
UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
before the
ATOMIC SAFETY AND LICENSING BOARD

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| In the Matter of | |
| Boston Edison Company, et al. | Docket No. 50-471 |
| (Pilgrim Nuclear Generating Station Unit 2) | |



# APPLICANTS' PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW IN THE FORM OF A PARTIAL INITIAL DECISION

VOLUME II



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H. Need for Power

395. The Board admitted as hearing issues the following contentions related to the need for the Pilgrim 2 facility.*/

Commonwealth Contention 6

The need for the electrical generating capacity of Pilgrim 2 has not been properly established because the Applicants have not developed a model adequately considering the effects of the following on demand:

(a) Voluntary curtailment of consumption electricity by the public;

(b) Elasticity of demand;

(c) Peak load pricing to flatten demand; and

(d) New standards for improved building insulation, hearing, lighting and air conditioning.

Cleeton Contention H

Applicants and Staff have not adequately demonstrated the need for additional power in that the projected needs are inaccurate and conservation has not been seriously examined.

Ford Contention M

The Applicants have not adequately demonstrated the need for the Pilgrim 2 facility.

1. Background

396. These issues were fully heard during an earlier phase of this proceeding and the evidentiary record concerning the issue was closed on July 1, 1977. Tr. 8804, 8805. Based

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*/ Board Memorandum and Order (February 18, 1975) at 6, 15 and 16.

upon that record the issues were fully briefed by all parties.*/ In the Partial Initial Decision Regarding Request Limited Work Authorization dated November 30, 1977 the Board elected not to rule on the issues at that time but to reserve that ruling for a later decision.

397. Following the close of the record in 1977 the Commonwealth twice, and the Cleetons once, moved to supplement the record on the issue of need for power.**/ Each of the motions

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*/ Applicants' Proposed Findings of Fact and Conclusions of Law to Authorize the Issuance of a Limited Work Authorization in the Form of a Partial Initial Decision on Environmental and Site Suitability Matters (July 25, 1977), pp. 63-92, paragraphs 114-184; Commonwealth of Massachusetts' Proposed Findings of Fact and Conclusions of Law Corresponding to Applicants' Request for a Limited Work Authorization (August 10, 1977), pp. 1-22, paragraphs 2-50; Intervenor Cleetons' Proposed Findings of Fact and Conclusions of Law Corresponding to Applicants' Request for a Limited Work Authorization (August 19, 1977), p. 1, paragraph 3; Nuclear Regulatory Commission Staff's Proposed Findings of Fact and Conclusions of Law to Authorize the Issuance of a Limited Work Authorization in the Form of a Partial Initial Decision on Environmental and Site Suitability Matters (August 15, 1977), pp. 34-50, paragraphs 78-131; Applicants' Reply to Proposed Findings of Fact and Conclusions of Law on Environmental and Site Suitability Matters of Intervenor Commonwealth of Massachusetts (August 22, 1979), pp. 2-21.

**/ Commonwealth of Massachusetts' Motion to Supplement the Hearing Record (April 28, 1978); Second Motion of the Commonwealth of Massachusetts to Supplement the Hearing Record on the "Need for Power" Issue (April 4, 1979); Cleetons' Motion #3: That the Board Order that the Hearing Record be Re-opened with Respect to the Issue of Need for Power and that Updated Testimony be Filed Thereon (January 25, 1979).

adverted generally to the passage of time since the close of the hearing record and the development of new or updated load and capacity forecasts. The Commonwealth's first motion and the Cleetons' motion were denied by the Board,*/ however, the Commonwealth's second motion was subsequently allowed and the Applicants were directed to supply copies of the most recent long-range energy and demand forecasts of Boston Edison Company and the New England Power Pool (NEPOOL) and all parties were allowed to submit further testimony on the issue of need for power.**/

398. Principally because of the time intervals since the commencement of evidentiary hearings and consequent deferrals in the scheduled in-service date of the unit, the Applicants and the Staff have, in effect, made three separate presentations in support of the need for Pilgrim 2. The first such presentations were made in 1975 and were based upon the then current NEPOOL load and capacity projection dated April 1, 1975 and were in support of a projected 1982 in-service date. The second set of presentations were made in 1977 and were based upon the then current NEPOOL load and capacity projections dated January 1, 1977 and were in support of a projected 1984 in-service date. The final presentations were made in July and August of 1979 and were based upon NEPOOL load and

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*/ Order (March 14, 1979).

**/ Order (May 9, 1979).

capacity projections issued on April 1, 1979 and were in support of a projected in-service date of December, 1985.

399. Prior to the initial close of the record in July, 1977, the Commonwealth had introduced evidence on the issue of need for power by witnesses Hendrik Houthakker, Tr. 2329-2456, Carl Stein, Tr. 3297-3406, 3425-3517, John H. Neely, Tr. 3518-3542, 3550-3646, Henry Lee and Paul F. Levy, Tr. 4959-5075, and Nancy A. Boxer, Tr. 8583-8787; and had also conducted extensive cross-examination of witnesses provided by the Staff and the Applicants.

400. Prior to July 1, 1977 the Staff had introduced the FES containing the Staff asesssment of the need for the facility, FES, following Tr. 897, pp. 8-1 through 8-15, and Section 11.1.8, pp. 11-21 to 11-23; the Staff Responses to Comments on the FES revisions required by the withdrawal of Pilgrim Unit 3, Staff Responses to Comments, post Tr. 897, pp. 4-9, 14-15; as well as the supplemental testimony of witnesses Hugh L. Thompson, Tr. 2939-3099, and Daryl A. Nash, Tr. 3102-3280. Due to the deferral in the schedule for Pilgrim Unit 2 from 1982 to 1984 and to the lapse of time between the original presentation of evidence on need for power and the July, 1977 close of the record, the Staff also produced witnesses Sidney Feld and Daryl Nash to present additional evidence to update the record on forecasting and the need for the facility. Tr. 8146-8196.

401. The Applicants prior to July 1, 1977 had introduced the Applicants' Environmental Report (ER) containing its evaluation of the need for the facility Applicants' Exhibit 1-K, ER, Vol. I, Ch. 1, pp. 1-1 through 1-36, and had presented a panel of witnesses. Tr. 2630-2926.*/ Also as a result of the deferral of Pilgrim Unit 2 from 1982 to 1984 and the time lapse between the presentation of evidence on need for power and the close of the record in July, 1977, the Applicants had introduced a panel of witnesses to update the record with respect to the Applicants' assessment of the need for the facility. Tr. 7865-7988, 8000-8144, 8566-8582.**/

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*/ The Applicants' first panel of witnesses on the subject of need for power consisted of: John H. Ferguson, then Director, Rate Research and Forecasting Department, Boston Edison Company (BECo); Donald V. Bourcier, then Senior Load Analyst, New England Power Planning; Abraham Gerber, Vice President, National Economic Research Associates, Inc. (NERA); Louis A. Guth, Vice President, NERA; Moshe Weiss, Senior Consultant, NERA; Kenneth O. Sten, then Manager, Research and Planning Department, BECo; and Benjamin H. Weiner, Vice President - Power Supply Administration, BECo.

**/ The Applicants' second panel of witnesses consisted of: Robert O. Bigelow, Vice President and Director of Planning and Power Supply, New England Power Service Company and member of the NEPOOL Planning Committee; Stephen J. Sweeney, then Vice President, Steam Operations, Environmental Affairs, Planning and Research Organization, BECo; Cameron H. Daley, Manager, Research and Planning Department, BECo; Louis A. Guth, NERA; Moshe Weiss, NERA; and Abraham Gerber, NERA.

402. Following the reopening of the record on the issue of need for power, the Applicants presented the testimony of two panels of witnesses.*/ Tr. 10,427-10,481, 10,730-10,947, 11,356-11,417. The Applicants also introduced into evidence three documents containing the most recent NEPOOL load and capacity projections as well as a description of the methodology employed in making the NEPOOL forecast.**/ Tr. 10,740.

403. At the reopened hearings the Staff presented the testimony of witnesses, Dr. Sidney Feld, Economist, Cost-Benefit Analysis Branch, NRC, Tr. 10,499-10,648, 11,320-11,345, and following Tr. 10,651, and Dr. Wen S. Chern, Economist and Group Leader, Energy Demand Analysis Group, Energy

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*/ Applicants' Revised Supplemental Testimony on Need for Pilgrim 2, following Tr. 10,430. Panel 1 consisted of Benjamin H. Weiner, Vice President-Power Supply Administration, Boston Edison Company (BECo); Philip A. Legrow, Generation Planning Engineer, BECo; Donald V. Bourcier, Chief of Load Forecasting, New England Power Planning; and Arthur W. Barstow, Manager of Generation Planning, New England Power Planning. (Although Mr. Barstow was nominally a member of the panel, because of schedule conflicts his testimony was presented separately.) Panel 2 consisted of F. Cort Turner, Vice-President Arthur D. Little, Inc. (ADL); Nigel Godley, Manager-Energy Economics Section, ADL; and David Hanna, Economics Section, ADL.

**/ Applicants' Exh. 20-A, "NEPOOL Forecast for New England, 1978-1989," dated 3/1/79; Applicants' Exh. 20-B, "Report of the NEPOOL Model-Based Forecast of New England Electric Energy and Peak Load, 1979-1989," dated March 1, 1979; Applicants' Exh. 20-C, "New England Load and Capacity Report, 1978-1989," dated April 1, 1979.

Division, Oak Ridge National Laboratory (ORNL). Tr. 11,231-11,345, following Tr. 11,352. The Staff also introduced into evidence one document which contained a description of the forecasting methodology employed by the Staff's witnesses.*/ Tr. 11,234.

404. Following the reopening of the record on the issue of need for power, the Governor's Massachusetts Office of Energy Resources (MOER) petitioned the Board to participate in the proceeding as an interested state agency "on the issue of need for power."**/ This petition was approved by the Board pursuant to Section 2.715(c) of the Commission's Rules of Practice.***/ At the reopened hearings MOER presented the testimony of witnesses John G. Buckley, Vice President and Director, Northeast Petroleum Industries, Inc., Tr. 10,370-10,426, and following Tr. 10,947 and Joseph S. Fitzpatrick, Director, Massachusetts Office of Energy Resources. Tr. 10,656-10,729, and following 10,947.

405. At the reopened hearings the Commonwealth presented the testimony of one panel of witnesses consisting of two

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*/ Staff Exh. 60, "Regional Econometric Model for Forecasting Electricity Demand by Sector and by State," by W.S. Chern, R.E. Just, B.D. Holcomb and H.D. Nguyen, NUREG/CR-0250.

**/ Petition of the Governor's Massachusetts Office of Energy Resources for Leave to Participate as an Interested State Agency or in Lieu Thereof to Make a Limited Appearance (May 23, 1979).

***/ Order (June 7, 1979).

individuals, Paul L. Chernick and Susan C. Geller, each of whom is employed by the Massachusetts Attorney General as a Utility Rate Analyst. Tr. 10,952-11,201, and following 11,224.

406. In dealing with the question of need for power, the Appeal Board has recognized that the process of load forecasting involves substantial margins of uncertainty and is at least as much art as science, due in no small part to the fact that nobody has yet learned to predict the future with a high degree of certainty. Niagara Mohawk Power Corp., (Nine Mile Point Nuclear Station, Unit 2), ALAB-264, 1 NRC 347, 365-366 (April 18, 1975). See Tennessee Valley Authority (Hartsville Nuclear Units 1A, 2A, 1B and 2B), ALAB-367, 5 NRC 92, 95 (January 25, 1977)).

407. The inherent uncertainties in load forecasting particularly affect an electric utility and bear upon the reasonableness of conservative planning to meet the higher level of demand within the range of load forecasts. In this connection the Appeal Board has observed:

> "Given the legal responsibilities imposed upon a public utility to provide at all times adequate reliable service - and the severe consequences which may attend upon a failure to discharge that responsibility - the most that can be required is that the forecast be a reasonable one in the light of what is ascertainable at the time made." Kansas Gas & Electric Co. et al, (Wolf Creek Generating Station, Unit 1), ALAB-462, 7 NRC 320, 328 (March 9, 1978).

The Appeal Board has further held:

> "Being legally obligated to meet reserve margin requirements any utility company must be expected to forecast load demands conservatively - i.e., favor the high side of such predictions, to ensure that it is always prepared for unexpectedly high demands. We find nothing untoward in this attitude." Niagara Mohawk Power Corp., (Nine Mile Point Nuclear Station Unit 2), ALAB-264, 1 NRC 347, 366 (April 18, 1975).

The Commission, ruling on a related issue, has recently observed:

> "The Nine Mile Point rule recognizes that every prediction has an associated uncertainty and that long-range forecasts of this type are especially uncertain in that they are affected by trends in usage, increasing rates, demographic changes, industrial growth or decline, the general state of industrial growth or decline, the general state of the economy, etc. These factors exist even beyond the uncertainty that inheres to demand forecasts: assumptions on continued use from historical data, range of years considered, the area considered, extrapolations from usage in residential, commercial, and industrial sectors, etc." Carolina Power & Light Co. (Shearon Harris Nuclear Power Plant), CLI-79- , 9 NRC ___ (May 2, 1979).

408. It is also settled that a "need for power" may be found not only on the basis that a facility is demonstrated to be necessary to provide capacity without which expected power needs cannot be met, but also on the concept of "substitution," i.e., that a nuclear facility is "needed" in order to substitute operation of it for plants fired by fossil fuel which may be in short supply or better utilized for other purposes. ALAB-264, supra, 1 NRC at 353-54; Public Service Company of New Hampshire, (Seabrook Station, Units 1 and 2), ALAB-422, 6 NRC 33, 95-99 (July 26, 1977).

409. In particular, the Appeal Board has specifically upheld the use of the "substitution" theory in the context of the somewhat unique situation in New England involving other nuclear units which are part of the same overall load and capacity plan as is Pilgrim 2. The Appeal Board has expressly found the substitution theory consistent not only with statutes designed to encourage conservation and other alternatives but also consistent with public policy calling for a reduction in the import of foreign oil. Id. at 98-99. More recently, statutes have been enacted as a part of the National Energy Act, such as the Powerplant and Industrial Fuel Use Act of 1978, P.L. 96-620, 92 Stat. 3289, et seq., expressly calling for the substitution of coal or other alternate energy sources, including uranium, for oil in electric powerplants and major fuel-burning installations. President Carter's energy message to the nation of July 15, 1979 further emphasized the importance of these objectives and further set forth the goals that the overall usage of imported oil in the United States be cut by one half over the next decade and, more fundamentally, that the nation's utilities cut their massive use of oil by 50% within the same time period and switch to other fuels. Congressional Record-House, H. 5924, July 16, 1979.

410. Pilgrim Unit 2 will be jointly owned by Boston Edison Company, and thirteen other investor or consumer owned utilities located throughout New England. Supra. para. 1. In this connection the concept of a specific service area is of minor importance in New England. Of more importance is the Applicants' membership in the New England Power Pool (NEPOOL). Regional load forecasting is performed by NEPLAN, a division of NEPOOL. NEPLAN also forecasts the type of generating capacity needed. NEPOOL provides for coordinated power supply planning, central dispatching, construction, operation and maintenance scheduling of electric power generation and transmission facilities of the participating companies throughout New England to provide for enhanced reliability and economy of the electric power supply in New England. The participation in New England includes 42 utilities serving over 95% of the New England load. NEPOOL also provides for regional interconnection and operating arrangements with utilities and power pools outside New England. The Northeast Power Coordinating Council, which also includes New York and Ontario, is the Regional Reliability Council with jurisdiction over NEPOOL. FES, §8.1; ER, §1.1, Applicants' Exh. 20-A, "NEPOOL Forecast for New England, 1979-1989," Introduction, p. 1.

411. The Applicants have presented evidence to establish the need for Pilgrim Unit 2 on three fundamental bases. The first such basis is to provide adequate generating capacity to meet the forecasted power needs in New England, including therein a sufficient reserve margin to assure adequate reliability levels. The second is economic, in that significant cost savings will accrue to New England electricity consumers from the installation of Pilgrim Unit 2 as scheduled, even if forecasted growth rates do not materialize and the Unit is not required for reliability reasons until a later date. The third is the reduction in dependence on (imported ) oil for electrical generation and the furtherance thereby of national, regional and statewide energy policies and goals. Applicants' witness Weiner, p. 3, following Tr. 10,430.

2. Reliability Requirements

412. The Applicants' scheduling of Pilgrim Unit 2 is based upon load and capacity forecasts and projections of required reserves and developed by the NEPLAN staff under the direction of the NEPOOL Planning Committee. The New England Load and Capacity Report, dated April 1, 1979, contains forecasts of peak loads and projected generating capabilities for the period through the winter of 1989/90. Applicants' Exh. 20-C, "New England Load and Capacity Report, 1978-1989".

413. NEPOOL's required levels of generating capacity reserves are based upon a generation reliability criterion so as to assure that it will be unnecessary to physically disconnect customers more frequently than once in ten years. Utilizing this criterion along with NEPOOL's projected loads and the amounts and types of capacity available to meet those loads, recent reliability studies indicate that generating reserves in the order of 23% to 28% of peak load will be required in the 1985 to 1989 time period. Applicants' witness Barstow, pp. 10-13, following Tr. 10,430.

414. The most current NEPOOL forecast of peak load for the winter peak of 1984/85 is 20,668 megawatts (MW), for 1985/86 is 21,502 MW, for 1986/87 is 22,267 MW, for 1987/88 is 22,989 MW, for 1988/89 is 23,595 MW and for 1989/90 is 24,120 MW. These figures reflect a projected 3.8% compound annual growth rate over the next decade. Applicants' witness Weiner, p. 9, and Exhibit NP-35, following Tr. 10,430.

415. The present NEPOOL long-range plan, as contained in the Load and Capacity Report, calls for the addition of approximately 8,000 megawatts of NEPOOL-planned generating capacity through December of 1989. Applicants'

Exh. 20-C, "New England Load and Capacity Report, 1978-1989," pp. 48-50. Since the publication of the Load and Capacity Report, two of the units scheduled therein, i.e., NEPCO Units 1 and 2, have been either eliminated or delayed to points in time entirely outside of the forecast period. Applicants' witness Weiner, Tr. 10,734-10,736.

416. With correction for the deferral of the NEPCO units, NEPOOL capability for the winter peak in 1984/85 is projected to be 23,768 MW,for 1985/86 is 25,869 MW, for 1986/87 is 26,804 MW, for 1987/88 is 27,271 MW, for 1988/89 is 27,272 MW and for 1989/90 is 27,274 MW. These projected capabilities assume the addition of two Stony Brook units (total 510 MW) in 1981 and 1982, Seabrook Unit 1 (1150 MW) in April, 1983, Seabrook Unit 2 (1150 MW) in February, 1985, Pilgrim Unit 2 (1150 MW) in December, 1985, Millstone Unit 3 (1150 MW) in May, 1986, and Sears Island (568 MW) in November, 1987. Applicants' witness Weiner, p. 10, and Exhs. NP-34, NP-35, following Tr. 10,430; Tr. 10,734-10,736.

417. Although the published load and capacity schedule projects the operation of a number of new units over the next decade, it is highly unlikely that all of these units will be available as planned. The delay in NEPCO Units 1 and 2 has already been referred to, supra, para. 415 and the Sears Island unit

has also run into significant opposition. Applicants' witness Weiner, p. 10, following Tr. 10,430; Staff witness Feld, Tr. 10,540-10,541. Indeed, Pilgrim Unit 2 is itself on an extremely tight schedule, as are Stony Brook and Seabrook. Applicants' witness Weiner, Tr. 10,901-10,902.

418. Projected generating reserve margins given in the current NEPOOL load and capacity forecast (exluding NEPCO Units 1 and 2) are 15.0% for 1984/85, 20.3% for 1985/86, 20.4% for 1986/87, 18.6% for 1987/88, 15.6% for 1988/89 and 13.1% for 1989/90. Without Pilgrim 2 installed in December, 1985, the reserve levels would drop to 15.0% in 1985/86, 15.2% in 1986/87 and 13.6% in 1987/88. Applicants' witness Weiner, Exh. NP-35, following Tr. 10,430, Tr. 10,734-10,736.

419. Given the current NEPOOL forecast, the New England reserve margin will be at or below minimum desired levels by 1984/85 thus Pilgrim 2 is clearly needed by the scheduled December, 1985 in-service date. Delays in Pilgrim 2 or in other units beyond this date would further reduce the level of reserves which are already projected at or below the minimum estimated recommended level of 23%. Applicants' witness Weiner, p. 10, following Tr. 10,430; Staff witness Feld, p. 5, following Tr. 10,651.

420. The Staff has also reviewed the NEPOOL load forecast and capacity plans and has concluded that from NEPOOL's perspective, based upon a minimum reserve margin of 23%, Pilgrim Unit 2 will be needed by 1985. Staff witness Feld, p. 5, following Tr. 10,651.

