The weighting of these different elements (crude oil, transportation, refining) varies with the source and type of crude processed, the complexity of refining operations, and the refinery location. Very approximately, when processing a Middle East crude oil, the crude oil itself now accounts for about 85%, ocean transportation for 5%, and refining for 10% of the cost of all the products at the wholesale level (before distribution costs, taxes, or entitlements benefits).

Internationally, crude oil prices are set by the principal producers belonging to the Organization of Petroleum Exporting Countries (OPEC). Generally, in the past, these producers set the price of the Arabian Light "marker crude oil" with all other crudes being related to the marker crude oil through differentials reflecting quality (sulfur content,

specific gravity, etc.) and location (distance from markets). More recently, since the Iranian crisis, many producers have added surcharges related to market conditions, over and above their parity price with Arabian L ɪt. The actual production cost of the marker crude is a small fraction (less than 5%) of the selling price and the same is true of most other OPEC crudes as well. Historic production costs are thus irrelevant as a factor in determining international crude oil prices.

U.S. crude oil prices are fixed by the U.S. Government under a complex set of regulations designed to stimulate the search for oil by allowing a higher price for "new oil" while preventing excess profits by holding down the price of "old oil". The average refiner acquisition cost of domestic crude oil was $12.06 per barrel in March, 1979 or about $5.50 per barrel less than the average acquisition cost of foreign crude oil. The composite refiner acquisition cost of all crude oil (domestic and foreign) was $14.52 per barrel or about $3.00 less than foreign oil. The Carter Administration has now implemented a phased program of crude oil price deregulation and has proposed a windfall profits tax which has yet to be approved by Congress. Under the Carter program U.S. domestic crude oil prices will reach international parity levels in fall 1981.

The other key elements in the cost build-up—transportation and refining—to a large extent reflect market conditions. Currently there is a large surplus of foreign flag tankers and freight rates, (particularly for "very large crude carriers" (VLCC's) of over 150,000 tons deadweight) have been driven down towards variable costs (i.e., rates which cover bunker fuel and port charges only). In the Caribbean, the source of most of New England's fuel oil, there is a large surplus of refining capacity. In recent years, refiners in this area have generally recovered

little more than variable costs (i.e., refinery fuel and power, additives, etc., which vary directly with output). Distribution costs which are important for retail sales of gasoline or home heating oil can be ignored for utilities which purchase fuel oil in cargo quantities.

Q. How did you forecast the price of utility fuels?

A. Much of the fuel oil used in New England comes from Caribbean refineries which process crude oil imported from the major OPEC countries in the Middle East, Africa, and South America. The Caribbean will continue to be a major source of products for the U.S. East Coast and so we chose this area as the basing point for our economic calculations. Arabian Light was selected as the crude type on the presumption (which in fact, is OPEC policy) that in normal times other crudes will be priced in equilibrium with this marker crude oil. Thus, the results would have been comparable had we chosen a different crude. Furthermore, the results would not differ significantly had we chosen a different refining location (say, an East Coast refinery). Next, we forecast the future price evolution of the Arabian Light marker crude and added the projected refining and transportation cost elements to arrive at the landed price of products in New England. These prices were then adjusted to reflect the impact of U.S. regulations (fees, duties, and entitlements).

Q. Since the price of crude oil accounts for such a major proportion of the cost of fuel, please describe what significant events have recently affected international oil supply and how oil prices have evolved in recent months.

A. In the late fall of 1978 a revolution took place in Iran, one of the major Middle East oil producing countries. Consequent to the revolution, the Shah departed from Iran and the Bakhtiar Government, appointed by him prior to his departure, fell. A new Islamic regime was established by the Ayatollah Khomeini. The revolution in Iran caused a cessation

of oil exports between late December 1978 and early March 1979. Exports are reported to be limited by the Government to about 3 million barrels per day, compared to an average export level of the order of 5 million barrels per day prior to the revolution. In response to the Iranian crisis, Saudi Arabia at first allowed production to increase in late 1978 to 10.4 million B/d. Subsequently, Saudi production was reduced such that it averaged 9.5 MMB/d in the first quarter of 1979 and is currently at a level of 8.5 MMB/d. Thus, it is clear that there have been significant crude oil supply difficulties and rearrangements in recent months.

Concerning prices, OPEC member states met in Abu Dhabi in December, 1978 and decided on a schedule of quarterly price increases for 1979. Under this schedule, the contract price for the Saudi marker crude was to have increased in steps during each quarter reaching $14.55/Bbl for the 4th quarter (an average of 10% over the year assuming level production). The original schedule was:

December 1978	$12.70/Bbl
1st quarter 1979	13.34
2nd quarter 1979	13.84
3rd quarter 1979	14.16
4th quarter 1979	14.55

However, in early February 1979, Saudi Arabia announced a retroactive (to January 1, 1979) price increase for all barrels sold in excess of the official allowable production of 8.5 million barrels per day. These excess barrels were to be sold at the scheduled 4th quarter price. In mid-February, certain countries (Libya, Abu Dhabi, Qatar, Iraq, and Kuwait) added surcharges to all volumes which in effect immediately implemented the prices scheduled for the 4th quarter. At the end of March, 1979 OPEC members met again for a "consultative" meeting in Geneva, at which it was decided to increase the official marker price of Saudi

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Arabian Light crude oil such that the scheduled 4th quarter price of \$14.55/Bbl would be effective from April 1, 1979. It was also decided that member countries should be free to add those market premia which they deemed justifiable in the light of circumstances. As a result, member countries have introduced premia which are currently in the range of \$2.50 to \$5.50 per barrel over the previously scheduled 4th quarter prices. It is noted that all OPEC member countries have added these price premia except Saudi Arabia. At the time of writing, OPEC members are meeting in Geneva to discuss official prices for the third quarter 1979.

Spot market crude oil prices have risen much more rapidly and have now reached unprecedented levels. Spot premia over official prices (already including the "official" premia mentioned above) were being quoted at \$15 to \$20/Bbl and although the volume of real transactions is small, some prices were recently reported to be in the range of \$35 to \$40/Bbl for various crudes in early June 1979.

Q. Please explain how you forecast the future price of crude oil given the many factors involved and the highly uncertain environment.

A. The price of crude oil is to a large extent politically determined: by OPEC deliberations and by individual producing governments in the case of foreign oil and by Presidential/Congressional action in the case of domestic oil. Thus, there is a high degree of uncertainty in any crude oil price projection. In this context, it is worth noting that the timing and magnitude of the OPEC 1973/4 and 1979 price hikes were largely unpredictable. Following the 1973 price hike, it was widely believed that the cartel would collapse as all previous cartels had. It is now generally believed that OPEC will continue to be able

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to set prices. An optimistic view of the future has the cartel acting in a responsible manner while a more pessimistic view holds that the cartel will act in an opportunistic manner, taking advantage of current economic circumstances much as it did in the 1973 crisis and as it is currently doing.

To better structure our views on these issues Arthur D. Little has made use of a Delphi technique. Basically, a panel of experts, in this case Arthur D. Little staff members located throughout the world, were asked to record their views on the future oil price levels and the paths by which these price levels would be reached. In addition, a series of consistency questions related to supply/demand conditions, resource availability, economic growth, cost of oil substitutes, etc. were asked. The oil price projection in constant 1979 dollars resulting from the most recent Delphi survey conducted in June 1979 is shown in Figure I.

Q. What was the concensus view, or reference case, arrived at through this process?

A. The events in Iran, the consequent disruptions to world oil supplies and the impact of those disruptions on crude oil prices have re-inforced our view that supply/demand pressures will trigger-off substantial upward revisions in crude oil prices as shown in Figure I. These recent events and the supply constraints introduced by Saudi Arabia have brought into sharp focus the underlying tightness of world crude oil supply and demand and the inherent instability of the supply situation. The impact of supply tightness on price has again been demonstrated. There was a general belief among the respondents that OPEC will continue to maintain its price setting capability in the absence of unexpected events such as military intervention or the discovery of significant new reserves of oil in non-OPEC countries.