421. Staff witness Feld also reviewed earlier NEPOOL load and capacity projections which had been prepared in previous years. On the basis of those projections the Staff had concluded in testimony presented in 1977 that Pilgrim Unit 2 would be needed by the winter of 1985, which at that time was one year later than the Applicants' proposed in-service date. Staff witnesses Feld and Nash, p. 11, following Tr. 8150. Dr. Feld noted that the forecasted peak demand growth rate had been reduced from 5.4% per annum at that time to 3.8% per annum at present with a resultant impact of lowering the forecasted 1985/86 peak by approximately 2300 MW. At the same time Dr. Feld noted that Pilgrim Unit 2 was officially delayed by approximately a year and a half, bringing it to its present December, 1985 projected in-service date, while other planned capacity for 1985/86 was reduced by approximately 2650 MW through various delays, size reductions, retirements and re-ratings. Staff witness Feld, pp. 2-5, following Tr. 10,651. Consequently, the reductions in peak load growth have been more than offset by delays in Pilgrim Unit 1 and other NEPOOL planned units.

422. Independent of its assessment of the load forecasting efforts of NEPOOL, the Staff has also developed a forecasting capability based upon a regional econometric forecasting model developed by the Oak Ridge National Laboratory (ORNL). The model has been utilized by the Staff to develop its own forecast of electricity demand for New England. Staff witness Feld, p. 6, following Tr. 10,651.

423. Utilizing the ORNL model, a range of peak demand forecasts for New England over the next decade was established. At the low end of the range the ORNL model forecasts a peak demand growth rate of 2.7%; at the high end the forecast is for a growth rate of 4.1% and the base case is for a growth rate of 3.4%. The Staff's view is that the entire range represents a reasonable index of future growth. Staff witness Feld, pp. 6-8, following Tr. 10,651.

424. Utilizing NEPOOL's capability projections and exluding the two NEPCO units as well as Pilgrim 2, the generating reserve margins in New England under the ORNL model base case scenario are 26.7% in 1985/86, 27.2% in 1986/87, 25.2% in 1987/88, 21.1% in 1988/89, 17.1% in 1989/90, 13.3% in 1990/91 and 9.6% in 1991/92. Under the low growth rate scenario the reserve margins are 33.8% in 1985/86, 35.2% in 1986/87, 34.0% in 1987/88, 30.5% in 1988/89, 27.1% in 1989/90, 23.7% in 1990/91, and 20.5% in 1991/92. Using the high growth rate scenario the reserve margins are 20.0% in 1985/86, 19.7% in 1986/87, 17.1% in 1987/88, 12.4% in 1988/89, 8.0% in 1989/90, 3.8% in 1990/91 and less than 0% in 1991/92. Using these ORNL model figures

the Staff concluded that need for Pilgrim Unit 2 for reliability purposes would occur under the base case scenario by the winter of 1988/89; that under the high growth rate scenario such need would occur by the winter of 1985/86; and that under the low growth rate scenario such need would not occur until the winter of 1991/92. Based upon the Staff's review of these figures, the Staff concluded that it would not be imprudent to maintain Pilgrim Unit 2 on its December, 1985 schedule. Staff witness Feld, pp. 7-9, following Tr. 10,651.

425. Contentions of the intervenors Commonwealth and the Cleetons have questioned the adequacy and accuracy of the load forecasts in the light of the forecasting methodology employed and, in particular, because of the inadequate consideration of the effects of conservation, demand elasticity, peak load pricing and new building standards on the growth rate in electric power consumption. Commonwealth Contention 6 and Cleeton Contention H, supra, para. 395. Additional criticisms of the forecasting methodologies of both NEPOOL and the Staff were presented in the testimony of Commonwealth witnesses Chernick and Geller, following Tr. 11,224, as well as in the cross-examination of the Applicants' and Staff's witnesses.

426. Load forecasting for NEPOOL is performed by NEPLAN under the direction of NEPOOL Planning Committee. Within NEPLAN is established the NEPOOL Load Forecasting Task Force, having members from utilities representing each of the

New England states and chaired by NEPLAN's Chief of Load Forecasting. The Task Force has been responsible for the development over the past several years of a long-term electric energy and peak load forecast for New England using an economic model (the "NEPOOL Model") which is the basis for the current NEPOOL forecast. Applicants' Exh. 20-B, "Report of the NEPOOL Load Forecasting Task Force on the NEPOOL Model-Based Forecast of New England Electric Energy and Peak Load, 1979-1989", p. 1; Applicants' witness Bourcier, pp. 4-6, following Tr. 10,430.

427. Applicants' witness Donald V. Bourcier, who presented testimony on two separate occasions concerning the NEPOOL load forecast (folloiwng Tr. 2647; following Tr. 10,430), is NEPLAN's Chief of Load Forecasting and is responsible for preparing forecasts of long range electric energy and peak demands for the six state New England region as well as chairing the Load Forecasting Task Force. Mr. Bourcier holds Bachelor's and Master's Degrees in, respectively, Economics and Resource Economics and has had extensive experience over the past thirteen years as a statistical economist and in the field of forecasting both for utility load forecasts and for other private industry. Since October, 1972 he has worked for NEPLAN developing and applying methodology for forecasting electric energy and peak demand. Applicants' witness Bourcier, pp. 4-6, following Tr. 10,430.

428. Prior to the 1979 NEPOOL load forecast, NEPOOL had forecast peak loads by the addition of member companies' peak load forecasts, such as Boston Edison Company's, with adjustments for losses and diversity. This method historically had been quite accurate until 1973. Applicants' witness Bourcier, pp. 32-34, following Tr. 2647.

429. The current NEPOOL forecast, Applicants' Exh. 20-A, NEPOOL Forecast for New England, 1979-1989, represents the first usage by NEPOOL of the NEPOOL Model and represents a substantial departure from the prior "sum of the individual companies' forecasts" methodology. Consequently, the forecasts of individual companies, such as Boston Edison Company, are no longer of any particular relevance in determining the NEPOOL forecast. Applicants witness Bourcier, Tr. 10,803-10,804.

430. The NEPOOL Model for long-range forecasting of electric energy and demand is a dynamic simulation model composed of two major sectors: an economic/demographic sector, and a power sector. A detailed description of the model is beyond the scope of these findings; however, basically the model develops its forecasts by examining the end-use components of load. It is composed of several discrete modules and submodules which are utilized to forecast such basic variables as population, employment and household income. The model is driven by national employment growth

rates developed by Wharton Econometric Forecasting Associates. Total electric usage is determined by summing the usages in the residential, industrial (manufacturing), commercial (non-manufacturing) and miscellaneous classes. Seasonal peak loads are forecasted by specifying a long term peak temperature profile for day-type and month, and then summing the forecasted load for each of some 50 end-use components, for each hour of the day. Annual load factor is calculated directly from forecasted energy (including line losses and forecasted peak load). Applicants' Exh. 20-A, NEPOOL Forecast for New England, 1979-1989, pp. 2-3. Detailed results of the development, calibration and testing of the NEPOOL model and explanations of the assumptions and data used are contained in summary form in the "Report of the NEPOOL Load Forecasting Task Force on the NEPOOL Model-Based Forecast of New England Electric Energy and Peak Load, 1979-1989". Applicants' Exh. 20-B.

431. Although much of the Commonwealth's previous testimony and criticism is of little relevance, inasmuch as it was directed at perceived deficiencies in the prior forecasting methodology, a certain portion of that testimony may nevertheless be deemed relevant to the present forecast and will be referred to briefly.

432. The Commonwealth presented witness John Neely whose testimony questioned the adequacy and accuracy of the Applicants' forecasting methodology, and recommended consideration of factors related to econometric modeling. The essence of Mr. Neely's testimony was to recommend to the Board that it not accept the Applicants' forecast without confirmatory results of such analyses. Commonwealth witness Neely, pp. 2-3, 9-11, following Tr. 3542. Neely further testified that he did not have a methodology that could be considered accurate, or even best. Commonwealth witness Neely, p. 3, following Tr. 3542; Tr. 3614. The essence of Mr. Neely's criticism has now been dealt with given the present NEPOOL Model-based forecast.

433. The Commonwealth also introduced Dr. Hendrik Houthakker who presented testimony on the econometric model mechanism for accounting for price elasticity of demand. Dr. Houthakker testified that demand for electric power will be sensitive to price and, therefore, projections of demand for electric power must take into account explicit assumptions concerning the price of electric power. He further presented an econometric equation that demonstrated price and income elasticities for residential electricity sales in New England which showed that increases in marginal prices would lead to a decrease in sales and that increases in real income would lead to increases in sales. Commonwealth witness Houthakker, p. 2,

following Tr. 2330; Tr. 2330-2332, 2339, 2455. Dr. Houthakker further indicated, however, that he did not purport to have a completely defined load forecast and that the "main purpose" of his study was "to show that consumption of electric power, by residences, is sensitive to the prices charged." He further noted that "these projections are based on assumptions which I don't claim to be realistic." Tr. 2374. In response to a question whether, as a utility company, he would rely on his econometric equation to make demand forecasts, he responded, "Certainly not." Tr. 2386. Again, the essence of Dr. Houthakker's testimony has been dealt with given the present NEPOOL forecast methodology.

434. Commonwealth witness Paul Chernick is employed as a Utility Rate Analyst by the Attorney General of the Commonwealth of Massachusetts. He holds a Bachelor's and a Master's degree, the latter in the field of Technology and Policy, received in 1978. Commonwealth witness Chernick, p. 1, following Tr. 11,224. In his present employment, which represents his first full-time employment since leaving school, Tr. 10,972, a substantial portion of the witness' time, on the order of about 40%, has been spent in developing criticisms of utility forecasts and cross-examination of utility witnesses who might be presenting such forecasts before regulatory agencies. Tr. 10,981. The witness

acknowledged that he neither held himself out to be a professional economist, statistician, econometrist, or demographer, Tr. 10,969-10,970, nor did he have, prior to his present employment, any experience or involvement with electric utility long range forecasting. Tr. 10,982. The witness also conceded that he had never prepared or assisted in the preparation of a long range electric energy or demand forecast (Tr. 10,984, 11,104) nor had he ever been involved in defending such a forecast (10,985).

435. Commonwealth witness Susan Geller is also employed by the Attorney General as a Utility Rate Analyst. She holds a Bachelor's degree in Economics and a Master's degree in Public Policy and is presently pursuing a Ph.D. in the same field. Commonwealth witness Geller, pp. 2-3, following Tr. 11,224. She considers herself to be trained in the field of public policy with a "working knowledge of the tools used in doing policy analysis." Tr. 10,971. Ms. Geller's experience is similar to that of Chernick and she joined in the responses of Mr. Chernick to most of the questions regarding the duties of her position and her lack of prior experience in the field of long range electric energy or demand forecasting. Tr. 10,972, 10,973, 10,980, 10,982, 10,985, 11,104.

436. The Commonwealth's Chernick-Geller testimony contains a lengthy list of criticisms of the NEPOOL Model finding "serious error" in each basic module and in virtually every specification contained therein.*/ Commonwealth witnesses Chernick and Geller, pp. 15-45, following Tr. 11,224. Witness Chernick summarized these errors as principally being in the categories of inadequate documentation and modeling errors arising from the use of incorrect concepts and incorrect values. Tr. 10,968-10,969.

437. Both witnesses agreed that the process of electric load forecasting is a combination of art and science and involves a fair degree of judgment on the part of the forecaster. Tr. 10,986. Witness Chernick further agreed that there probably never would be a forecast which he and Ms. Geller couldn't criticize on one basis or another, Tr. 19,986-10,987, and that the NEPOOL forecast was no exception to this general rule. Tr. 10,989.

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*/ Although the Commonwealth testimony was presented as joint testimony of witnesses Paul Chernick and Susan Geller, it appeared as a result of cross-examination that the entire responsibility for the criticisms of the NEPOOL forecast lies with Mr. Chernick while principal responsibility for criticisms of the ORNL forecast lies with Ms. Geller, Tr. 10,990, 11,180-11,181, however, citations herein to the joint testimony will be attributed to both witnesses.

438 In response to questioning as to whether the NEPOOL Model was a "good" model or a "bad" model or whether it represented the "state of the art" in load forecasting, witness Chernick testified that he believed the model to be a bad model and not to represent the state of the art. Tr. 11,075-11,076. Further questioning revealed, however, that the witness never had seen or reviewed a model which he considered to be a good model, although he did recall that there was one model which he may have seen which was in fact a better model than the NEPOOL Model but he hadn't gone into it in enough detail. Tr. 11,075-11,077. Witness Geller, based upon what she had read of witness Chernick's testimony, also believe the NEPOOL Model to be a bad model. Tr. 11,078.

439 One of the basic criticisms of the NEPOOL Model raised by witness Chernick was that of inadequate documentation and further that much basic material which he desired to review remained unreported or unpublished. Commonwealth witness Chernick pp. 15-16, following Tr. 11,224; Tr. 10,968. As noted by the witness at the outset of his testimony, however, he could not necessarily be sure that this lack of documentation was due to the non-existence of such documentation as opposed to the fact that he had not seen the documentation. Tr. 10,958, 10,960-10,961. While the witness felt that this was in large measure due

to an inadequate opportunity to review the large amount of data supplied in response to the "very limited" set of interrogatories he had prepared concerning the NEPOOL Model (Tr. 10,991), the witness nevertheless acknowledged that he had in his possession the basic report on the model since the Fall of 1978, that he had received the Applicants' three exhibits based upon the model (i.e., Applicants' Exhs. 20-A, 20-B and 20-C) shortly after they were published early in 1979, that he had received a series of some forty-five documentations on the model in May of 1979 and that he had also sat in on four days of cross-examination of Applicants' witness Bourcier by counsel for the Commonwealth in May of 1979 in another proceeding dealing with the NEPOOL Model. Tr. 10,991-10,995.

440. The witnesses also raised a number of alleged modeling errors in various sectors of the model, not all of which can possibly be dealt with herein. The inability of the Board to deal with each and every criticism is in large measure due to the scattershot nature of the criticisms and the conspicuous failure of the witnesses to document or otherwise quantify the effect of their criticisms in terms of the forecast results.

441. An example of the witnesses' approach was their discussion of so-called "cross-sectional fallacy." Commonwealth

witnesses Chernick and Geller, pp. 17-20, following Tr. 11,224. In response to lengthy cross-examination Tr. 10,995-11,001; 11,109-11,112; 11,150-11,157; 11,167-11,173, caused in no small part by the fact that to demonstrate the "cross-sectional fallacy" the witness constructed a figure model (Commonwealth witnesses Chernick and Geller, p. 19, following Tr. 11,224) which confused more than it clarified, witness Chernick acknowledged that the model was not based on data which would support the existence and effect of the fallacy, but was hypothetically plotted to be illustrative of what "could have" happened. Tr. 10,997-10,999.

442. Other errors raised by the witnesses in their prepared testimony raised questions as to whether the witnesses had just misunderstood the model and supporting documentation or whether they had, in fact, even asked NEPOOL for the supporting documentation or reasoning. An example of the latter was Mr. Chernick's admitted failure to request data of NEPOOL which would support his "cross-sectional fallacy" argument. Tr. 11,000-11,002. Other examples of possible misunderstandings, or, at the very least, of differences in interpretation, included statements made by the witnesses with respect to non-manufacturing employment growth, Tr. 11,004-11,007, with respect to DOE efficiency standards, Tr. 11,012-11,016, and with respect to miscellaneous use per household. Tr. 11,032-

11,044. The existence of the problem was acknowledged by witness Chernick on cross-examination. Tr. 11,039-11,040.

443. While each individual problem the witnesses had with the NEPOOL Model cannot be discussed in detail, it is clear that the various allegations of the witnesses raise, in turn, the same sort of questions as the witnesses raise concerning the NEPOOL Model. The witnesses repeatedly score the NEPOOL Model because of an asserted lack of underlying data or because it is contrary to some other data of which the witnesses claim to be aware, however, their criticisms are unaccompanied by any documentation. For example, the witnesses criticize the NEPOOL Model because it failed somehow to account for "Cold War military activity" and the use of colleges for "draft avoidance." Commonwealth witnesses Chernick and Geller, p. 18, following Tr. 11,224, however, on cross-examination witness Chernick indicated that he had no data or documentation for that effect either. Tr. 11,003-11,004. Other examples abound. See, e.g., Tr. 11,010; Tr. 11,052; Tr. 11,176.

444. Further, both on an individual and an overall basis, the witnesses assiduously avoided any quantification of the effect on the forecast of the various errors they alleged. Tr. 11,158-11,160. In response to Board questioning, the

only quantification of effect of any kind identified by the witnesses (i.e., the effect of discount rate) in fact, had nothing to do with the forecast. Tr. 11,159-11,160. Witness Chernick acknowledged that, while many of the alleged "errors" found by the Commonwealth had the effect of overstating demand, many might have an indeterminate effect and still others might understate demand. Tr. 11,106-11,107. The "cross-sectional fallacy" was identified as an example of an "error" which might in fact operate in either direction. Tr. 11,109-11,110. On cross-examination it developed that one error, identified as "serious" turned out to have projected effects only of the order of nine megawatts, out of 24,000 MW projected at the end of the forecast period. Tr. 11,025-11,027. Other errors remained unquantified and the direction of their effect, if any, remained uncertain.

445. In response to questioning by the Board as to what the proper load forecast should be for New England, witness Chernick announced that it was his belief that the appropriate growth rate was approximately one percent annual growth rate in peak demand over the next decade. Tr. 11,162. Witness Chernick further explained that this estimate represented his own "realistic expectation for growth" and was not derived by starting with any particular model and making refinements to that model. Tr. 11,163.

446. On further examination of witness Chernick concerning his one percent forecast, the witness indicated that he had a 95% level of confidence that the actual growth rate would lie between minus .5% and plus 2.5%. Tr. 11,192-11,193. The witness described his methodology as "entirely subjective". Tr. 11,193. Given the contentions of the Commonwealth relative to alleged methodological errors in the Applicants' forecasts as well as the testimony presented by other Commonwealth witnesses on adequate and defensible forecast methodology, the Board is not inclined to place much weight on a "forecast" such as that offered by Mr. Chernick.

447. Another of the particular problems raised by the Commonwealth and by the Cleetons in their respective contentions was that of alleged inadequate consideration of conservation in the Applicants' forecast. Supra, para. 394. The issue was raised initially with forecasts presented by the Applicants in 1975 and 1977, Commonwealth witness Stein, following Tr. 3299; Applicants' witness Weiss, pp. 81-104, following Tr. 2647, and pp. 42-49, following Tr. 7927; Staff witness Thompson, following Tr. 2967, and was subsequently raised again with respect to the NEPOOL Model-based forecast through the testimony of Commonwealth witness Chernick and Geller, following Tr. 11,224 and cross-examination of the Applicants' witnesses.

448 The contribution of conservation to reducing electric demand growth can logically be disassociated into price-induced and non-price-induced conservation. Applicants' witness Weiss, pp. 94-85, 102-104, following Tr. 2647; Applicants' witness Bourcier, Tr. 10,830; Staff witness Thompson, p. 5, following Tr. 2967. The effects of price-induced conservation may be dealt with in an econometric model by way of the price elasticities for electricity. Applicants' witness Weiss, pp. 86-87, following Tr. 2647, and p. 49, following Tr. 7927. However, it is also necessary in such a model to deal with the effect of price-induced substitution of electricity for other fuels. Applicants' witness Weiss, p. 82, 87-89, 103-104, following Tr. 2647, and pp. 43-44, following Tr. 7927; Applicants' witness Bourcier, Tr. 10,822-10,823. The effects of non-price-induced conservation are, however, much more difficult to assess in that they depend upon a level of governmental action which may not yet be established. Applicants' witness Weiss, pp. 44-45, 49, following Tr. 7927. Even where such governmental actions could be assessed it may not in fact be possible to distinguish between that conservation which occurred due to the governmental action and that which occurred due to simple economic or price effects. Applicants' witness Bourcier, Tr. 10,829.

449 The NEPOOL Model does in fact contain specific assumptions relative to conservation in all classes of service during the forecast period. Federal appliance efficiency goals have been included as well as the effects of wood burning stoves in two of the states (New Hampshire and Maine) where sufficient data exists to permit their recognition. In other classes conservation effects are implicitly captured in the historic data base involving both pre- and post- oil embargo years. In addition, electricity price effects are explicitly recognized thorugh the use of short- and long-run price elasticities. Applicants' Exh. 20-B, Report of the NEPOOL Load Forecasting Task Force on the NEPOOL Model-Based Forecast of New England Electric Energy and Peak Load, 1979-1989, pp. 14-15.

450. Commonwealth witness Stein presented an assessment of the potential for energy conservation in the event of implementation of conservation measures applied to buildings. Utilizing his estimate of potential energy reduction per building and his estimates of the number of residential buildings and the "effective" commercial stock of building in the year 2000, the witness arrived at the conclusion that the residential and commercial categories of use will decline by 7.5% from 1975 to the year 2000. Commonwealth witness Stein, pp. 1-4, following Tr. 3299. This methodology implicitly assumes that there will be no additional

applications of electricity in residential and commercial use, no increase in the saturation of any electric applicance or service, and no substitution of electricity for other energy sources. Witness Stein provides no assessment of the rate at which, or the likelihood that, the changes he describes will be introduced, stating that "[i]t is not the intension [sic] to evaluate strategies for promoting their introduction" and relying upon the assertion that "economic governmental and social pressures will effect the changes sought." Commonwealth witness Stein, p. 8, following Tr. 3299. Given that witness Stein's estimates were made with respect to a now outdated forecast and given the imponderable nature of the pressures relied upon by Mr. Stein to effect the changes he foresees, it is difficult to apply his testimony to the present NEPOOL forecast.

451. The prepared testimony of witnesses Chernick and Geller contained a number of assertions relating to the inadequate consideration of conservation in the NEPOOL Model-based forecast. Principally, these concerns were with the application of DOE appliance efficiency standards, potential price-induced substitution of fuels, governmentally-mandated building and lighting codes and temperature restrictions, potential commercial cogneration, revised rate structures, including potential time of use rates, and load management. Commonwealth witnesses Chernick and Geller, pp. 29-30, 31-32, 43, 44, following Tr. 11,224.

As with the remainder of their criticisms of the NEPOOL forecast, the witnesses neither quantify the impact of the identified conservation measures, nor in most cases do they indicate precisely how or when the measures they identify will be implemented.

452. At least some of the areas of concern (e.g., building temperature controls and appliance efficiency standards) were taken into consideration by the NEPOOL Model, although there are apparently significant differences in interpretation of their meaning or application within an econometric model. Applicants' witness Bourcier, Tr. 10,829-10,830, 10,836-10,838. Other conservation areas raised by the Commonwealth witnesses such as potential substitution effects of natural gas for electricity were also considered in formulating the model; however, they were rejected by NEPOOL as not statistically significant in influencing electric use. Applicants' witness Bourcier, Tr. 10,823-10,824.

453. Mr. Bourcier conceded that the NEPOOL Model-based forecast did not take into consideration the potential impact of time of use rates, or peak load pricing. Applicants' witness Bourcier, Tr. 10,775, however, this was based upon several very good reasons, including the absence of any completed studies which can be used to derive an

hourly price elasticity for use in the forecast as well as a large area of unknowns as to whether such rates can even be offered in an economic sense by utilities and the form which such rates might take. Applicants' witness Bourcier, Tr. 10,775-10,776.

454. In addition, the implementation of peak load pricing of necessity would require state public utility commission actions (Staff witness Nash, Tr. 3243) and would introduce difficult rate design considerations. Applicants' witness Guth (Supplemental), p. 7, following Tr. 2647. The effect of peak load pricing would be slow in any event, due to physical system requirements for metering and the design and installation of equipment designed to take advantage of off-peak power. Applicants' witness Ferguson, p. 32, following Tr. 2647; Applicants' witness Guth (Supplemental), pp. 6-7, following Tr. 2647; Staff witness Nash. Tr. 3243-3244.

455. Furthermore, it is likely that peak load pricing would not reduce the need, but might even increase the need for Pilgrim Unit 2 since the economic principle of peak load pricing would act both to reduce peak demand and to increase off-peak demand. The effect is not limited to moving on-peak use to off-peak use (which would improve the load factor and, therefore, justify a larger percentage of total capacity as base-load as well as increase required

reserves) but also by potentially encouraging an increased off-peak use due to the price elasticity effects of the lower cost of off-peak consumption. Applicants' witness Guth (Supplemental), pp. 6-8, following Tr. 2647; Applicants' witnesses Ferguson, p. 32, following Tr. 2647, Bigelow, Tr. 7966-7968, 7974-7978, and Weiss, Tr. 8046, 8115-8117; Staff witness Nash, p. 23, following Tr. 3110; Staff witness Feld, Tr. 11,322-11,323.

456. The ORNL model which was utilized by the Staff is a regional econometric forecasting model which forecasts electricity demand and price. The model utilizes a system of simultaneous equations employing a number of key input assumptions including growth rate in population, residential, commercial and industrial customers, real per capita income, value added in manufacturing and fuel prices. Varying the fuel price assumptions from the base case permits the creation of a high price and a low price scenario in order to establish a range of projected energy growth rates. Conversion of the energy growth rate to a peak load projection is accomplished assuming a constant system load factor. Staff witness Feld, pp. 6-7, following Tr. 10,651.

457. The ORNL model has been developed by a highly qualified group of economists and other professionals under the leadership of Dr. Wen S. Chern at ORNL. Professional

qualifications of Wen S. Chern, following Tr. 11,352. The present model which has been under development under the sponsorship of the Nuclear Regulatory Commission since May of 1976 represents essentially a second generation model which has undergone a process of constant testing, redevelopment and improvement over previous modeling efforts, including the methodologies of other academicians and authorities in the field of econometric modeling.*/ Staff witness Chern, Tr. 11,234-11,238. During the development of the model on the order of approximately two hundred equations or specifications were tested. Staff witness Chern, Tr. 11,322-11,323. The model has undergone extensive peer review in a number of conferences and professional journals. Staff witness Chern, Tr. 11,237. In addition, the model has also undergone an extensive process of validation based upon historical data for the period 1955 to 1974 and tested against data for 1975 and 1976. Staff witness Chern, Tr. 11,302-11,308

458. The Commonwealth presented testimony critical of several aspects of the ORNL model by witnesses Chernick and Geller. Problems raised with the methodology included alleged

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*/ Including therein Commonwealth witness Dr. Hendrik Houthakker, with apologies for the misspelling of his name. Tr. 11,236, 11,265, 11,270.

improper modelling of average price per kwh, inadequate documentation of the model specifications chosen by ORNL, problems of estimation and interpretation of certain of the independent variables, and projections of total average electric cost that are too low. In addition, the witnesses felt that industrial price elasticities were far too low, conservation was inadequately treated and the energy forecast was improperly converted to a peak demand forecast. Commonwealth witnesses Chernick and Geller, pp. 5-14, Following Tr. 11,224. As with the criticisms which were raised with the NEPOOL Model, the Board finds it extremely difficult to examine and evaluate criticisms of this nature absent some quantification of the effect on the forecast or other characterization of the relative importance and significance of the alleged error.

459. One of the problems raised with the ORNL model, which the witnesses felt "called into question the validity of the entire industrial forecast" was the selection of industrial price elasticities for New England which were felt to be far too low. Commonwealth witnesses Chernick and Geller, p. 12, following Tr. 11,224. When asked on cross-examination by the Board for their basis for this criticism, the witnesses indicated that this was based upon their general knowledge of the literature in the field; however, they were not aware of any actual data relative to industrial

price elasticity in New England, Tr. 11,175-11,176. Dr. Chern was also cross-examined closely on this subject by the Commonwealth and the Board and, while recognizing that the value was low, Dr. Chern indicated that it was based on actual observed industrial response to the price of electricity and it was indeed the value he considered appropriate given the nature of the industrial sector in New England as compared to the rest of the nation and the high potential for interfuel substitution. Staff witness Chern, Tr. 11,265-11,274, 11,317-11,319.

460. The Commonwealth criticised the ORNL model for its asserted failure to adequately consider natural gas as a substitute fuel. Commonwealth witnesses Chernick and Geller, pp. 9-11, following Tr. 11,224. When questioned on the subject, Dr. Chern confirmed that, in fact, the model was tried using various natural gas variables; however, they were not found to be statistically signifcant. Staff witness Chern, Tr. 11,257.

461. Still another of the problems raised by the Commonwealth pertained to the fact that the ORNL model projected declining profit margins which were felt to be implausible. Commonwealth witnesses Chernick and Geller, p. 7, following Tr. 11,224. On cross-examination Dr. Chern agreed that profit margins did decline under the model; however,

he further pointed out that the model was not designed to determine profit margins. Staff witness Chern, Tr. 11,261.

462. None of the criticisms of the ORNL model raised by the Commonwealth witnesses were quantified. On cross-examination by the Board, Commonwealth witness Geller was asked for the effect of the problems she had raised on the model's peak load forecast for New England. She stated that in her opinion the equations in the model "don't make any sense" and "[b]asically the model isn't good" and she was unable to determine what correction would be appropriate to the forecast value. Tr. 11,165. Given the qualifications of Dr. Chern and the national reputation of the Oak Ridge National Laboratory and the extent of the development, testing and review of the ORNL model, the Board finds it difficult to accept such sweeping criticism without qualifications, documentation or elaboration.

463. The principal testimony concerning appropriate reserve levels was presented by Applicants' witness Arthur W. Barstow, who testified that, given the anticipated loads and capacities during the late 1980's, the appropriate reserve margin in order to maintain an adequate level of system reliablity was between 23% and 28%. Applicants' witness Barstow, pp. 10-14, following Tr. 10,430. On cross-examination, Mr. Barstow noted that the upper level

of 28% might possibly be lowered to 26% or 26.5% as a result of the deferral of the NEPCO units, although he did not expect any effect on the lower level of 23%. Tr. 11,410-11,412. The figure of 23% was therefore used as representing a minimum desired level of reserves both by the Applicants and the Staff. Applicants' witness Weiner, p. 9, Exh. NP-36, following Tr. 10,430; Staff witness Feld, p. 3, following Tr. 10,651.

464. Staff witness Dr. Sidney Feld independently evaluated the reasonableness of use of a 23% planning reserve margin by NEPOOL. Dr. Feld noted approvingly of the fact that NEPOOL used a one day in ten year loss of load calculation in deriving its figures. He also noted that the Federal Power Commission had recognized that such a calculation typically corresponded to a reserve margin of 15% to 25% and that the FPC further had recommended that five to ten percent additional should be added for purposes of long range planning in order to account for contingencies of potentially faster growth or unanticipated problems in bringing new units on line. Finally, Dr. Feld noted that the Staff only utilized the lower end of the range suggested by NEPOOL's studies with the result that he believed the use of a 23% reserve figure to be reasonable under the circumstances. Staff witness Feld, Tr. 10,511-10,514.

465. The intervenors cross-examined but presented no direct testimony concerning the projected required level of reserves.

466. On questioning by the Board, Mr. Barstow pointed out that the increased sophistication of loss of load probability calculations together with the different sizes and generation and reliability characteristics of newer units has caused the industry to move away from reserve requirements fixed simply as a percentage of the available capacity. Tr. 11,409-11,410. One of the principal factors identified affecting required reserves was the number, size and timing of new nuclear units, given the fact that large immature units tend to raise required reserves markedly. Tr. 11,392. The fact that beginning in 1983 and thereafter in close progression there were projected several new large nuclear units, indicated to the witness that there would be a significant impact on reserves. Tr. 11,392-11, 395, 11,411-11,412. The fact that NEPCO Units 1 and 2 were postponed would probably lower the upper range from 28% by one or two percentage points but would not affect the lower range. Tr. 11,394-11,412. The other significant factor identified by Mr. Barstow included the impact of the new NEPOOL Model-based forecast which tends to require a higher reserve margin than previous forecasts. Tr. 11,393, 11,395.

Part of the reason for this latter effect is the projected increase in load factor over the next decade, see Applicants' witness Bourcier, Exh. NP-33, following Tr. 10,430 and, as was noted by Dr. Feld, such an increasing load factor would have the effect of increasing the required reserve margin. Staff witness Feld, Tr. 10,647-10,648, 11,323-11,324.

467. The Board finds that both the NEPOOL model and the ORNL model are reasonable forecasting methodologies which appear to represent the state of the art in forecasting efforts: The Board takes particular note of the Commonwealth witnesses' inability to quantify the criticisms they have raised or to document and of their alternative formulations. While not finding that the witnesses are unqualified to offer criticisms of long range forecasting models, the Board nevertheless finds that both witnesses lack essential forecasting experience as well as the perspective which might be gained from actually preparing or defending a forecast instead of striving for an unrealistic level of ideological purity in forecasts prepared by others. The Board has thus placed significantly greater weight upon the testimony of Mr. Bourcier and the work of the NEPOOL Load Forecasting Task Force and the testimony of Dr. Chern and Dr. Feld and the work of the Oak Ridge National Laboratory. While

giving note to the criticisms by the Commonwealth with the methodologies, the Board is unable to accept on the record before us that the questions raised are as far reaching as suggested by Mr. Chernick and Ms. Geller.

468. The Board does not find it necessary to attempt to select between the NEPOOL end-use and the ORNL econometric models but instead finds that despite their essentially different formulations they are in actuality confirmatory of each other in establishing a reasonable projection of future electric energy and peak demand in New England.

469. The Board notes that neither the capacity projections nor the anticipated reserve margins were seriously contested by the intervenors and accepts the projections of those quantities presented by the Applicants.

470. Given the acknowledged delay in the NEPCO units and the prospect of further delays in other units, together with the prospect under several of the forecast scenarios of reserve levels dropping to under 10% in the late 1980's and further given NEPOOL and Staff projections which show reserve levels dropping to below minimum desired levels even before the scheduled in-service date, the Board finds, on the basis of reliability requirements of the NEPOOL system, that there is a need for power from a unit of the general size and type of Pilgrim Unit 2, and that

December, 1985 is a reasonable in-service date for the unit. In making this finding, the Board is fully cognizant of the fact that the probabilities of attaining a December, 1985 in-service date are vanishingly small, given the passage of time to date and yet to occur before these proceedings are completed and construction begun.

3. Economic Advantage of Early Installation

471. Even if growth in electricity demand over the next decade were such that Pilgrim 2 were not strictly required as presently scheduled in December, 1985 for reliability purposes, it may nevertheless be economic to install Pilgrim 2 as scheduled. As an alternative basis for the Board to conclude that Pilgrim 2 is appropriately scheduled to commence operation in December, 1985 both the Applicants and the Staff prepared analyses to demonstrate the economics of an early installation of Pilgrim 2 apart from reliability purposes. Applicants' witnesses Weiner and Legrow, pp. 3-4, 15-19, Exhs. NP-37, NP-39, NP-41, following Tr. 10,430; Staff witness Feld, pp. 10-22, following Tr. 10,651.

472. The Applicants' analysis consisted of a comparison of the costs of installation of Pilgrim 2 in 1985 as opposed to 1988 (actually year-end 1985 and 1988) for three different assumed load growths - 3.8%, 3.4% and 3.0%. The comparison included both capital cost and fuel cost effects resulting

from the two in-service dates. The annual differences in cost were then summed on a present worth basis using Boston Edison Company's marginal cost of money over the expected life of the unit to determine the savings which would result from an earlier installation. The capital cost effects begin with the differing capital costs of Pilgrim 2 depending upon the year in which it is installed to which is applied the annual capital recovery, income tax, property tax, investment tax credit and other carrying charges beginning with the respective in-service date and continuing over the life of the unit. The fuel cost effects result from the displacement of more expensive oil-fired generation and are derived using a computerized production costing program which simulates the loads, capacities and dispatching of the interconnected New England generating system. In performing the analysis a number of assumptions, including various estimates and forecasts of future costs, escalation rates and power plant performance characteristics were employed. Applicants' witnesses Weiner and Legrow, pp. 15-19, following Tr. 10,430.

473. Based upon this anslysis the installation of Pilgrim 2 in 1985 as opposed to 1988 is shown to result in approximately $1.4 billion worth of savings (1986 present value) over the life of the unit assuming a load growth rate of

3.8% as forecast by NEPOOL. Utilizing 3.4% load growth as forecast by the ORNL model "base case" the savings would amount to approximately $1.1 billion, while at 3.0% load growth the savings would be approximately $1.05 billion. Applicants' witnesses Weiner and Legrow, Exhs. NP-37, NP-39, NP-41, following Tr. 10,430.

474. Similar studies done by NEPOOL have consistently shown the same result -- that the early installation of nuclear base-load capacity, as would occur if such capacity were constructed based upon a projected high load growth which failed to materialize, results in substantial cost savings, where the system is far from its most economic generation mix, as is the case in New England. Those savings are largely attributable to the early installation of nuclear capacity which enables the substitution of nuclear-supplied energy for the more costly fossil-supplied energy. Applicants' witness Barstow, pp. 14-15 following Tr. 10,430, Tr. 11,414-11,415, 11,402-11,406.

475. The Staff's analysis of the economic benefits associated with the early installation of Pilgrim 2 was similar to that of the Applicants, although it was simplified in order to avoid the use of a production costing program and it employed a number of differing assumptions which led to different dollar figures for the resulting savings.

The key assumptions identified by the Staff included the projected nuclear capacity factor, the projected price of oil, the nuclear capital cost and the capital cost escalation rate. In addition the Staff performed sensitivity analyses for many of these key assumptions in order to determine the effect of various changes in assumptions. Staff witness Feld, pp. 10-12, following Tr. 10,651. The Staff's analysis showed total savings (1986 present worth) accruing to the operation of Pilgrim 2 in 1985 as opposed to 1988 of $148 million for its base case. Sensitivity studies in which key assumptions were varied showed total savings which varied from $34.8 million to $357.9 million with one case (out of the eight reported) showing no savings and a net cost of $130.7 million. Based upon these sensitivity studies the Staff concluded that an economic advantage will most likely occur with early construction but that the magnitude of the savings is highly uncertain. Staff witness Feld, p. 22, following Tr. 10,651.

476. As noted previously, the Staff identified the cost of oil, nuclear capacity factors, nuclear plant capital costs and capital cost escalation rates as the key assumptions in their analysis. Similarly, the Applicants' witness Legrow identified oil costs, followed by nuclear

capital costs and nuclear capacity factors as the key assumptions in the Applicants' anslysis. Applicants' witness Legrow, Tr. 10,786. The Commonwealth through cross-examination and through the testimony of witnesses Chernick and Geller presented a number of criticisms of these assumptions and others.

477. One of the key assumptions in the analysis of the economic benefits accruing to the early installation of Pilgrim Unit 2 relates to the projected future price of oil. Staff witness Feld, pp. 12, 16-17, 22, following Tr. 10,651.

478. Testimony concerning the projected future price of oil was presented by the Applicants consisting of a panel of witnesses from Arthur D. Little, Inc. (ADL). Their testimony described a series of oil price forecasts performed for Boston Edison Company. Applicants' witnesses Turner, Godley and Hanna, following Tr. 10,430. A Delphi technique was employed by ADL in its forecast in order to sound out the judgments and opinions of a panel of experts in order to arrive at a consensus view. Basically, the technique consisted of a series of questions and answers whereby the individual panelists, in this case a group of ADL staff oil experts located thorughout the world, were asked to record their views on future price levels as well as various factors deemed likely to affect price levels.

These responses were then coordinated and assembled into a consensus outlook. During subsequent rounds the panel participants were then exposed to the consensus views and permitted to alter their earlier responses if they deemed it appropriate. Applicants' witnesses Turner, Godley and Hanna, p. 8, following Tr. 10,430, Tr. 10,436-10,438.

479. The price of delivered fuel oil contains a number of elements including the acquisition of crude oil, transportation to refineries, refining, delivery and distribution as well as taxes and regulatory costs, however the dominant element (approximately 85%) is the cost of the crude oil. International crude oil prices are largely set based upon Arabian Light "marker crude oil." Since most fuel oil in New England is imported, Arabian Light marker crude was selected as the basis for the price forecast; to this was added projected refining, transportation and tax costs. Applicants' witnesses Turner, Godley and Hanna, pp. 3-5, following Tr. 10,430.

480. The price of international crude oil is largely politically determined and thus any projection contains a high degree of uncertainty. In addition, political developments in the Middle East, such as the recent Iranian revolution, have the capacity to cause disruptions in supplies and thus trigger dramatic upward revisions in prices. Discovery

of other non-OPEC supplies together with increased conservation and availability of alternative fuels will have a moderating impact on oil prices. The consensus view which developed was thus a series of sharp upward price movements triggered by supply disruptions or bottlenecks which would be followed by periods of consolidation in which there was little price movement outside of inflation. Applicants' witnesses Turner, Godley and Hanna, Panel 2, pp. 7-10, following Tr. 10,430.

481. The ADL Delphi forecast produced a reference case for delivered fuel oil of various types along with a plus and minus 70% and 95% confidence interval representing a range of uncertainty around the reference case. Selecting 1% Sulfer Residual the ADL reference case forecasts (in 1979 constant dollars) a price for 1980 of $3.06 per Million BTU, for 1985 of $4.29 per Million BTU, for 1990 of $5.03 per Million BTU and for 2000 of $6.15 per Million BTU. Applicants' witnesses Turner, Godley and Hanna, Panel 2, pp. 13-15, following Tr. 10,430.