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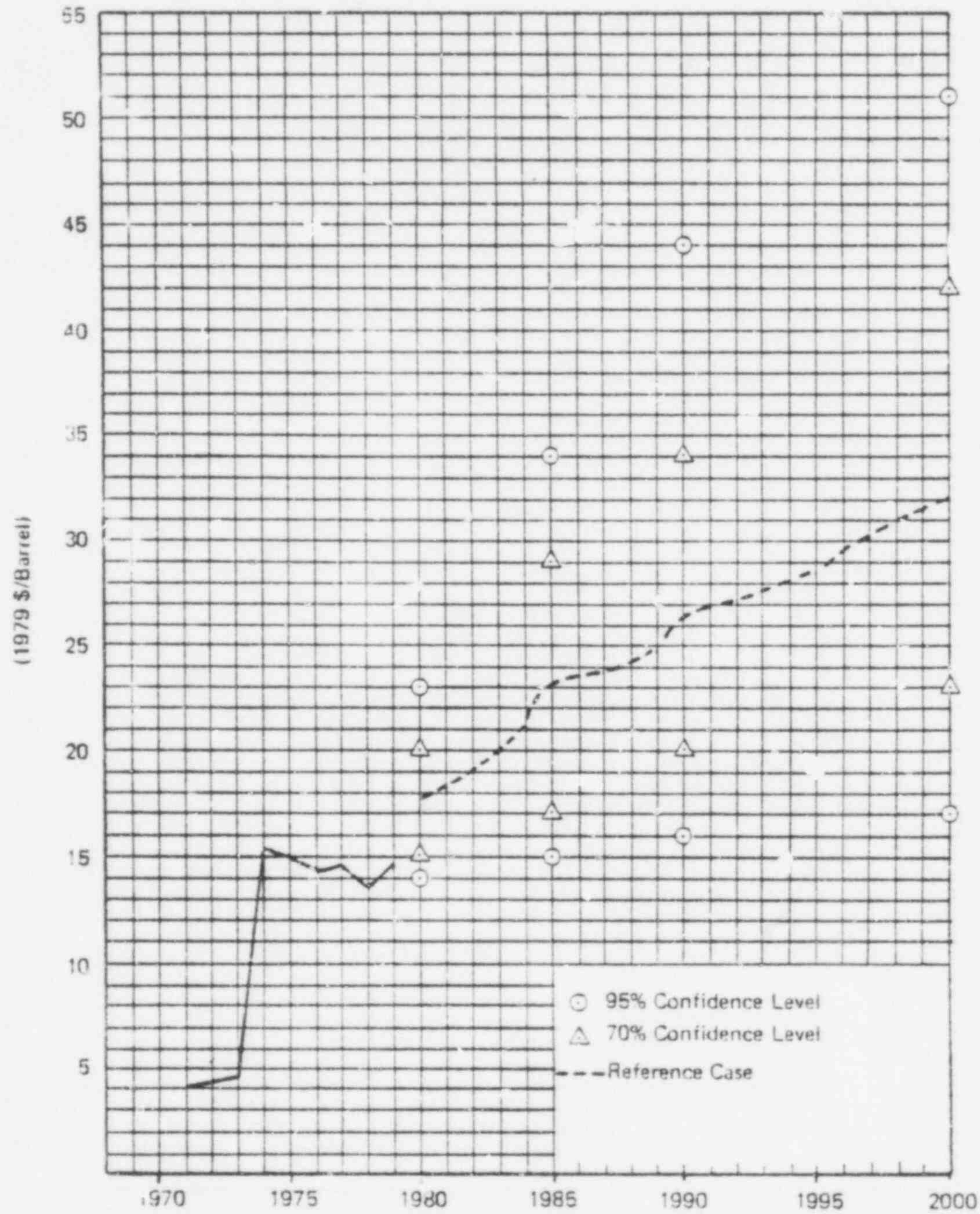
PRICE FORECAST FOR SAUDI ARABIAN LIGHT
FOB RAS TANURA