482. Converting these figures to dollars per barrel in current dollars, using 6.287 Million BTU's per barrel, see, Staff witness Feld, p. 17, following Tr. 10,651, and assuming

6% general inflation, see Applicants' witness Legrow, Exh. NP-43, following Tr. 10,430, gives a per barrel cost of $20.39 in 1980, with the plus or minus 70% confidence interval range of $17.39 to $33.72. The corresponding cost in 1985 is $38.26 with a 70% confidence interval range of $27.91 to $47.53; the corresponding cost in 1990 is $60.03 with a 70% confidence interval range of $45.47 to $76.38; and the corresponding cost in 2000 is $131.44 with a 70% confidence interval range of $95.32 to $170.56.

483. Also presenting testimony on the projected future cost of oil was John G. Buckley on behalf of MOER. Mr. Buckley is a Vice President and Director of Northeast Petroleum Industries, Inc. He holds an undergraduate degree in Government and a Master's degree in Economics. He has had business responsibilities in the world crude oil market for over a decade. He currently serves as Chairman of the Fuel Oil Marketing Advisory Committee to the Department of Energy. MOER witness Buckley, p. 3, following Tr. 10,947.

484. Mr. Buckley on the basis of his training and experience was of the opinion that imported crude oil prices of about $22.50 per barrel would take place by the end of the summer of 1979 with inflation thereafter of 8-10% which would result in world prices of $37 to $40 per barrel by

1985 or 1986. The witness noted that this assumed no drastic real increases such as those experienced in 1979 and no supply interruptions. MOER witness Buckley, pp. 6-7, following Tr. 10,947.

485. Mr. Buckley further commented upon the price projections produced by ADL to the effect that those price projections were conservative and that their reference case should be advanced at least four years to recognize those developments. MOER witness Buckley, pp. 8-9, following Tr. 10,947.

486. Although some confusion developed as a result of cross-examination which attempted to elicit from Mr. Buckley and th ADL witness who had the higher forecast (MOER witness Buckley, Tr. 10,373-10,376; Applicants' witnesses Turner, Godley and Hanna, Tr. 10,448-10,449, 10,456-10,457), both the Applicants' witnesses and Mr. Buckley appear to agree on the approximate current dollar price for imported crude oil in 1985 of nearly $40 per barrel. Further, they appear to be by and large in agreement over the large effect of political instability in the Middle East region. Applicants' witnesses Turner, Godley and Hanna, pp. 5-8, following Tr. 10,430; MOER witness Buckley, pp. 4-7, following Tr. 947, Tr. 10,403-10,405.

487. The Staff utilized in its analysis oil price estimates prepared by the U.S. Department of Energy. The DOE estimates

were contained in an as-yet-unpublished annual report for 1978 and were expressed in 1978 dollars. The Staff then escalated these estimates at 5% per year to account for general inflation and to obtain estimates for 1985 and 1990 in current dollars. The DOE estimate included a low, medium and high range. In 1985 the medium range price for delivered residual was $22.70 per barrel and in 1990 the medium range price was $35.00 per barrel. Staff witness Feld, pp. 16-17, following Tr. 10,651.

488. Dr. Feld acknowledge on cross-examination that the DOE forecast used by the Staff considerably understates the future price of oil. He testified that the DOE forecast was prepared before the Iranian situation and is already far too low given that in 1979 there exists a $22 per barrel price in 1979 dollars while the forecast shows that price in current dollars not being reached until 1985. Staff witness Feld, Tr. 10,616-10,617.

489. The Staff performed sensitivity studies to determine the effect of a change in the forecasted future price of oil on the economics of an early installation of Pilgrim 2. These sensitivity studies showed that, as compared to base case savings of $148.1 million using the reference case with the DOE medium price forecast, use of the DOE low price forecast produced lesser savings in the amount

of $115.1 million and use of the high price forecast produced savings of $357.9 million. The DOE high projection showed residual oil prices of $32.10 per barrel in 1985 (in 1985 dollars and $44.21 per barrel in 1990 (in 1990 dollars). Staff witness Feld, pp. 17, 22, following Tr. 10,651.

490. Of the three oil price forecasts presented (i.e., by ADL, DOE and MOER witness Buckley) all predict significant oil price increases in the years to come. The lowest of the three is the DOE forecast, however this predated many of the most recent developments and was acknowledged to be too low. Even the DOE forecast, including the "low" version thereof, however, is high enough to show substantial savings resulting from the early installation of Pilgrim 2. The higher the forecasted oil price, the higher the projected net savings. Of the other two forecasts there are significantly different assumptions as to inflation and "real" price effects as well as in the selection of a particular grade of crude oil as opposed to an overall mix of crudes. Despite the differences however, both forecasts are sufficient to support a finding that the price of oil in the mid to late 1980's will be even higher than that utilized in the Staff's analysis and that the price of oil used in the Applicants' analysis is reasonable.

491. Another key assumption employed in the economic analyses of both the Applicants and the Staff is the projected Pilgrim Unit 2 capacity factor.

492. The Applicants' analysis assumed that the Pilgrim Unit 2 capacity factor would be 59% in the first year of operation and undergo a maturation process whereby the capacity factor increased to 70% by the sixth year of operation. Applicants' witness Legrow, Exh. NP-43, following Tr. 10,430. The use of this capacity factor assumption was based upon an analysis of the operation of previously built nuclear units. Applicants' witness Legrow. Tr. 10,785-10,786.

493. The Staff in its analysis utilized an assumption of a 60% average annual capacity factor. In its sensitivity analysis the Staff also used capacity factors of 50% and 70% which it felt reasonably bracketed the expected capacity factor of the unit in its early years. Staff witness Feld, p. 16, following Tr. 10,651.

494. On cross-examination Dr. Feld defended the choice of 60% as a capacity factor. Typically, the NRC has used a range of either 55% to 75% or 50% to 70% in making its comparisons. In addition, two recent reports were referred to as providing support - one by R. G. Easterling of Sandia Laboratories, NUREG/CR-0382, projects an average

capacity factor of 57% plus or minus 8% at the 95% confidence level, and the other being a study by Komanoff entitled Nuclear Plant Performance Update No. 2 dated June of 1978 which projects a capacity factor of 58.9% with an uncertainty in the range of 6% or 7%. Staff witness Feld, Tr. 10,562-10,565.

495. In further discussion of the Komanoff report, Dr. Feld admitted that Komanoff's methods had been subject to criticism for some of the statistical and sampling techniques employed (Tr. 10,565) and that the report was, in any event, not something which he came across until after he had performed his own analysis of capacity factors. Tr. 10,569.

496. Considerable testimony concerning nuclear capacity factors was also presented in connection with consideration of the subject of alternative energy sources prior to reopening the record on need for power in the proceeding. Commonwealth witness Boxer presented testimony at that time concerning two earlier studies by Komanoff including Power Plant Performance, dated November, 1976 and the first update of that study entitled Nuclear Plant Performance dated March, 1977 (Commonwealth witness Boxer, p. 2, following Tr. 8587), whereas Dr. Feld's testimoney dealt with a second update which presumably enabled the study to include still further years of reactor

operation. In any event, the 1978 update testified to by Dr. Feld produced an expected capacity factor some ten percentage points higher than the estimate presented by Ms. Boxer. Staff witness Feld, Tr. 10,563; Commonwealth witness Boxer, p. 9, following Tr. 8587.

497. Sensitivity analyses performed by the Staff show that variation of the assumed capacity factor from 60% to 50% reduces the expected net savings from the early installation of Pilgrim 2 from $148.1 million to $82.2 million. Variation of the assumed capacity factor to 70% would increase the net savings to $213.9 million. Staff witness Feld, p. 22, following Tr. 10,651. The Applicants' analysis would also be sensitive to capacity factor variation, principally in the fuel savings component; however, such sensitivity would be less than the other factors such as expected fuel cost and capital costs. Applicants' witness Legrow, Tr. 10,786.

498. A further key assumption utilized in both the Applicants' and the Staff's analyses was the assumed cost of Pilgrim 2 in December, 1985 and the assumed cost of the plant if it were delayed to December, 1988.

499. The Applicants utilized an assumed cost of the plant of $1.895 billion for the 1985 completion date and $2.550 billion for the 1988 completion date. Applicants' witness Legrow, Exh. NP-43, following Tr. 10,430; see also Amendment No. 9 to the License Application [General and Financial], Applicants' Exh. 1-00, p. V-1, Tr. 9601. The selection of the 1985 figure was based upon detailed cost engineering studies while the 1988 figure utilizes the same study and implies an escalation rate of 9.7% per annum. Staff witness Feld, pp. 19-20, following Tr. 10,651.

500. The Staff utilized for its reference case an assumed cost of the plant of $1.310 billion in 1985 and $1.611 billion or 1988 based upon the CONCEPT computer program. The CONCEPT program provides a detailed cost estimate based upon the input of plant type, location, net capacity, beginning construction date, beginning operation date and rate of interest during construction utilizing cost index data to which the program has access. Staff witness Feld, pp. 18-19, following Tr. 10,651.

501. Dr. Feld acknowledged that the costs produced by the CONCEPT program were significantly lower than Applicants' estimates, and that Applicants' estimates should, in fact, reflect the construction cost more accurately than

the CONCEPT estimates, and thus the Staff also re-performed its analysis using Applicants' capital cost estimate. In addition, the Staff also varied the escalation rate employed in determining the 1988 plant cost from the 1985 plant cost, using a low escalation rate of 5%, a moderate escalation rate of 7.1% and a high escalation rate of 9.7%. As compared to $148.1 million in savings in the reference case using the CONCEPT cost estimate, the result of using the Applicants' estimate with moderate escalation was $130.7 million in costs (i.e., for this case it would be more costly to install Pilgrim 2 in 1985 than it would be to wait until 1988) and with high escalation was $246.9 million in savings. Staff Witness Feld, pp. 19, 22, following Tr. 10,651.

502. On cross-examination Dr. Feld noted that the higher the rate of capital cost escalation, the more advantageous it would be to bring the plant on line at an earlier date and from this perspective the choice of 7.1% as a moderate escalation rate was in fact conservative. The witness also agreed that recent industry experience has been in excess of the 7.1% figure. Staff witness Feld, Tr. 10,547-10,548.

503 Commonwealth witnesses Chernick and Geller made two criticisms of the Applicants' capital cost estimate for Pilgrim 2. The first criticism was that the Applicants' architect-engineer failed to multiply its detailed capital cost estimate by a factor of from 2.0 to 2.6 to correct for its "tendency to underestimate." The witnesses discern this "tendency" from their analysis of one previous Bechtel estimate. Commonwealth witnesses Chernick and Geller, pp. 55-56, following Tr. 11,224. The witnesses offered no testimony or other evidence that the one case they cited was typical or would afford any basis for generalization. The witnesses' testimony contains no analysis of the Pilgrim 2 cost estimate at all which would indicate what elements were too low or were overlooked. The witnesses indicated that their conclusion was supported by a study which they cite by one W. E. Mooz which utilizes regression equations based on past trends. Id. Again, the study itself was not produced or offered and the witnesses did not explain either the trends or the equations relied upon; or, more fundamentally, why a methodology of using regression equations to estimate the capital cost of a plant is superior to an engineering cost estimate. The witnesses' second criticism was that there may be additional capital costs after the plant has gone into service which certain "past analyses" by

Boston Edison Company have failed to capture. The witnesses support this observation by stating that Pilgrim 1 has had increases in capital cost amounting to 1-2% per year since it went on line. Id. The witnesses do not identify the past analyses to which they refer nor do they indicate the basis for the apparent conclusion that this trend would occur, or the extent to which it would occur for Pilgrim 2.

504. The Commonwealth also criticized the Applicants' economic analysis insofar as it felt that operation and maintenance (O & M) costs were improperly handled. Commonwealth witnesses Chernick and Geller, pp. 57-59, following Tr. 11,224. The witnesses candidly admitted, however, that they couldn't tell what O & M costs were used in the Applicants' case nor how they were determined and thus they chose to criticize the manner in which O & M was determined in another case. On cross-examination Mr. Chernick indicated that he had done no sensitivity analysis to determine to what extent variations in O & M cost would even affect the results of the Applicants' economic analysis. Tr. 11,072-11,073. In fact, since the Applicants' economic analysis was a comparison between two in-service dates for Pilgrim 2, three years apart, the assumed O & M costs would, in fact, be a wash for all

but the first three years of the comparison and even they would tend to be offset by fossil O & M costs which were displaced, and thus O & M costs play no role in the analysis. Applicants' witness Legrow, Tr. 10,791-10,792. The staff's analysis did include O & M costs for the interim period utilizing projections derived from the OMCST computer code, Staff witness Feld, pp. 20-21, following Tr. 10,651, Tr. 11,320-11,321; however, this component is not a deciding factor in any of the analyses. Staff witness Feld, p. 22, following Tr. 10,651.

505. The economic analyses of both the Applicants and the Staff involved a comparison of a stream of benefits and costs received over a series of years. In making such an analysis if was necessary to "present worth" or discount these figures utilizing a discount rate. For this purpose the Applicants utilized Boston Edison's discount rate of 10.83%, Applicants' witness Legrow, Tr. 10,790, while the Staff used a utility discount rate of 10%. Staff witness Feld, p. 21, following Tr. 10,651. While the Commonwealth criticised the employment of a utility rate rather than a ratepayers rate the challenge is deemed academic by the Staff since the differences between using different discount rates would be very subtle or technical in nature and in any event would not alter the underlying conclusions of the analysis. Tr. 10,552,

11,334-11,337. This conclusion was agreed to by Applicants' witness Legrow, who further observed that changing the discount rate which was used would not vary the result of the analysis showing the economic benefit of an early installation of Pilgrim 2. Applicants' witness Legrow, Tr. 10,790-10,791.

506 The Commonwealth also criticized the use of the cost of capital of Boston Edison and the AFUDC rate assumed in the Applicants' analysis. Commonwealth witnesses Chernick and Geller, pp. 51-52, following Tr. 4,224. Aside from the ideological purity which would be achieved by such a refinement, the witnesses failed to indicate how sizeable an adjustment in discount rate would be caused thereby if any, or whether such adjustment would even affect the results of the analysis in which the "unrefined" figure was used. The other criticism, was that the estimation by Boston Edison its own cost of capital as well as its own AFUDC rates was too low. Commonwealth witnesses Chernick and Geller, p. 53, following Tr. 11,224. It is also not clear to what extent the Commonwealth feels these figures are too low or the effect of making such an adjustment on any of the analyses presented in the Applicants' direct case. Tr. 10,956-10,957.

507. The Commonwealth further suggests that only a "regional cost-benefit analysis" can evaluate the total impact of Pilgrim 2 on New England. Commonwealth witnesses Chernick and Geller, p. 54, following Tr. 11,224. Cited approvingly as such a study is the "NEEPA Study"*/ which purportedly concluded that "New England would be better off with fewer nuclear plants and more conservation." Id. The Commonwealth witnesses also quoted approvingly from the study elsewhere in their testimony where they indicated that the study supported "not building or delaying an additional nuclear plant in the region by 1985." Commonwealth witnesses Chernick and Geller, pp. 48-49, following Tr. 11,224. When confronted with the conclusion that the report was not in conflict or inconsistent with the current construction schedule of nuclear plants in New England by 1985, Mr. Chernick opined that the NEEPA report was in error. Tr. 11,137.

508. The Commonwealth offered one final area of criticism of the Applicants' economic analysis in a section entitled "NEPOOL NEED VS. BOSTON EDISON NEED," wherein it states that the Applicants' case fails to address Boston Edison

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*/ New England Energy Policy Alternatives Study (NEEPA-1), October, 1978, Commonwealth Exh. 110, admitted for limited purposes, Tr. 10,708.

Company's need for power and instead focuses upon NEPOOL's need. Commonwealth witnesses Chernick and Geller, p. 60, following Tr. 11,224. This is, of course, precisely the point which both the Applicants and the Staff stated at the outset of their respective cases -- that the need for Pilgrim 2 was in order to assure adequate reliability levels in New England and to provide benefits to New England electricity consumers. Applicants' witness Weiner, p. 3 following Tr. 10,430; Staff witness Feld, p. 1, following Tr. 10,651. Since, as all the parties apparently agree, NEPOOL is a highly integrated and interconnected system which is dispatched on a single system basis and since all the power will go into that system it is appropriate to examine the need for the unit from the perspective of the system instead of from each individual joint owner's viewpoint. If such need is established from a system viewpoint, then it is of significantly less importance that participant A might have too much and participant B too little since they are both a part of the same system. Staff witness Feld, Tr. 10,636, 10,642-10,655.

4. Displacement of Imported Oil.

509. Aside from the economic benefits resulting from the early installation of Pilgrim 2, such installation is also highly desirable from the standpoint of reducing national dependence on imported oil and furthering state, regional and national energy policies and goals. Applicants' witness Weiner, pp. 3, 19-24, following Tr. 10,430, Staff witness Feld, pp. 22-23, following Tr. 10,651; MOER witness Fitzpatrick, pp. 2-9, following Tr. 10,947.

510. Presently, the United States imports nearly 45% of the oil consumed in this country. This represents a substantial increase even since the 1973-74 oil embargo and current trends indicate that this demand will continue to increase without strong action to reduce demand. This imported oil is not only extremely expensive, and increasingly so, but it is also an extremely unreliable and insecure source of energy. This imported oil is also a tremendous drain on the United States' international balance of payments. National energy policy, as expressed in the National Energy Plan in 1977, the Powerplant and Industrial Fuel Use Act of 1978 and other statements of national policy unequivocally demands that all steps possible be taken to reduce the nation's dependency on oil. Applicants' witness Weiner, pp. 19-24, following Tr. 10,430; MOER witness Fitzpatrick, MOER Exh. 1, pp. 2-5 following Tr. 10,947.

511. The most recent Presidential expression of national policy on the subject of imported oil not only underscored the importance of reducing the nation's oil dependency but particularly emphasized the role of electric utilities in reducing such demand by calling for a 50% reduction by utilities from present oil use by 1990. Congressional Record-House, H. 5924, July 16, 1979.

512. On a state and regional level, the Commonwealth of Massachusetts and New England are even more precariously dependent on imported oil than is the national as a whole with over 84% of the region's oil being imported in 1977. In addition New England is particularly dependent upon petroleum as its source of energy. Thus, not only does New England bear a disproportionate burden of the cost of imported oil; it also bears a disproportionate burden of the risk resulting from an interruption of supplies. MOER witness Fitzpatrick, pp. 4-5, following Tr. 10,947; Applicants' witness Weiner, pp. 23-24, following Tr. 10,430.

513. The installation of Pilgrim 2 will make a significant contribution to the goal of reducing the nation's and the region's oil dependency. Such contribution is in two parts - first, in that it prevents increased dependency as would be the case if future load growth were met through additional oil-fired capacity; second, in that it represents savings resulting from the displacement of existing oil-fired capacity. Applicants' witness Weiner, pp. 21, 24, following Tr. 10,430; MOER witness Fitzpatrick, p. 7, following Tr. 10,947.

514. Analyses were presented by both the Applicants and the Staff of the resultant oil savings comparing a 1985 and 1988 in-service date for Pilgrim 2. The Applicants' analysis showed approximate oil savings of 35 million barrels accruing to the early installation of Pilgrim 2, virtually independent of assumed load growth. Applicants' witness Weiner, Exhs. NP-38, NP-40, NP-42, following Tr. 10,430. The Staff's analysis concurred in a figure of approximately 30 million barrels of oil saved from the three year earlier installation of Pilgrim 2; almost all of this oil would represent a reduction in imported oil and a direct contribution to the United States balance of payments. Staff witness Feld, pp. 22-23, following Tr. 10,651.

515. Mr. Fitzpatrick also presented an analysis prepared by his staff evaluating overall oil savings from the installation of Pilgrim 2. Assuming that the energy produced by Pilgrim 2 over its lifetime would otherwise be produced by existing oil-fired generation and using Mr. Buckley's basic oil price data projected to account for inflation, the analysis revealed that Pilgrim 2 would produce oil savings of from 8 to 19 billion dollars with the range in results depending upon choice of inflation and discount rate. MOER witness Fitzpatrick, pp. 8-9, following Tr. 10,947. Mr. Fitzpatrick concluded that these figures were "an indication of the impact this single facility could have in the national effort to reduce expensive foreign oil imports." Id.