We anticipate that the surcharges levied by most OPEC producers will be consolidated into the official price for Saudi Arabian Light (currently \$14.55 per barrel) such that the median price in 1980 is expected to be \$17.8/Bbl in 1979 \$. A slowdown in demand growth rates due to the combined effects of conservation, oil substitutes, and depressed economic growth rates, coupled with the addition of new supplies from Alaska, the North Sea and Mexico, will lead to a potential easing of the tight supply position during the early 1980's. Price increases in this period are therefore likely to be modest and limited to inflation type adjustments. Moving into the mid-1980's, the situation begins to change. New non-OPEC supplies will have largely been absorbed and increases in OPEC production will be needed to meet demand. During the mid-1980's there will be a strong likelihood of another significant upward revision of crude price to levels which would be targeted to make high cost hydrocarbon resources such as shale oil, tar sands, or remote natural gas cost competitive.

The timing of such an increase would depend on economic conditions but would most likely occur when a bottleneck (in production, refining, and/or transportation) develops within the oil supply system. This increase would be followed by a further period of consolidation and digestion, during which the crude oil prices would stabilize in real terms. Later, in the mid-1990's, it was felt that further price increases would take place as physical oil resource constraints were strongly perceived. There was a general perception among respondents that the major instabilities occuring during the 1980's as the crude oil price is ratcheted upwards will give way during the 1990's to a period of greater stability once the transition to greater use of alternative energy forms is well under way, a higher degree of conservation has taken effect and oil prices are more in line with the cost of the alternates.

There was, however, considerable uncertainty in future oil prices as evidenced by the confidence limits shown in Figure I and Tables 1 to 5. There is also considerable uncertainty surrounding the timing of price increases since shortages in supply could develop at any time as a consequence of accidental or deliberate cutbacks by individual OPEC countries.

Q. How were the other elements of cost projected?

A. The projection of refining cost poses particular problems since joint costs must be allocated to individual products. In the simplest type of refinery, crude oil is separated into individual fractions by boiling off the lighter fractions in a process called distillation. A portion of the crude oil does not boil off and is called residual fuel oil. This is the product typically used by utilities in oil fired electric plants. The raw fractions obtained by this primary distillation, however, may not satisfy the product demand patterns or the product quality characteristics required. For example, the residual fuel oil may have to be treated to remove sulfur and this desulfurization cost causes a price difference between high sulfur and low sulfur fuel oils. In some markets, the yield of residual fuel oil is larger than can be absorbed at economic fuel oil prices. Refining processes are available (catalytic cracking, hydrocracking, etc.) to convert fuel oil into gasoline and No. 2 fuel oil. The cost of these conversion processes is reflected in the price differential between fuel oil and these lighter products. To further complicate matters, individual crude oils vary widely in their prope[illegible] ranging from crude oils with a very high natural proportion of re[illegible] fuel oil (heavy crudes) to those with a low proportion (light crudes) and ranging from crude oils with a high sulfur content to crudes with very little sulfur. Refiners continually balance crude

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oils, processing, and markets to achieve optimal results and this complex interaction is reflected in individual product prices. At the present time in the Caribbean there is both a surplus of distillation capacity and a surplus of fuel oil desulfurization capacity. This situation causes a low allocation of refining cost to residual fuel oil on the one hand and price differentials between high sulfur and low sulfur fuel oils below the full cost of desulfurization on the other hand. At the same time, there is a shortage of processing capacity to convert fuel oil to light products (gasoline and No. 2 fuel oil) and prices for these products reflect margins higher than the full cost of conversion processing. Our forecast of the refining element in the fuel prices projected in this study reflects a gradually increasing trend to full cost recovery during the period to the year 2000.