516 . The Commonwealth offered one criticism of the displacement of oil generation by nuclear generation. Commonwealth witness Chernick and Geller, pp. 46-49, following Tr. 11,224. While admitting the essential point, i.e., that Pilgrim 2 would displace oil, the Commonwealth argued that there are also other assertedly more cost-effective ways of displacing oil. Mr. Chernick misconstrues the substitution portion of the Applicants' case. As was pointed out on numerous occasions, the economic analysis presented by the Applicants was designed only to compare the installation of Pilgrim 2 on two alternative in-service dates and to show that even with some reasonable variation in projected load growth rates, it was cost effective to install Pilgrim 2 at the earliest possible date. Applicants' witnesses Weiner and Legrow, pp. 15-17, following Tr. 10,430. Likewise with substitution. The substitution portion of the Applicants' case is advanced not to support the need for the plant in the first instance but to support its early rather than later installation. Within the context of this analysis, Mr. Chernick's criticisms are completely irrelevant since, ex hypothesi, they reintroduce the further alternative; i.e., the non-installation of Pilgrim at any time, which contention has already been addressed.

517 . As was suggested by MOER Director, Joseph Fitzpatrick, the implementation of conservation and the construction of additional nuclear generation are not in opposition at all and indeed represent the energy policy of the Commonwealth of Massachusetts.

MOER witness Fitzpatrick, Tr. 10,694-10,696. Thus the Executive Department of the Commonwealth of Massachusetts supports both conservation and the implementation of Pilgrim 2 as parts of the strategy to reduce oil dependency. Fitzpatrick, p. 7, following Tr. 10,947, Tr. 10,695-10,696.

5. Conclusions

518. As noted previously the Board finds that the forecasts presented by the Applicants and the Staff establish a reasonable basis for concluding that Pilgrim 2 will be needed in the time period following December of 1985. The Board recognizes that there can be no guarantees in forecasting the future. We cannot seek proof in assessing forecasts, only prudence. There are necessarily factors of uncertainty in forecasts of peak and energy loads more than five years into the future. We are not unmindful of the problems raised by the Commonwealth, particularly through witnesses Chernick and Geller, however, we are unable to find that they are of the import claimed by them. We find further assurance in making such finding from their own inability to quantify their criticisms. Similarly we are not unmindful of the possibilities suggested by the Commonwealth of greater conservation, changes in rate structures and the like. These possible events could limit growth to a degree greater than recognized in the detailed forecasts of the Staff and the Applicants. The record, however, does not demonstrate that there are any reasonably foreseeable or existing conditions that have not been reflected in the forecasts before us. We are unable and unwilling to modify the conclusions of these

forecasts on the basis of conditions the existence of which is uncertain and the effectiveness of which, if initiated, is open to substantial conjecture.

519. The Board is afforded further assurance of the correctness of its finding that there is a need for Pilgrim 2 as of December 1985 from the economic analyses presented by both the Applicants and the Staff which establish that Pilgrim 2 will be cost effective even if on line at an early date. While the Board will not try to debate each and every estimate or assumption employed in these analyses, the Board finds that the analyses were as a whole performed in a reasonable manner and utilized reasonable assumptions. The fact that the Staff employed sensitivity analysis in order to determine the effect of varying certain of these assumptions, gives us further confidence in the correctness of their overall conclusion that there would be such economic benefits.

520. The Board finds also that the unit is needed from the standpoint of displacing imported oil. We find that New England is presently heavily dependent upon imported oil for electric generation. We note that even with projected new nuclear capacity at Seabrook, Millstone and Pilgrim and new coal capacity at Sears Island, over the next decade New England will still rely heavily on oil because so many of the existing units are oil-fired. Bringing Pilgrim 2 on line will directly and significantly affect the amount of imported oil used in New England for electric generation purposes. The Board notes the existence of strong national and regional and state policies calling for the reduction in dependence on imported oil and the Board finds that the

installation of Pilgrim 2 will contribute to the implementation of those policies.

521. Based upon the foregoing the Board concludes that there is a need for Pilgrim 2 and that the current schedule for Pilgrim 2 reflects prudent planning in light of the load forecasts presented and the need to maintain an adequate level of electric system reliability, in light of the need to reduce New England's dependence on imported oil and further in light of the economic benefits that stand to be realized from bringing Pilgrim 2 into service on the planned schedule.

I. Alternative Energy Sources

522. In its Memorandum and Order of February 18, 1975, the Board admitted several issues raised by intervenors on the question of alternative energy sources. On a motion of the Commonwealth of September 25, 1975, Commonwealth Contention 3 was amended to include solid wastes. Tr. 832. The contentions admitted are as follows:

> Commonwealth Contention 3 (as amended)
>
> The Applicants and the Staff have not given adequate or accurate consideration to solar power, wind power, the use of fossil fuels, the use of fuel derived from solid waste resource recovery, or the high temperature gas-cooled reactor as alternative sources of power.
>
> Ford Contention N
>
> The Applicants have not adequately considered alternatives to the facility and therefore are not in compliance with 10 CFR §51.20(a)(3).
>
> Cleeton Contention I
>
> Applicants have not adequately considered alternate sources of power in that they have not considered: methods of thermonuclear fusion; wind power; solar energy; utilization of ocean temperature differences; gasification of coal; production of low sulfur oil from garbage; animal waste and coal; or cultivation of high energy algae for conversion to methane or for direct power plant combustion.

523. In an initial presentation during the October 1975 hearings, the Applicants presented testimony on alternative sources

of energy through a panel of twelve witnesses*/. Following Tr. 955.

524. 1. Fossil Fuels

NEPOOL, acting by its Management Committee, reviews the need for, and recommends additions to and changes in, generation and transmission facilities for its members. The Executive Committee considers the reports of the NEPOOL Planning Committee, which with a full-time professional staff (NEPLAN), provides analysis and advice to the Executive Committee to make determinations of the most economical, effective, practical, and productive mix of generation to meet present and future New England base load, peak load and energy demands. The Planning Committee has Generation, Transmission, Stability, and System Design Task Forces which, with the NEPLAN staff and the NEPOOL Environmental Subcommittee, perform the studies and evaluations of alternative plans for generation and transmission expansion which are presented to the Executive Committee for review and final approval.

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*/ Kenneth O. Sten, Manager, Research and Planning Department, Boston Edison Company; (BECO);Benjamin H. Weiner, Vice President, Power Supply Administration, BECo; Robert M. Butler, Manager, Nuclear Projects Department, BECo; Russell J. Maroni, Manager, Planning and Cost Control, Nuclear Projects Department, BECo; Theodore P. Heuchling, Vice President, Arthur D. Little, Inc. (ADL); Sidney M. Stoller, President, S.M. Stoller Corporation; Nigel Godley, Manager, Energy Economics Section, ADL; Donald W. Smith, Senior Staff Member, Management Consulting Section, ADL; Abraham Gerber, Vice President, National Economic Research Associates; William M. Irving, Vice President, Research and Environmental Affairs, BECo; David C. White, MIT, Energy Laboratory.

ER at 1-2; Applicants' Witnesses Weiner, p. 105 and Sten, pp. 108-109, following Tr. 2647; and Applicants' Witness Bigelow, pp. 7-8, following Tr. 7929.

525. The underlying study for New England generation expansion planning is the Interconnected New England Generation Study, Generation Task Force No. 4 which recommended a nuclear base load expansion strategy for New England for the stated reason that large nuclear base load units are the more economic given due consideration to reliability, and to meeting environmental concerns. ER at 1-15 and 1-21; Applicants' Witness Sten, p. 109, following Tr. 2647; and Applicants' Witness Bigelow, pp. 9-12, following Tr. 7927.

526. NEPOOL has concluded that, of the choices of coal, oil and nuclear power considered available for base load generation in New England, nuclear capacity should be expanded to 52% to 57% of total NEPOOL capacity to be consistent with NEPOOL long-term objectives of providing the most economical, reliable and environmentally compatible system. NEPOOL expects that, in the long term, nuclear units can achieve capacity factors of about 75%. However, economics favor nuclear unit operation even if operated at a 50% capacity factor. At a 75% capacity factor, Pilgrim 2 will save annually 14,700,000 barrels of oil

(or $256,000,000), or 3,300,000 tons of coal (or $193,000,000). Applicants' witness Sten, pp. 18-19, following Tr. 955, p. 109, following Tr. 2647; Applicants' Witness Bigelow, p. 8-10, following Tr. 7929. While the foregoing figures were reflected in the record developed in 1975 and 1977, NEPOOL continues to maintain the goal of achieving an economic generation mix of approximately 60% nuclear base load capacity Applicants' witness Barstow, Tr. 11,402, 11,403. In addition, given the meteoric rise in oil prices, more recent testimony reflects that over its lifetime Pilgrim 2 will save from $8 to $19 billion in oil costs. MOER witness Fitzpatrick, pp. 8-9, following Tr. 10,947.

527. In light of NEPOOL generation expansion plans and Boston Edison's own system capacity needs, Boston Edison offered to sponsor a base load unit sized to meet its and NEPOOL's needs through joint ownership arrangements and unit contract sales to other companies. Studies undertaken by Boston Edison, independently of NEPOOL, with respect to the relative economics of nuclear and fossil generation, based on total generating costs, customer revenue requirements and load demand, indicated that the unit to be built should be a nominal 1100 MW light-water reactor. Thereafter, Boston Edison proceeded with contractual undertakings to construct Pilgrim 2. From 1972 to 1974, studies were conducted of

plant and fuel costs and schedule factors with results confirming the nuclear alternative as preferable to oil. In 1975, a study was undertaken by Arthur D. Little, Inc. (ADL) for Boston Edison as a result of substantial escalation in the expected capital costs of Pilgrim Unit 2 and the emergence of coal as the more likely base load alternative due to the Arab oil embargo and the resultant increase in the price of oil. Applicants' witness Butler, pp. 23-26, following Tr. 955.

528. The ADL study concluded that oil must be considered a marginal source for base load power due to resource constraints, price levels and federal regulations. On the other hand, coal and uranium were determined to be available in sufficient supply to meet the base load requirements for a unit of the size of Pilgrim 2. Mr. Heuchling, Vice President of ADL, testifying as to the results of the study, concluded that, based on "reasonably likely combinations" of capital cost, capacity factors and fuel costs, power from Pilgrim 2 will be produced in the 1985 to 1990 time-frame at annual costs in the order of $50 to $100 million less than power from an equivalent coal-fired plant, and that this margin was expected to increase at a moderate rate throughout the life of the plant. Reliability or regulatory constraints would have to reduce the nuclear plant capacity factor to 40 to 50 percent before the costs of Pilgrim 2 plus make-up

power from existing oil-fired plants in the Boston Edison system would become as costly as an equivalent coal-fuel plant operating at a 70 percent capacity factor. Applicants' witness Heuchling, pp. 29-30, following Tr. 955.

529. In its FES for Pilgrim 2, the Staff reported that its economic analysis concluded that Pilgrim 2 had an estimated $200 million advantage compared to coal and oil over the life of the plant. The significantly lower generating costs favor the selection of a nuclear plant. FES, pp. 9-4 through 9-7, following Tr. 897.

530. The Staff also presented supplemental testimony on fossil fuel alternatives to Pilgrim 2 including natural gas, oil and coal. Staff witness Vetrano, following Tr. 1409.

531. Noting that natural gas reserves are limited and that rising costs and foreign dependence make oil less attractive as an option, the Staff analyzed more fully the coal alternative in light of its independence from foreign influences, abundance of reserves and the advanced state of extraction and utilization technology. Staff witness Vetrano, pp. 15-16, following Tr. 1409.

532. Using the CONCEPT computer code, the Staff estimated the capital costs for an 1180 MW(e) PWR and an equivalent coal-fired plant for 1982 service. Fuel costs and operation and maintenance costs were separately estimated. The Staff

concluded that the nuclear unit is the least expensive alternative when capital costs are amortized with equivalent assumptions of plant load factors; that the difference between the nuclear and coal alternative was such that even at a 50% capacity factor, the nuclear option has a lower total generating cost than a coal plant operating at a 70% capacity factor; and that a nuclear unit operating at a 60% load factor would have a lower total cost than a coal plant at any load factor. The computer code analysis indicated that even if the coal plant were operated at an 80% capacity factor, the nuclear plant would be competitive at a 50% capacity factor. Staff witness Vetrano, pp. 20-23, following Tr. 1490; Tr. 1477.

533. Due to the deferral of Pilgrim 2 from 1982 to 1984 and the lapse of time following its initial presentation of evidence of coal and nuclear costs, the Applicants presented testimony of a further panel of six witnesses to reflect the increased costs for both the coal and nuclear option, interim changes in plant design and new financial

accounting methods.*/ Applicants' Supplemental Direct Testimony on the Cost of Pilgrim 2 and Alternate Sources of Power, following Tr. 8207.

534. The Applicants introduced testimony drawing from a report prepared by Bechtel Corporation for the Electric Power Research Institute (EPRI) which examined the costs of 1000 MW coal plants (consisting of two 500 MW units) in four regions of the United States. The computed cost of one of these plants, hypothetically located in Bethelehem, Pennsylvania, was adjusted to reflect the construction and operation of two 590 MW units at Boston Edison's Edgar Station. Coal and transportation costs were determined by ADL. The generation cost of power from the coal plant and Pilgrim 2 were calculated for 1988 to reflect mature plant operation. Capacity factors were assumed to be 70 percent in each case. The total generating costs for Pilgrim 2 were calculated to be 50.2 mills/kwh with the total generating costs for the two 590 MW coal-fired units at 68.1 mills/kwh. The resulting 17.1 mills/kwh difference is equivalent to a nuclear advantage of $130 million over coal in 1988. Applicants' witness Maroni, pp. 6-7, following Tr. 8207.

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*/ Russell J. Maroni, Manager, Planning and Cost Control, Nuclear Projects Department, Boston Edison Company (BECo); Max G. Madsen, Jr., Pilgrim 2 Project Cost Engineer, Bechtel Power Corporation; Steve J. Poulos, Principal, Geotechnical Engineers, Inc.; James A. Seery, Head, Nuclear Fuel Division, BECo; William Dunlop, Manager of Services, Bechtel Power Corporation; Donald R. Gibbons, Senior Staff Member, Chemical Management Consulting Section, Arthur D. Little.

535. The Staff similarly performed an updated review of alternatives to nuclear power found in the FES and the earlier testimony of Vetrano. It reaffirmed its earlier judgement that the nuclear option was substantially less costly than the coal option. The Staff concluded that under the more likely case, Pilgrim 2 is expected to generate power at 53 mills/kwh on a levelized basis with 68.7 mills/kwh for the coal-fired alternative. Staff witnesses Nash and Feld, p. 25, following Tr. 8304.

536. The Commonwealth presented the testimony of three witnesses relating to the economics of nuclear generation vis a vis the coal option. The testimony of the first of these witnesses, Henry Lee, Director of the Massachusetts Energy Policy Office, consisted of a report by the Energy Policy Office entitled, "The Economics of Nuclear Power: A New England Perspective," dated December 1975. Lee Report, following Tr. 4962.

537. The Lee Report was compiled by "exploring all of the secondary sources and talking to a wide variety of individuals who were familiar with the nuclear question" Tr. 5016. Mr. Lee stated that "we analyzed a wide variety of secondary sources and verbal comments and made what we felt was a best judgment." Tr. 5017.

538. The Report first of all declares that "it is evident that additional capacity will be required within the next ten years, and that shall be the assumption of this report." Lee Report, p. 7, following Tr. 4962. Narrowing the choice of additional capacity to coal or nuclear the Report concludes that the decision rests with plant reliability, which the experience of the next five to 10 years should answer. The Report acknowledges that, "because of long lead times we cannot wait five to ten years to decide between a coal or nuclear plant that must be completed in the mid-1980's. While observing that, "(o)nly West Virginia, Kentucky and mid-Western states with access to inexpensive strip-mined coal or abundant hydroelectric power are not planning nuclear plants" and that, "(a)ll except two states east of the Mississippi have nuclear plants planned, under construction or operating," the Report nevertheless cautions that, "(u)tility executives...have been known to make mistakes in power planning..." Lee Report, p. 36, following Tr. 4962.

539. The Report concludes, "(o)ur most likely estimates indicate that coal and nuclear plants will be competitive in the 1980's. The critical variable in this comparison is the reliability of both types of plants. If coal plants achieve the reliability we have used in this analysis (75%), they will be competitive with nuclear plants. If their reliability worsens, they will lose competitiveness. If the relia-

bility of nuclear plants does not improve, there will be a slight cost advantage to coal plants. If the reliability of nuclear plants does improve, there may be a slight cost advantage to nuclear." Lee Report, p. 37, following Tr. 4962.

540. As we read the Lee Report, it appears that only if one assumes the best case for coal, as does the Report, with respect to capital costs, fuel costs and reliability; and assumes the worst case within the ranges presented for nuclear capital costs, fuel costs and capacity factors will coal have an economic advantage over nuclear. Further, according to the Report for coal to be economically competitive in the first instance it must achieve a 75% capacity factor, although as the Report notes, the coal average capacity factor has dropped to 60% and below as coal plants have increased from smaller (100-300 MW) to large units over 600 MW) and difficulties with sulfur scrubbers have started reducing their reliability. Lee Report, pp. 18-19, following Tr. 4967. The conclusion in the Report that coal will do better "at about 75%" has no foundation in the Report and appears to be offered solely on the basis of faith. (Id.)

541. Commonwealth witness Dr. Gordon J.F. MacDonald offered a statistical analysis, the results of which purported to show that a large nuclear plant would appear to be less economical than would either a large coal plant or two smaller nuclear

plants or coal plants delivering the same amount of total electricity. Commonwealth witness MacDonald, following Tr. 5690; Tr. 5692.

542. Dr. MacDonald's statistical technique consisted of a regression analysis of nuclear and coal plant performance in which the dependent variable was the cumulative capacity factor (CCF) and the independent variables were, alternatively, the plant size, "years of operation" and "year of commercialization." Commonwealth witness MacDonald, pp. 1-2, following Tr. 5690.

543. Upon examination of the MacDonald testimony it appeared that Dr. MacDonald had made the erroneous underlying assumption in his computations (admitted by Dr. MacDonald, Tr. 6273, 6277) that the kilowatt cost of a nuclear plant was the same regardless of the size of the plant, and as a consequence Dr. MacDonald's analysis erroneously concluded that one could built twelve 100 MW nuclear plants at the same cost per kilowatt as a 1200 MW plant. Thus the cost of smaller units were understated throughout his analysis and conclusion. Tr. 6273.

544. Dr. MacDonald's regression model employed, as independent variables, "years of operation" and the "date of commercialization" of nuclear plants along with the variable "plant capacity." As the "years of operation" variable is a linear function of the "date of commercialization," these

independent variables in the model are perfectly correlated with the correlation coefficient between the variables a minus one. Statistically, therefore, it makes no difference which one is included in the regression analysis. Tr. 5796-5797. Depending upon which variable is used, the result will be either a continuing increase or decline in the expected cumulative capacity factor. One can show results which either go up or downwards. In the nuclear case, Dr. MacDonald chose to go down. Tr. 5797-5799.

545. Dr. MacDonald's model, when employed to compute the expected capacity factors of a 1200 MW plant similar to the size of Pilgrim 2, was found to show negative capacity factors after ten years. This was explained by Dr. MacDonald as a logical result of the limitation of his data set and "the answer that you get using this limited kind of analysis." Tr. 5821-24.

546. As sources for the data base of his regression, Dr. MacDonald used two publications, viz, "Nuclear Power Plant Reliability, 1973-1974 Record," Comey, 14 February 1975, Applicants' Exh. 7 for identification, Tr. 5697, and "Not Man Apart," mid-September, 1975, Vol. 5, No. 18, p. 7, Applicants' Exh. for identification, Tr. 5698.

Dr. MacDonald also relied partially on Table 1 of his prior testimony in the Seabrook licensing proceeding. Applicants' Exh. 9 for identification, Tr. 5699.

547. During examination (April 1, 1976) Dr. MacDonald insisted that he had used "net design capacity" in computing cumulative capacity factors (CCF) for Table 1 of his direct testimony, but admitted that a number of the results were inconsistent with his position. Tr. 5691-5692, 5700, 5702, 5728, 5720-5724. He further offered to provide the conversion calculations which he had already performed but he asserted they were not readily available. Tr. 5710, 6262. Ultimately, in cross-examination, Dr. MacDonald admitted that his earlier statements regarding his use of net design capacity as opposed to maximum dependable capacity were in error. Tr. 6258-6259. Dr. MacDonald also testified that the list of coal plants appearing in Table 2 of his direct testimony were "exhaustive", but examination of his associate, Ms. Madden, suggested otherwise. Tr. 5746, 5750, 5763.

548. The Board, while noting, but passing, the continuous stream of errors disclosed and acknowledged in Dr. MacDonald's study during the course of his examination, observes that Dr. MacDonald did not in any event value highly whatever results he achieved. When asked why no standard errors

were supplied with his analysis, he replied, "Basically because the number of data points is small. The statistics are not good. I refer to the large uncertainty associated with the data points and what I was trying to demonstrate is that given the data as they were, this is the kind of answers that you come up with. I am not making any supposition that these have--are highly significant in a strict sense, statistical sense." Tr. 6293-6294.

549. At the request of the Staff and the Applicants and the Board, Dr. MacDonald supplied confidence intervals at the 95% level for Tables 3A, 3B, 3C, 4A and 4B, following Tr. 8798. A reading of these confidence levels with respect to the reported capacity factors confirms our belief that no weight can be given to Dr. MacDonald's conclusions. For example, the confidence interval for the expected CCF of 23.6% for an 1150 MW reactor after 15 years results in a range from 3.7% to 121.6% indicating that there is reasonable (95%) confidence that the cumulative capacity factor will be somewhere between 3.7% and 121.6%. We can only conclude that results of Dr. MacDonald's analyses are of little value.

550. The testimony of the third Commonwealth witness, Nancy A. Boxer, was offered in rebuttal to the Applicants' Sup-

plemental Testimony insofar as that testimony assumed a 70% capacity factor for Pilgrim 2 for the year 1988. Commonwealth witness Boxer, following Tr. 8587.

551. Ms. Boxer employed a multiple regression analysis similar to that of Dr. MacDonald. Ms. Boxer considered each year of a nuclear plant's operation as a separate data point, although only one unit (Trojan at 1130 MW) was of a size which might be considered comparable to Pilgrim Unit 2. Commonwealth witness Boxer, pp. 4-5, 9, following Tr. 8588; Tr. 8601-8602. The study data base was further subcategorized into boiling water reactors (BWR's) and pressurized water reactors (PWR's). The twenty-nine PWR"s had accumulated ninety-five unit years of operation with an accumulated average capacity factor of 60.9%. Ms. Boxer noted that Combustion Engineering (CE) reactors are scattered throughout the range of cumulative capacity factor levels achieved with Palisades at the lowest (26.5% after five years) and Calvert Cliffs at the highest (84.9% after one year). CE's performance, although worse than the average, was observed by Ms. Boxer to be significantly influenced by the youth of two of its best performing units and the maturity of its worst performing unit. Commonwealth witness Boxer, p. 5, following Tr. 8588; Tr. 8623-8624.

552. Applying three equations of her regression analysis which were set forth as Exhibit E to her testimony, Ms. Boxer concluded that the statistically expected capacity factor for Pilgrim Unit 2 in the year 1988 would be 47.75%, 47.12% or 47.14%, respectively. Although admittedly not an engineer, Ms. Boxer proffered a number of judgments regarding factors which have, or might have affected the performance of nuclear power plants (i.e., different components, and "mixing" of plant components such as nuclear steam supply systems and turbine generators) which might, on balance, temper these statistical conclusions. Commonwealth witness Boxer, pp. 10-14, following Tr. 8588, Tr. 8603-8610. These evaluations led her to the opinion that the expected capacity factor of Pilgrim Unit 2 could run from 45% to 55%.

553. As was true at least in part with Dr. MacDonald, statistical modelling with a paucity of data leads to certain less than credible conclusions. This was illustrated clearly during examination of Ms. Boxer when she was asked to apply the Exhibit E equation used to project the 1988 capacity factor for Pilgrim 2 to project 1976 capacity factors for CE plants appearing in Exhibit B of her testimony. Ms. Boxer's model projected Calvert Cliffs in

1976 to be 52.40%, whereas the actual capacity factor was 84.9%. Similarly disparate results were achieved with the other CE plants, i.e., Maine Yankee (Boxer projection: 60.27%, actual: 85.4%); Fort Calhoun (Boxer projection: 67.55%, actual: 54.7%) and Palisades (Boxer projection: 60.48% - actual: 39.5%) Tr. 8613-8618. Ms. Boxer described her estimate as a reasonable statistical expectation but admitted that "in point of fact, they (the estimates) do not come close" Tr. 8618. Based on these results, Ms. Boxer could provide no assurances that her projection for Pilgrim Unit 2 would not fall equally "wide of the mark," a projection whose confidence interval would even be further widened by the fact that the projection extended beyond the data set of the regression Tr. 8619.

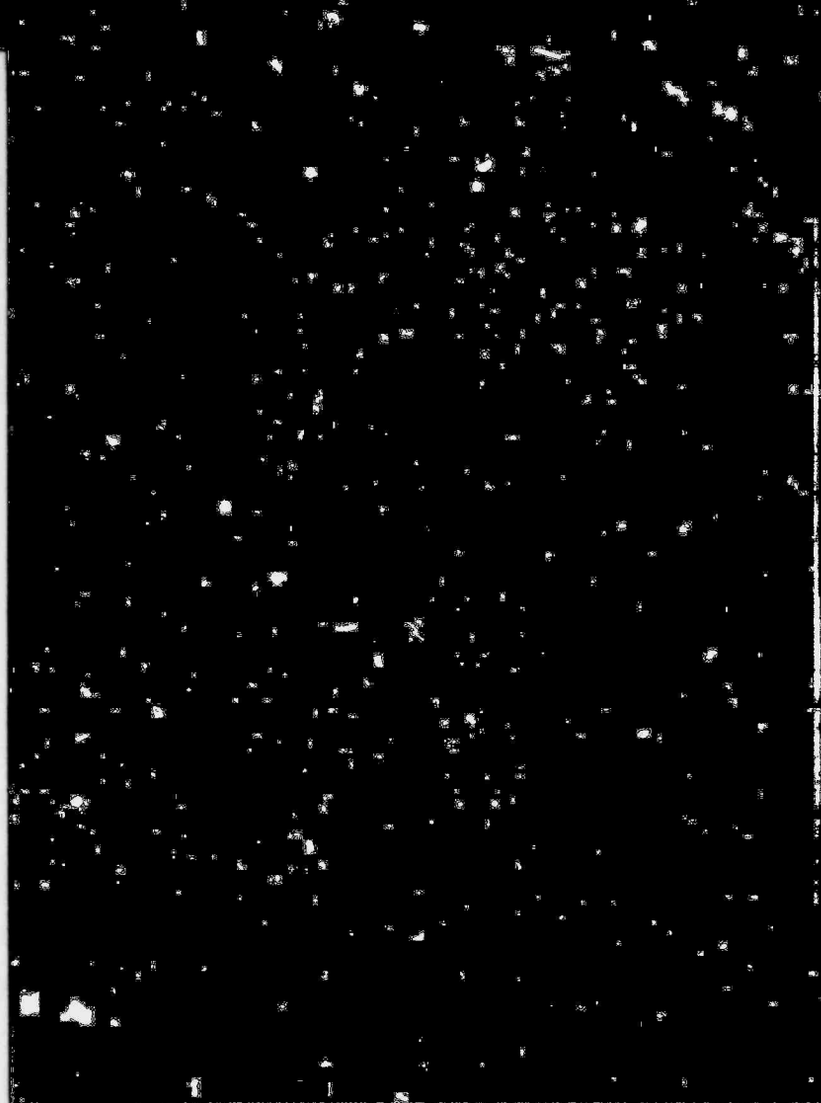
554. A further weakness of the model appears to be its inability to predict major improvements in capacity factors such as the 15% improvement which occurred between 1976 and 1975 in the performance of CE reactors, and further that the model itself limits such improvement to 1-1/2 percent per year. Tr. 8650-8651.

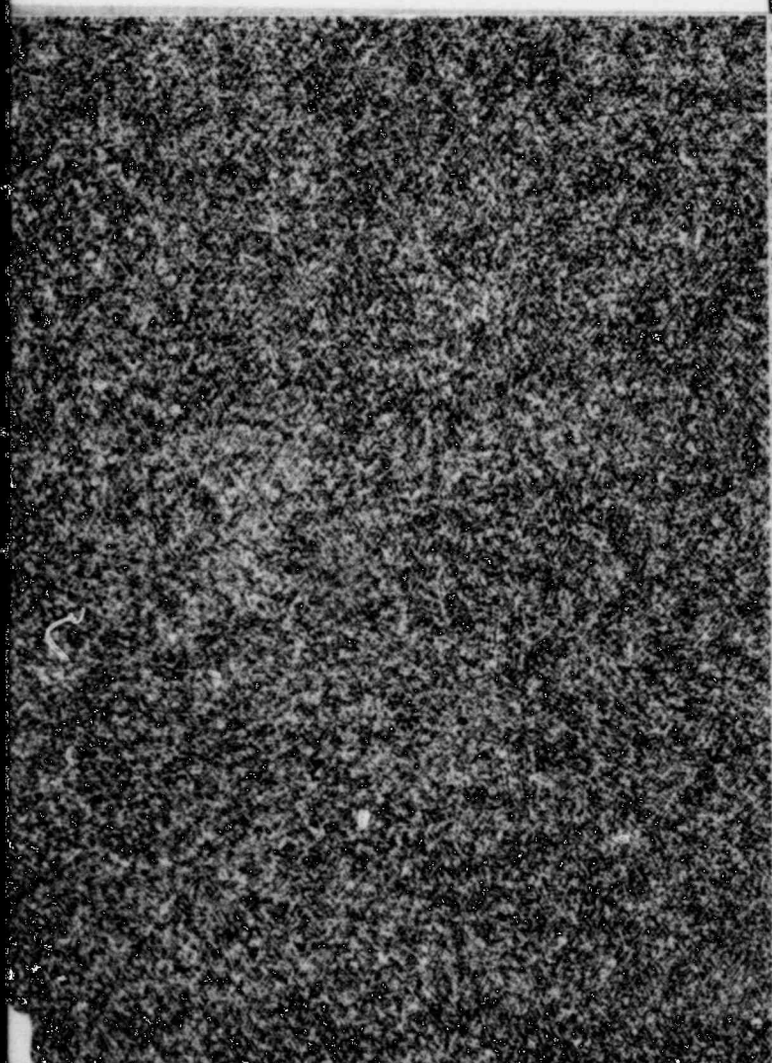
555. The principal source for Ms. Boxer's calculations and analyses were identified as a report by Komanoff which was originally prepared in November, 1976 and further updated in March, 1977. Commonwealth witness Boxer, p. 2, following Tr. 8587. The Board notes that a further update of the Komanoff study has now been prepared which projects a capacity factor for Pilgrim 2 some eleven percentage points higher than that testified to by Ms. Boxer. Staff witness Feld, Tr. 10,563-10,565; see para. 494, supra.

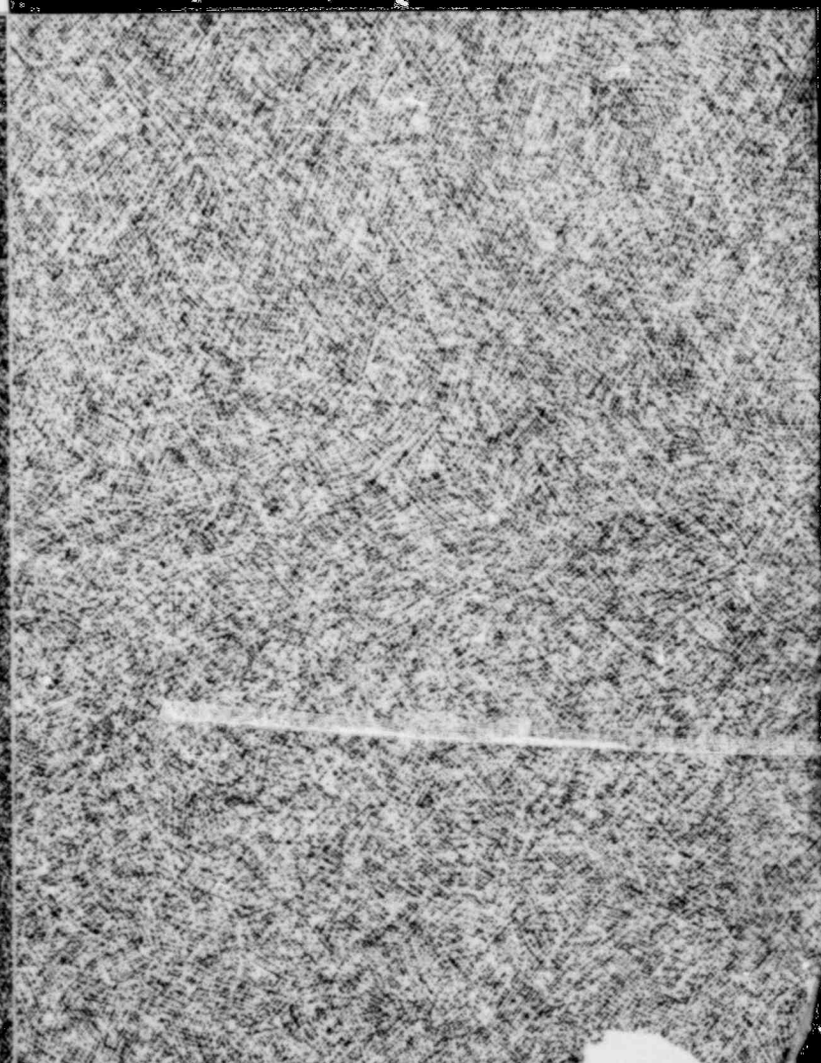
556. We are not persuaded on the basis of the Commonwealth evidence that the Staff's and Applicants' testimony has been overcome and that coal would offer a cost advantage over Pilgrim Unit 2. Moreover the Commonwealth testimony nowhere evaluates the societal and environmental cost of the coal option.

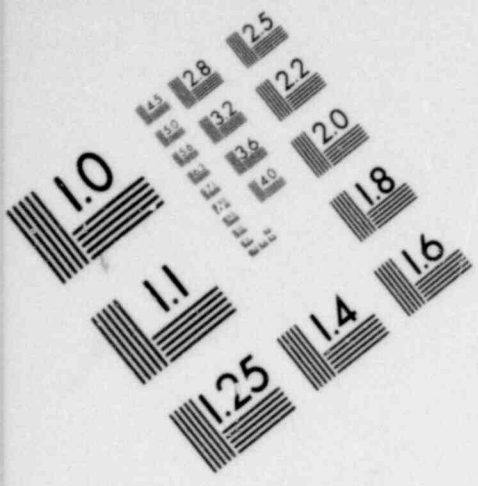
557. The Staff through its witness, Dr. R.L. Gotchy, presented a supplement to the FES on the health effects of the coal and nuclear fuel cycles "Supplement to Pilgrim Unit 2 FES Regarding Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives", following Tr. 8358. The Staff estimated that excess deaths (i.e., higher than normal rates) arising from the nuclear fuel cycle to be about 0.48 per 0.8 gigawatt-year electric (GWy(e)), (equivalent to Pilgrim Unit 2 operating at an

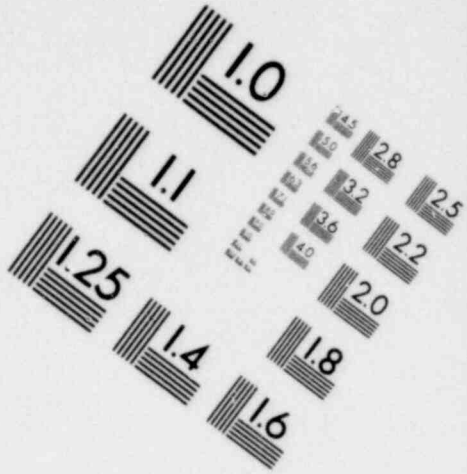
approximate 70% capacity factor) for an all-nuclear economy, with an uncertainty factor of about one order of magnitude. If 100% of the electrical power requirements of the uranium fuel cycle comes from coal-fired plants, the Staff estimates that there would be about 1.1 to 5.4 excess deaths per 0.8 GWy(e) of which 0.62 to 4.9 excess deaths would be attributable to the coal power. The total number of injuries and diseases resulting from normal operations and accidents was estimated to be 14 per 0.8 GWy(e) for an all nuclear economy and 17-24 per GWy(e) if 100% of the electrical power used by the uranium fuel cycle were assumed to come from coal-fired plants. Dr. Gotchy noted that there was a greater uncertainty (about two orders of magnitude) in estimating the health effects of the coal cycle due to relatively sparse and equivocal data regarding cause-effect relationship for most of the principal pollutants in the coal fuel cycle and the unknown future beneficial effects of federal laws on the performance of coal-fired plants, mine safety and culm bank stabilization. Based on several studies, however (including those of Brookhaven and Argonne National Laboratories), Dr. Gotchy presented estimates of excess deaths for the entire coal cycle ranging from 15 to 120 per 0.8 GWy(e) which disease and







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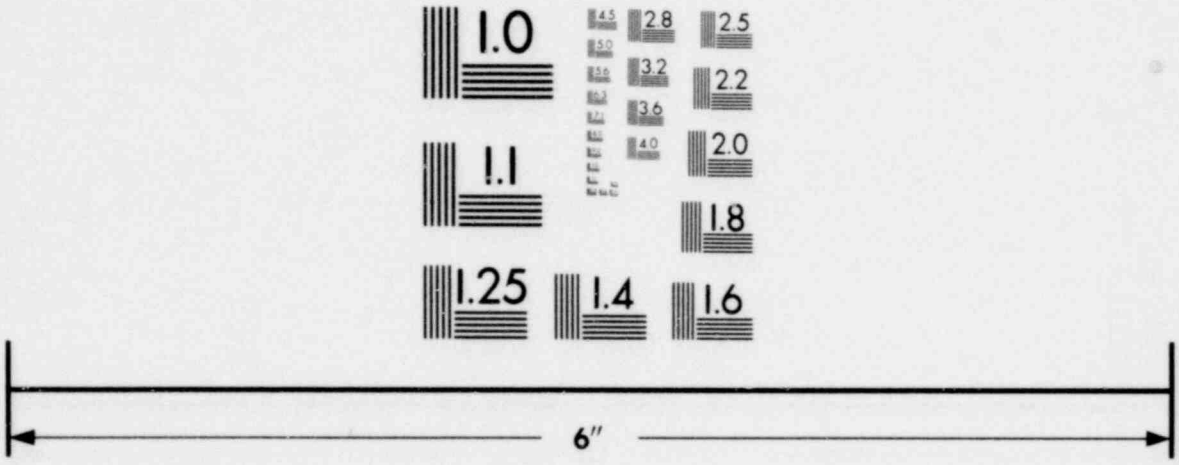


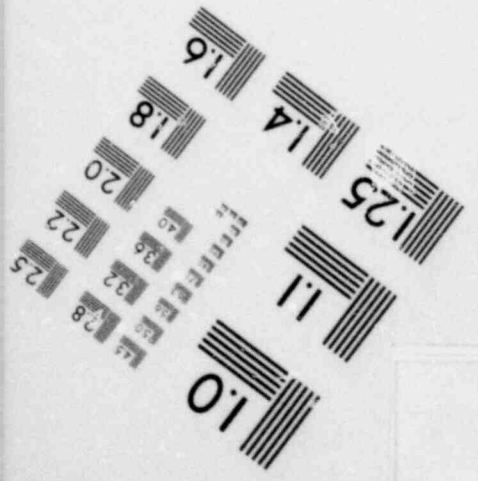


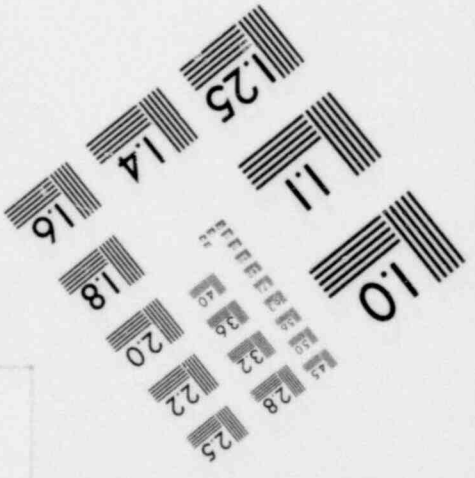

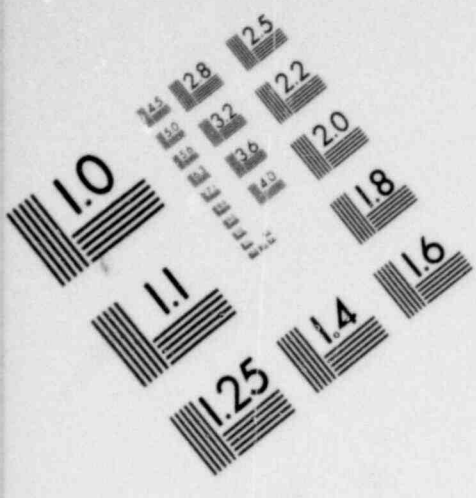


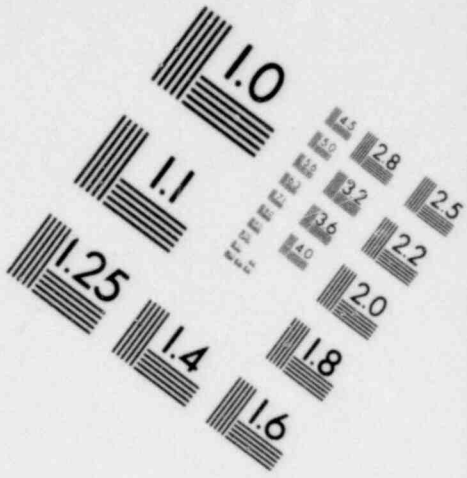


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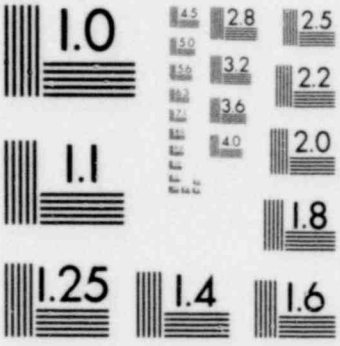