Foreign flag tankers are in much the same position as offshore refineries. The surplus tanker capacity has driven freight rates below cash costs for large tankers. For smaller product tankers, freight rates are currently higher than fully allocated costs. As in the case of refineries we expect rates for larger tankers to change gradually as tanker supply and demand come into balance such that freight rates will reflect full costs including a return on investment by the early 1990's. Both the tanker cost forecast and the refinery cost forecast reflect projected crude price increases which influence bunker costs in the case of tankers and refinery fuel in the case of refining.

Current U.S. regulations reduce the cost of fuel oil below import parity by granting importers an "entitlement credit" of about $1.00 per barrel (50% of the entitlement credit for imported crude oil). In addition, import fees are theoretically payable on certain import volumes, but have currently been suspended. The administration has recently implemented a special $5.00/Bbl entitlement credit for distillate imports. In

preparing the price projections, it has been assumed that only a fee of 42¢ per barrel will apply to imported products as protection for U.S. refiners.

Q. What are the results of your analysis?

A. Applying the procedures just outlined, we have obtained the results shown below in Table 1 which are expressed in 1979 dollars per million Btu, for the reference case:

TABLE 1

DELIVERED FUEL OIL PRICE FORECAST

Reference Case

(1979 $ per Million Btu)

	1980	1985	1990	2000
No. 2 Fuel Oil	3.75	4.90	5.71	6.90
0.5% Sulfur Resid	3.17	4.45	5.24	6.40
1.0% Sulfur Resid	3.06	4.29	5.03	6.15
2.2% Sulfur Resid	2.83	3.95	4.61	5.63
2.7% Sulfur Resid	2.74	3.83	4.46	5.44

Tables 2 and 3 show the +70% and -70% confidence limit cases and Tables 4 and 5 the +95% and -95% confidence limit cases.

TABLE 2

DELIVERED FUEL OIL PRICE FORECAST
Plus 70% Case
(1979 $ per Million Btu)

	1980	1985	1990	2000
No. 2 Fuel Oil	4.18	6.01	7.16	8.85
0.5% Sulfur Resid	3.53	5.53	6.65	[illegible]9
1.0% Sulfur Resid	3.41	5.33	6.40	7.98
2.2% Sulfur Resid	3.15	4.93	5.90	7.35
2.7% Sulfur Resid	3.06	4.79	5.71	7.12

TABLE 3

DELIVERED FUEL OIL PRICE FORECAST
Minus 70% Case
(1979 $ per Million Btu)

	1980	1985	1990	2000
No. 2 Fuel Oil	3.21	3.67	4.41	5.12
0.5% Sulfur Resid	2.72	3.26	3.98	4.66
1.0% Sulfur Resid	2.61	3.13	3.81	4.46
2.2% Sulfur Resid	2.42	2.87	3.47	4.06
2.7% Sulfur Resid	2.34	2.77	3.35	3.91

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TABLE 4

DELIVERED FUEL OIL PRICE FORECAST

+95% Case

(1979 $ per Million Btu)

	1980	1985	1990	2000
No. 2 Fuel Oil	4.77	6.99	9.11	10.61
0.5% Sulfur Resid	4.02	6.48	8.55	10.01
1.0% Sulfur Resid	3.88	6.25	8.24	9.65
2.2% Sulfur Resid	3.59	5.79	7.62	8.91
2.7% Sulfur Resid	3.49	5.63	7.40	8.64

TABLE 5

DELIVERED FUEL OIL PRICE FORECAST

-95% Case

(1979 $ per Million Btu)

	1980	1985	1990	2000
No. 2 Fuel Oil	3.02	3.28	3.63	3.94
0.5% Sulfur Resid	2.55	2.88	3.21	3.52
1.0% Sulfur Resid	2.45	2.76	3.07	3.35
2.2% Sulfur Resid	2.27	2.52	2.78	3.02
2.7% Sulfur Resid	2.20	2.44	2.67	2.89