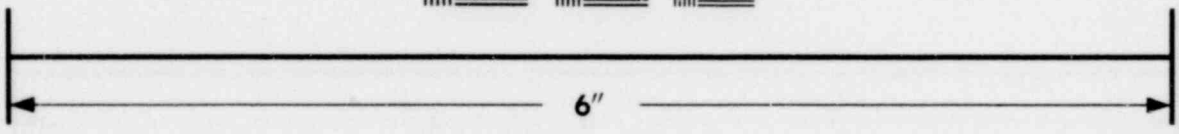


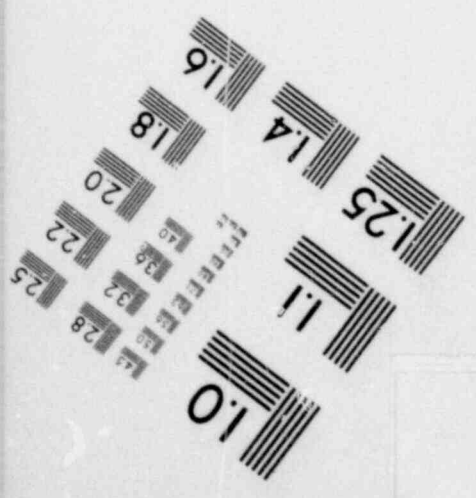


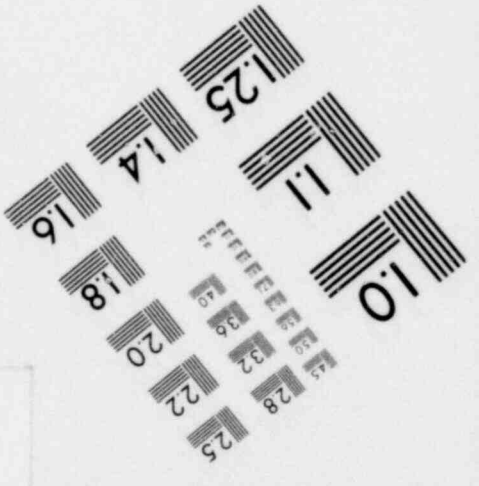

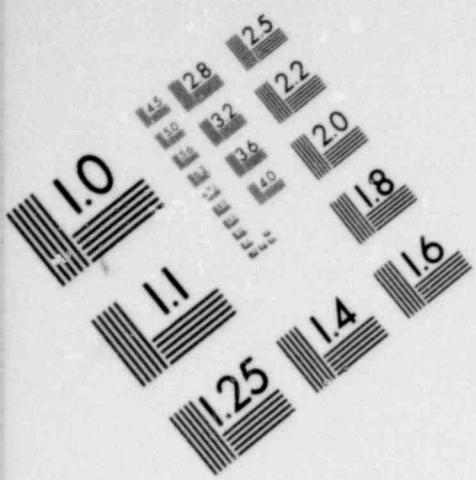


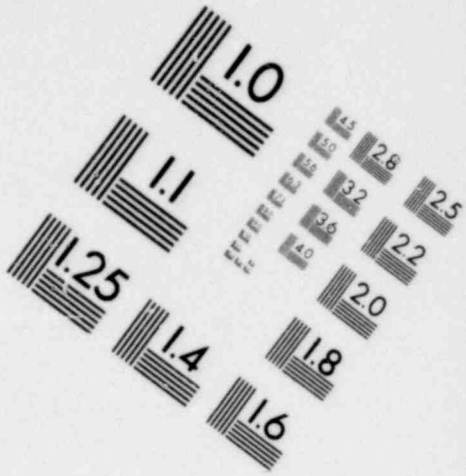


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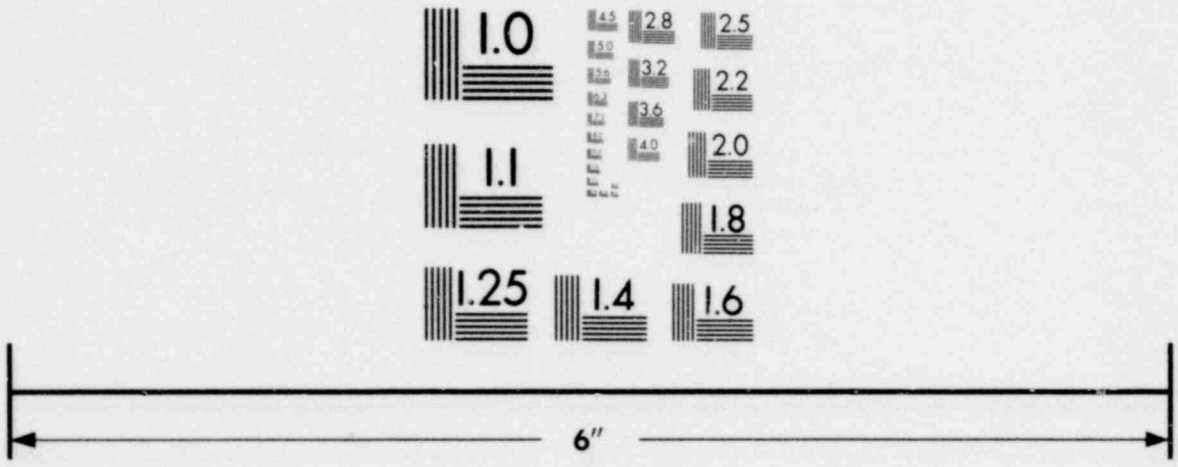


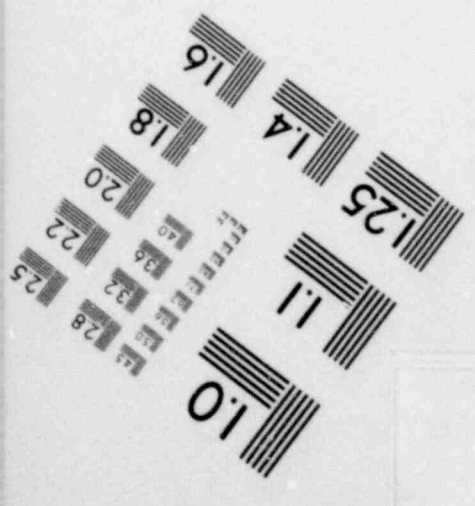


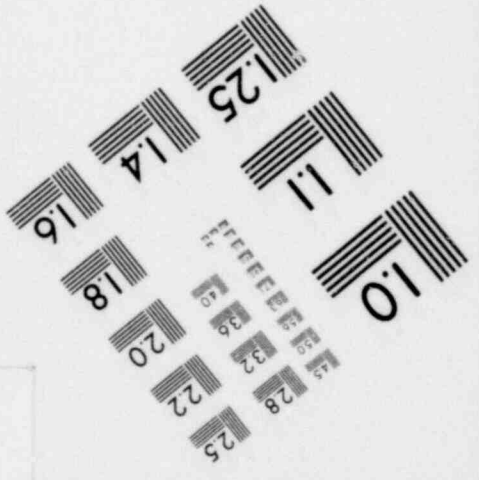

injury estimates run from 57 to 210 per 0.8 GWy(e). FES Supplement, pp. 1-8, following Tr. 8358.

558. Dr. Gotchy also identified several societal costs arising from the coal fuel cycle which have not yet been quantified adequately including the effects of acid rain and acid mine drainage, contamination of soil and vegetation, damage to materials such as paint and the so-called "Greenhouse effect". Dr. Gotchy noted that some recent studies have concluded that societal costs from one coal-fired plant may be about $50 million per year. FES Supplement, pp. 9-10, following Tr. 8358. Dr. Gotchy concluded that, compared to nuclear power, the coal fuel cycle may be more harmful to man by a factor of from 4 to 250 (depending on the effects being considered) for an all nuclear economy, or by a factor of from 3 to 22 if one assumes that all of the electricity used by the uranium fuel cycle comes from coal-fired plants. FES Supplement, p. 11, following Tr. 8358.

559. Environmental disadvantages attendant upon the use of coal are the greater land requirements for coal storage (for 500,000 metric tons assuming a minimum 60 day storage capacity), the production of large amounts of both ash and gaseous byproducts (approximately 140,000 metric tons per year) and the large amounts of coal -- over 10,000

metric tons per day -- which must be transported to the facility. An 1180 MW(e) nuclear plant would require only 30 or 40 metric tons of fuel per year and would create radioactive wastes which are of lesser impact than the transportation and onsite storage of the large amounts of coal required for the coal-fired alternative. FES, pp. 9-5 through 9-7.

560. Based on the testimony presented relating to the economics of Pilgrim 2 and a coal plant alternative and regarding the environmental impacts unique to the coal and nuclear alternatives, the Board finds that nuclear is the preferable alternative.

561. 2. Solar Energy

Both Applicants and the Staff have presented testimony to the effect that solar energy does not present a feasible alternative to Pilgrim 2. Applicants' witness, Dr. David C. White, Director of the Energy Laboratory at MIT, described bulk solar energy by photovoltaic cells or solar thermal generation as being in the research stage today with the possibility of some "proof of concept" demonstration plants in the process of construction in 1982. Further, Dr. White testified that storage of solar produced energy is a major problem in view of the one-eighth sun availability factor in New England. He con-

jectured that a "day-time only" solar plant the size of Pilgrim Unit 2 might be possible in the 1990's. To produce the energy equivalent of Pilgrim a much larger collector facility would be required occupying 300 square miles plus storage capability. Dr. White stated that the cost of such a facility would be $7000/kw(e) or $50 billion Applicants' witness White, pp. 75-77, following Tr. 955.

562. With respect to solar home heating, if production-line systems were available, installed costs for a $45,000 three bedroom home designed to handle 20 percent of the heat requirements for colder days and 50 percent of the average seasonal heat requirements would be $5,000; and if the system were designed to handle one hundred percent of the heat requirements, the cost would be in the order of $15,000. Further, such a house would require a backup heat system which, in light of the cheaper capital requirements, might be electric. To obviate the need for 1180 MW of capacity, 170,000 new electrically-heated homes would have to be equipped with solar panels. In the opinion of Dr. White, less than one percent of the total space heating load could be supplemented by solar energy, although beginning in the late 1990's or early 2000's solar energy could be a partial alternative even

though there are serious problems of environmental impact. Applicants' witness White, pp. 78-80, following Tr. 955

563. The commercial technical feasibility of a solar cycle to provide steam for use in a turbine generator has not been demonstrated, although a 100 MW(e) plant will be tested by the mid-80's if the technological problems of smaller plants are solved. The use of solar or photovoltaic cells for central power stations will require the solution of certain problems including those of decreasing present costs by a factor of 100, developing methods to prevent cell degradation and developing energy storage methods Staff witness Vetrano, pp. 4-5, following Tr. 1401.

564. Home solar heating and cooling based on the use of heated water from a storage tank for space heating in the winter and the use of heated water in the summer for an absorption air conditioning unit for cooling is the most promising solar energy utilization technology. Present engineering problems relate to 1) the need to optimize collector systems since total system cost is very dependent on the size and design of the collection system and a larger collector than necessary adds substantially to the total system cost and 2) the problem of integrating them into building structures. Solar energy will begin to replace

other methods of heating and cooling if the installed costs and discounted operating costs become less than for comparable systems with the most sensitive factors being collector costs and future oil, gas and electric costs Staff witness Vetrano, p. 13, following Tr. 1409. Wide acceptance and rapid growth of solar home heating and cooling in New England would primarily influence the consumption of oil in New England because oil is the primary heating source. Tr. 1457.

565. Commonwealth witness Converse testified that the use of solar energy for space heating could result in a substantial reduction in demand for imported oil and/or nuclear power since space heating represents such a large portion of the total demand for energy in New England Commonwealth witness Converse, p. 1, introduced at Tr. 1540. Dr. Converse presented his testimony based in part on his experience in monitoring a solar heated building in White River Junction between December, 1974 and October, 1975. From this experience he developed a comparison of solar heating with other systems including electric baseboard heating, storage of electricity, oil-hot air and oil-hot air combined with air conditioning, using the system he monitored as a basis for comparison.

Dr. Converse concluded that electric baseboard was more expensive than solar heating with total annual costs of $2,200 for solar heating versus a range of $2,876 to $3,266 for electric baseboard heating. Commonwealth witness Converse, pp. 2-6, introduced at Tr. 1540.

566. Under cross examination, Dr. Converse stated that the capital costs of collector systems on the commercial market would be $8 to $15 per square foot, but that the experimental building upon which his comparative analysis was based, had budgeted collectors at only $5 per square foot. Tr. 1548-1551, 1561-1566. Maintenance costs were based simply on 2% of capital expense, however, Dr. Converse stated that maintenance costs will be of "paramount importance" and that "I really do not know what they are going to be." Dr. Converse had not considered experience nor considered specific potential problems related to solar systems such as "yellowing" of collector cover plates and the potential for freezing. Tr. 1553-1556. Dr. Converse estimated that 50 to 70 percent of heating energy for a house could be supplied by a solar heating system; that the most likely source of back-up heating (to supply the additional 30 to 50 percent required) would be electricity; and that, to the extent solar installations are

made in New England, they are likely to increase the electric share of space heating requirements since New England is presently largely dependent on oil for space heating. Tr. 1556-1561.

567. Dr. Converse stated that he did not know the rate at which solar energy would be introduced (Tr. 1584) but that he did not expect any momentous breakthroughs in the area of solar energy and that he looked for a gradual development of the market Tr. 1614. Further, since housing stock changes slowly he would be surprised if solar energy would account for 10 percent of energy requirements before the turn of the century. Tr. 1614-1615. Dr. Converse also agreed that support services must emerge and that he would not disagree that that would take a decade. Tr. 1618-1620.

568. The Board is of the opinion that solar energy technology for electric power generation is not sufficiently advanced at this time to anticipate it as a viable substitute for the base load generation which Pilgrim 2 is intended to supply during the period needed. Further, in the Board's judgment the economics of central solar generation and its potential environmental impacts are such that it would not present a reasonable alternative to traditional base load fossil and nuclear capacity. With respect to solar

home heating (and air conditioning) the Board finds that given further progress on the technology of home solar energy (particularly in the solar collector panel area) and further reductions in costs, there will be increasing use of solar energy in New England with impact principally in the oil-supported share of home heating. However, this increase will be offset to a significant degree by the need for electric energy for back-up systems. Accordingly, the Board finds that solar home heating (and air conditioning) will not obviate the need for base load generation during the period under consideration.

3. Wind Energy

569. Applicants' witness, Dr. White, stated that wind energy is more likely to be available in small blocks in the short term but that there are storage requirements, and capital cost problems and technological difficulties associated with large-scale wind generation. ERDA/NASA research projects are presently in the order of 100 kw with the current system limited to 5 kw. Applicants' witness White, p. 81, following Tr. 955. Staff witness Vetrano testified that with the high average wind velocity off the coast of Massachusetts (corresponding to 800 watts/$M^2$) approximately 2000 large off-shore windmills would be required to equal the output of Pilgrim 2; or approximately

10,000 on-shore windmills would be required, "even assuming they could be built". To avoid interference, it would be necessary to disperse the windmills to a density of about two large 0.5 MW(e) units per square mile. The requirement for energy storage makes wind energy completely uneconomical.

570. Staff witness Vetrano reviewed various cost projections for windmills, and found them to be, in general, two to three times higher than coal or nuclear plants. Staff witness Vetrano, pp. 30-32, following Tr. 1409. No contrary evidence was brought forward by any other party.

571. The Board finds that wind-generated power is neither technically nor economically suited to provide the base load power of a unit of the size of Pilgrim Unit 2.

4. Solid Wastes

572. Applicants' witness, Dr. White, testified that solid waste will most likely be useful only as a fossil fuel supplement because: 1) only the technology for supplemental use has been found to be viable and 2) large amounts of waste are required. To provide 1180 MW(e), for example, a collection system would be required which could gather all of the solid wastes of approximately 4-1/2 million people Applicants' witness White, p. 81, following Tr. 955.

573. Staff witness Vetrano concluded that direct burning of garbage is a practical alternative, but that it can add little power to the New England area and that it cannot affect the need for power represented by Pilgrim 2 capacity. According to Mr. Vetrano, with no credit for salvage, the cost of burning trash in the Boston area would be approximately 8 mills/kwh. However, a major cost factor in the direct burning of trash is the collection and transportation of the trash to the separator and shredder. The Staff noted that the Haverhill plant planned for northeastern Massachusetts would have a rated capacity of about 60 MW(e) and that it would take about 20 plants of that size to equal the output of Pilgrim 2. In the judgment of Mr. Vetrano, while simultaneous disposal of waste and generation of power should be encouraged, it can never be a complete substitute for more conventional power generation systems. Staff witness Vetrano, pp. 35-37, following Tr. 1409.

574. Commonwealth witness Alden Cousins, Director of the Commonwealth's Bureau of Solid Waste Disposal, testified concerning the enrgy potential of solid waste resource recovery. He cited as a particular example the proposed Haverhill facility which is designed to process at least 3000 tons/day of mixed refuse and will produce approximately 60 MW of power. Mr. Cousins has estimated that

the potential energy value from all the solid waste generated within the Commonwealth would amount to 470 MW of power although he conceded that "(c)ertainly not all of this power could or would be used for the direct generation of electricity." Commonwealth witness Cousins, pp. 1-5, following Tr. 5416. When asked the question directly, Mr. Cousins stated "I don't think solid waste will replace Pilgrim 2." Tr. 5452-5453.

575. Based on the evidence adduced on the subject of direct burning of solid wastes, the Board finds that such technology does not offer a reasonable alternative to provide the power to be generated by Pilgrim 2.

5. Other Sources

The Staff presented direct testimony on several other energy conversion technologies Staff witness Vetrano pp. 24-25, following Tr. 1409. From a technological standpoint it is possible to convert coal to a high Btu gas for boilers but that there is little incentive for doing this when coal can be burned directly in a steam power plant. Current research is directed at improving low Btu content gasification. Since the "older" technology employed for manufacturing coal gas is not competitive economically with the direct burning of coal due

to the added conversion steps, it is too early to judge the economics of the resulting current research programs Staff witness Vetrano, pp. 24-25, following Tr. 1409. No other party advanced contrary evidence.

576. The Board finds that the gasification of coal is not a reasonable alternative for Pilgrim 2.

577. The Staff also considered the High Temperature Gas Cooled Reactor (HTGR) as an alternative to Pilgrim 2 as presently designed. The principal advantage of an HTGR is a higher thermal efficiency of 38-40% compared to 33-34% for a Light Water Reactor, thus requiring approximately 8% less thermal discharge per unit of electricity generated. In addition, an HTGR requires less uranium than an LWR -- about 113 tons/year per 1000 MW(e) HTGR versus 201 tons/year per 1000 MW(e) LWR. This differential is somewhat offset by the need for 8 tons of $ThO_2$/yr for an HTGR. Capital and operating costs are essentially identical for both types of reactors. While there is some minor environmental advantage for the HTGR, there would be considerably added costs if a decision were made to change reactor types at this stage. Staff witness Vetrano, pp. 26-28, following Tr. 1409.

578. The Staff analyzed other alternatives such as the conversion of garbage and wastes to oil and concluded that while research and development should continue on such processes, the requirement of 38,000 tons of garbage per day is not available in collectable form in a concentrated region Staff witness Vetrano, pp. 37-38, following Tr. 1409. The Staff reached similar conclusions with respect to the production of gas by anaerobic digestion. While noting that the technology is well in hand, the Staff pointed out that the problems with utilizing the technology stem from the low yield of gas, low heat content, and the economics of transportation and high costs of production. The Staff has performed calculations which show that with the maximum utilization of trash generated by each person only 30 watts per person could be generated. Staff witness Vetrano, pp. 38-39, following Tr. 1409.

579. Concerning the utilization of ocean temperature differentials, the Staff concluded that the ocean temperature differentials in New England are so small that the efficiency may be so low as not to permit a positive power output. Also significant problems arise with respect to transmitting the power to load centers. Further,

there are potential environmental effects of pumping large volumes of water from surface and bottom layers into different regimes. Staff witness Vetrano, p. 40, following Tr. 1409.

580. Based on the evidence adduced and the foregoing findings, the Board finds that none of the alternative sources suggested by the intervenors represent a reasonable alternative*/ which either alone or in combination could replace all or a significant portion of Pilgrim 2.

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*/ Carolina Environmental Study Group v. AEC, 510 F.2d 796, 800-801 (D.C. Cir. 1975)

J. Environmental Impact of Routine Releases of Radioactive Materials

581. At the request of Intervenors Cleetons the Board admitted into controversy a contention (Cleeton Contention E) that:

> The routine discharges of radioactive materials and/or attendant routine doses of radiation caused by the operation of Pilgrim Unit 2 constitute an unreasonable threat to the health and safety of the intervenors' family.

Board Memorandum and Order (February 18, 1975), at 17.

582. The Applicants objected to the admission of Cleeton Contention E into controversy, contending that this contention presents an issue which is a challenge to the adequacy of the Commission's regulations governing permitted releases of radioactivity from nuclear power plants. Applicants' Objections to the Atomic Safety and Licensing Board Order Admitting Certain Contentions As Issues in the Proceeding (February 28, 1975), at 9.

583. The Staff concurred with the Applicants that insofar as the contention could be read as challenging the adequacy of the Commission's regulations, specifically 10 CFR §§20.1(c) and 50.34a, which require that radioactivity in effluents to unrestricted areas must be kept as low as practicable, it could be properly

dismissed under 10 CFR §2.758 since there had been no showing of "special circumstances" as to why these regulations would not apply to this proceeding. However, the Staff assumed that the contention was admitted by the Board, not to challenge the Commission's regulations, but rather to raise the environmental issue of the impact of routine releases. NRC Staff's Response to Applicants' Objections to the Atomic Safety and Licensing Board Order Admitting Certain Contentions as Issues in the Proceeding (March 12, 1975).

584. The Board agreed with the Staff's interpretation of the issue and overruled the Applicant's objections, stating that the issue was not intended to raise a generic problem, but rather was admitted to permit the Cleetons to demonstrate, if they could, the specific environmental impact, if any, on the health and safety of the Intervenors' family by routine releases of radioactive materials caused by the operation of Pilgrim Unit 2. Memorandum and Order on Applicants' Objections to the Board's Order of February 18, 1975 Admitting Certain Contentions (April 2, 1975), at 9-10.

585. The Cleetons introduced direct testimony to support the contention by Dr. Arthur Tamplin, Tr. 6946-7013A,

Dr. Rosalie Bertell, Tr. 7033-7119, 7192-7198, and Dr. Helen Caldicott. Tr. 7139-7184. None of the witnesses, however, presented testimony on the specific environmental impact that would accrue to the Cleetons from the routine releases of radioactive materials caused by the operation of Pilgrim Unit 2. The testimony of all of the Cleeton witnesses was directed to a challenge of the assessment of risks associated with low-level radiation on a generic basis.

586. The Cleetons also offered direct testimony by Mrs. Martha Drake who offered a report she had performed analyzing leukemia death rates around three small nuclear plants. Drake, Martha, "An Analysis o. Leukemia Death Rates in Populations Near Boiling Water Reactor Nuclear Plants" (Drake Report), Master's Thesis in Human Ecology, Michigan State University (1976), following Tr. 7138 . Her testimony was objected to by the Applicants as admittedly inadequate as statistical evidence and because the report contained an analysis of areas surrounding three small boiling water reactors. Tr. 7120-24. The Applicants' objection was joined by the Staff, Tr. 7124, who pointed out that the report specifically stated:

> "These findings cannot be generalized beyond these three areas because they were not randomly selected. They cannot be generalized to other health effects except to the ratio of twenty solid cancers appearing about ten years later for each leukemia." Drake Report at 19.

The MWF, on the other hand, argued that the objections were directed to the weight of the evidence rather than its admissibility. Tr. 7124.

587. The Board was finally persuaded that the direct testimony of Mrs. Drake offered by the Cleetons was inadmissible on the basis that it was not relevant to this proceeding since it specifically addressed boiling water reactors and excluded pressurized water reactors. Tr. 7130-7131. Furthermore, the Board noted the author's own candid disclaimers internal to the report which questioned the significance of her findings. The Board did, however, receive the testimony as a limited appearance statement. Tr. 7138.

588. In connection with Cleeton Contention E the Applicants presented a panel of witnesses consisting of Mr. W. Wade Larson, Systems and Safety Analysis Group Leader of the Boston Edison Nuclear Engineering Department and Mr. Joel I. Cehn, a Nuclear Environmental Sciences Consultant, previously Radiological Engineer in the Environ-

mental Sciences Group of the Boston Edison Nuclear Engineering Department. Tr. 7339-7435. The Staff presented Dr. Reginald L. Gotchy, Senior Radiobiologist in the Radiological Assessment Branch in the Office of the Nuclear Reactor Regulation. "Relating to Cleeton Contention E, Supplemental Testimony of Dr. R. L. Gotchy", following Tr. 6496; Tr. 6483-6535, 6600-6646, 6649-6751; "Affidavit of Dr. Reginald L. Gotchy", following Tr. 7437; "Corrected Affidavit of Dr. Reginald Gotchy", following Tr. 7820.

589. The Staff's radiological evaluation of normal releases of radioactivity is also presented in the FES as supplemented FES, §§5.3-5.8; as supplemented by Staff Exh. 11-B, following Tr. 7828 to reflect the comprehensive analysis required by 10 CFR Part 50, Appendix I.

590. The Applicants' assessment of the radiological consequences of the normal release of radioactive materials from liquid effluents, performed in accordance with the requirements of Appendix I to 10 CFR Part 50, is calculated to be 0.00408 millirem per year to the whole body of the hypothetical maximum exposed individual at the site boundary, an exposure 735 times less than the

Appendix I limit of 3 millirem per year and 0.146 man-rem per year to the population. The maximum exposure of any organ is calculated to be 0.00847 millirem per year, 1180 times smaller than the Appendix I limit of 10 millirem per year. Applicants' witness Larson, pp. 6-7 and Exhibit LR-2, LR-3, following Tr. 7352.

591. The Applicants' Appendix I evaluation of the consequences of the release of radioactive materials in gaseous effluents is determined to be 0.282 millirem per year to the whole body of the hypothetical maximum exposed individual, a value 18 times less than the Appendix I limit of 5 millirem per year and 1.8 man-rem per year to the population. The maximum exposure of any organ is calculated to be 0.42 millirem per year as compared to the Appendix I limit of 15 millirem per year. Applicants' witness Larson, pp. 8-10, Exhs. LR-10, 11 and 12, as amended by Supplemental Testimony, unnumbered pp. 2 and 3 and replacement Exhs. LR-10, 11 and 12, following Tr. 7352.

592. The Applicants' witness Larson estimated that the exposure of the Cleetons, located 40 miles west of the site, to liquid effluents would be more than 1000 times less than the hypothetical maximum exposed individual

(on the order of 0.000004 millirem per year whole body) and that allowing for use of facilities on Cape Cod Bay removed from the site, based on the assumptions that were used for evaluating the exposure of the maximum exposed individual, the exposure of the Cleetons would be more than 100 times less than the maximum exposed individual. Applicants' witness Larson, pp. 7-8, following Tr. 7352.

593. Applicants' witness Larson estimated that the exposure of the Cleetons, 40 miles west of the site, to gaseous effluents would be more than 2000 times less than the hypothetical maximum exposed individual (on the order of 0.001 millirem per year whole body). Allowing for some substantial time in the vicinity of the site and consumption of fresh leafy vegetables grown in the vicinity of the plant, reasonably expected maximum exposure is 200 times less than the maximum exposed individual. Applicants' witness Larson, pp. 9-10, following Tr. 7352.

594. Applicants' witness Cehn established that the radiation exposure from natural background radiation to the population in the region surrounding the plant is approximately 120 millirem per year with an approximate

range of 81 to 160 millirem per year and that the annual background exposure of the population of about 6 million projected to live within 50 miles of the plant in the year 2000 would be about 720,000 man-rem whole body. Applicants' witness Cehn, pp. 12-13, following Tr. 7352.

595. The potential maximum exposure of the hypothetical "maximum exposed individual" from anticipated radioactivity releases from the plant, conservatively taken as the sum of maximum exposures from liquid and gaseous pathways, is 410 times less than the average natural radiation exposure and 275 times less than the variation in natural background exposures. The average additional exposure is approximately 270,000 times less than the variation in natural background. The population exposure is approxiamtely 380,000 times less than natural background exposure. Applicants' witness Cehn, pp. 13-14, as amended by Applicants' Supplemental Testimony, unnumbered p. 3, following Tr. 7352.

596. The additional risk of cancer to the population within 50 miles of the plant, due to an increment of 1.9 man-rem attributed to plant operations to the 720,000 man-rem attributed to natural background, applying the linear

dose model as established by the Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR Report), is estimated to be 1/38,000,000 of the natural, spontaneous cancer rate. Applicants' witness Cehn, p. 16, as amended by Applicants' Supplemental Testimony, unnumbered p. 3, following Tr. 7352.

597. Staff witness Dr. Gotchy estimated that the dose rate of the hypothetical maximum exposed individual in the vicinity of the proposed Pilgrim 2 is 1.9 millirem per year. Staff witness Gotchy, p. 3, following Tr. 6494. Cleeton witness Dr. Tamplin found that the model used by the Staff to evaluate doses in accordance with Appendix I is satisfactory. Tr. 7006-07.

598. Dr. Gotchy, applying the linear dose model established by the BEIR Report, concluded that the added lifetime risk of cancer to a hypothetical person exposed to 1.9 millirem per year is 1/89,000 and that the risk to the Cleetons living in Franklin, Massachusetts would be an order of magnitude lower. Staff witness Gotchy, pp. 1, 4-6, following Tr. 6494.

599. Dr. Gotchy further compared the estimated risks associated with the radiation resulting from plant

operations with other risks to which this societ is exposed based on 1973 U. S. mortality statistics and concluded that the incremental risk to the Cleetons is not unreasonable. Staff witness Gotchy, pp. 6-7, following Tr. 6494.

600. Dr. Gotchy testified that the estimated exposure of the population surrounding the plant is 1.81 man-rem per year as the result of calculations performed by the Staff in compliance with 10 CFR Part 50, Appendix I, Corrected Affidavit p. 3, following Tr. 7820, and that based on the BEIR linear dose model the average increase in lifetime radiation exposure to an individual due to lifetime operation of Pilgrim 2 would increase the total individual risk of cancer mortality by one chance in 550 million. Corrected Affidavit, p. 5, following Tr. 7820.

601. Cleetons' witness, Dr. Tamplin, did not testify on the risk to the Cleetons from the operation of Pilgrim Unit 2. Dr. Tamplin did testify that based on studies completed since the report of the BEIR Committee in 1972 it was his experience that there are indications that the generic bases for health effect estimates established by the BEIR Report are likely to underestimate effects

by a factor of at least 10 for cancers and a factor of at least 4 for genetic effects. Cleeton witness Tamplin, pp. 6-8, following Tr. 6959-A. His testimony did not address whether the risk is reasonable or unreasonable. Tr. 7013-A. Although Dr. Tamplin stated his belief that the BEIR Report could understate an individual's risk by as much as 1000 times he did not substantiate the basis for establishing such an upper limit, nor did he attempt to establish that the Cleetons would be among the segment of the population that would be "significantly different" with respect to their sensitivity to radiation. Tr. 6965-6976.

602. Cleetons' witness Bertell also did not testify on the magnitude of the risk to the Cleetons but rather that, in her opinion, the genetic basis for health effects estimates established by the BEIR Report understates by some undefined amount the health effects of radiation exposure. Cleeton witness Bertell, p. 2, following Tr. 7044; Tr. 7045-46, 7096-7098, 7118-7119.

603. Although Dr. Bertell testified that the estimated radioactive discharges from a reactor of the type and size proposed for Pilgrim 2 have not been adequately tested and are probably not conservative, Cleeton witness Bertell,

p. 1, following Tr. 7044, she was unable to identify the type of reactor proposed for Pilgrim 2 and stated her belief that there is no plant in operation of the type it is intended to be; that she had no knowledge of the estimated discharges from the plant; that she had not reviewed the Applicants' Preliminary Safety Analysis Report nor the Staff's Safety Evaluation Report; and that she was not aware of the radiological program proposed for Pilgrim 2. Dr. Bertell further testified that "The relationship between sample measurements and the population from which samples were taken is not known with any degree of clarity", Cleetons witness Bertell, p. 1, following Tr. 7044, explaining that the statement refers to radioactive discharge measurements and that the lack of knowledge relates to the taking of intermittent samples of continuous releases and inferring releases at other times to estimate the total. Tr. 7057-7059 The PSAR and the SER establish that the proposed discharge monitoring program will provide continuous monitoring for all potential continuous release pathways, and batch samples of batch process releases. The systems are designed to assure that all normal and potential releases are monitored and controlled. PSAR, §11.4.3.2; SER, §11.5.

604. Dr. Bertell explained that she believed that "unusual occurrences" that would result in actual doses as high as 100 millirem as "well within the realm of possibility", Tr. 7054, as the basis for testifying that discharges "are mostly probably not conservative". Cleeton witness Bertell, p. 1, following Tr. 7044. The discharge monitoring systems described by the Applicants and the Staff and the assessments of normal releases and accidents performed by the Applicants and the Staff to estimate the radiation dose consequences of releases, ER, §§5.3, 7.1; FES, §§5.3.2, 7.1, preclude anticipated unusual occurrences resulting in dose rates as high as presumed by Dr. Bertell. Specifically, in the Applicants' analysis of the complete spectrum of postulated plant accidents under "realistic" assumptions no event results in a dose at the site boundary in excess of 100 millirem. ER, Table 7-5.

605. Dr. Bertell argues that the monitoring of human health, including assessment of the present human health situation in the area within 50 miles of the proposed Pilgrim 2, is not, but should be, provided for. Cleeton witness Bertell, p. 3, following Tr. 7044; Tr. 7095-7096, 7118-7119. Dr. Bertell also states that the problem of the

failure to measure health effects is a generic problem with respect to a lack of sophistication in public health services compared to sophisitication in technology, Tr. 7074-7075, that it applies to "PCB's and all the rest of the industrial pollution, which is being put into our environment and into our food", Tr. 7075, that this is a failure of the public health structure and system in the United States, Tr. 7073, 7074-7075, and that this is a public health responsibility, Tr. 7096-7097. Dr. Bertell further testified that such a method of monitoring public health is not being performed to monitor health effects of any pollutant identified. Tr. 7076. Dr. Bertell acknowledges that the radiological releases from the plant will be within regulatory guidelines, Tr. 7104, 7107, in a range between "a lower limit of zero and an upper limit of the guidelines", Tr. 7107, but that nothing within that range could be acceptable. Tr. 7107.

606. The Board must reject the position on monitoring advanced by Dr. Bertell. Dr. Bertell misconceives the radiological monitoring proposed for Pilgrim 2. The Applicants' environmental radiological monitoring program for the proposed Pilgrim 2 facility has been reviewed and approved by the Staff as meeting all of the regulatory requirements of

the Commission, with which determination we concur. See, para. 84 to 107, supra. Whatever the merits of epidemiological monitoring of the health conditions of the population at large, such as the program urged by Dr. Bertell, these kinds of studies are more appropriately performed by those federal and state agencies and institutions responsible for basic public health research.

607. The Board must also reject the position taken by Dr. Bertell that no amount of radiation is acceptable and that any amount of radiation comprises an unreasonable risk. The Commission's rules and regulations establish that certain levels for release of radioactive materials and levels of radiation exposure to persons in unrestricted areas are compatible with public health and safety, 10 CFR §§20.105 and 20.106; 10 CFR Part 20, Appendix B, with further restrictions that releases to unrestricted areas be kept "as low as reasonably achievable" 10 CFR §50.34a; 10 CFR Part 50, Appendix I.

608. Cleeton witness Dr. Caldicott also provided no testimony on the magnitude of the risk to the Cleetons and took the position that any additional radiation is unacceptable. Cleeton witness Caldicott, pp. 1-2, following Tr. 7150; Tr. 7151-7152, 7177-7179, 7180.

609. Dr. Caldicott admitted, however, that she did not know the magnitude of the releases of radioactivity anticipated from Pilgrim 2 nor did she have an estimate of the radiation doses to the population. Tr. 7153-7155. Dr. Caldicott stated that:

> "Background radiation is different from the stuff that comes out of nuclear power plants. Because background radiation is gamma radiation and the dose is averaged over millions and millions of cells in the body, which means that each cell gets a minute dose...(A)n internal emitter...is not averaged over all of the cells of the body... (A) few cells or one particular organ, gets the dose...(T)hose cells are going to get a higher dose than...from background radiation which is averaged over all of the cells of the body." Tr. 7157-7158.

610. Dr. Caldicott also provided descriptions and assessments of background radiation sources and comparisons with radioactivity to be emitted by the plant that demonstrated general unfamiliarity with the subject. Tr. 7157-7161. Dr. Caldicott also stated that there was no way of establishing radiation doses to the population surrounding the proposed plant because "it is impossible to tell which persons get which dose". Tr. 7152-7154.

611. It must be noted that the presumptions of both Cleeton witnesses Bertell and Caldicott on the adequacies of estimating radiation exposures from a proposed nuclear power plant are at odds with the position of Cleeton witness Tamplin who stated in response to a Board question on

whether he had a quarrel with the Staff's dose evaluation: "The whole approach toward estimating the dosage from power plants is sort of derived from Appendix I. There were substantial hearings held on Appendix I and my feeling was for once we resolved something. So I have no quarrel with that up to the dose point." Tr. 7006-7007.

612. The Board finds that the incremental risk to the Cleetons from routine releases of radiation, including anticipated unusual occurrences, is vanishingly small. The potential incremental radiation exposure to the Cleetons, established by the analyses of the Staff and the Applicants performed in accordance with the requirements established by Appendix I to 10 CFR Part 50, is only a minute increment to natural radiation exposure. By using the linear dose/response model established by the BEIR Report, the resulting incremental risk to the hypothetical maximum exposed individual is small in comparison both to the risk that may be associated with exposure to natural radiation and to risks that are accepted from other natural and human-caused activities, particularly the risks of automobile travel and the risks associated with pollution from other sources. As noted by the Applicants, even assuming that the BEIR Report could eventually be found to understate substantially the relationship between radiation exposure and health effects, a possibility that we find unsubstantiated at this time by the record

before us, the incremental risk would still be very small and would not likely cause an unreasonable risk to the health of the Cleetons. The Cleetons will be exposed to radiation from the plant that is orders of magnitude less than the exposure of the "maximum exposed individual", and assuming that the Cleetons may be among the population group which is "more sensitive" to radiation, a condition that has not been established on this record, the incremental risk to the Cleetons must be less than the negligible risk established for the "maximum exposed individual".*/

K. Transportation Risks

613. The Board admitted in controversy a contention by Intervenor Cleetons (Cleeton Contention B) that the Applicants and the Staff have not properly assessed the radiological risk to the Cleetons' health and safety resultant from possible future accidents in the transportation of nuclear fuels and nuclear wastes to and from the Pilgrim 2 site. (Board Memorandum and Order (February 18, 1975), p. 17). The Cleetons introduced no direct testimony in support of their contention on transportation accident risks but instead cross-examined witnesses presented by the Applicants and the Staff. Tr. 3652-3677; 2541-2615.

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*/ See Citizens For Safe Power, Inc. v. Nuclear Regulatory Commission, 524 F. 2d 1291, 1300 (D.C. Cir. 1975).

614. The Applicants and the Staff take the position that the Commission's generic evaluation of transportation risks as set forth in 10 CFR §51.20(g), Table S-4 (Environmental Impact of Transportation of Fuel and Waste To and From One Light Water Cooled Nuclear Power Reactor) and WASH-1238 (Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants, December 1972) is applicable to the transportation risks including risks from accidents associated with the operation of Pilgrim Unit 2.

615. 10 CFR §51.20(g)(2) provides that the values contained within Summary Table S-4 apply only if:

> "(i) The reactor is a light-water-cooled nuclear power reactor with a core thermal power level not exceeding 3,800 megawatts; (ii) The reactor fuel is in the form of sintered uranium dioxide pellets encapsulated in zircaloy rods with a uranium-235 enrichment not exceeding 4% by weight; (iii) The average level of irradiation of the irradiated fuel from the reactor does not exceed 33,000 megawatt days per metric ton and no irradiated fuel assembly is shipped until at least 90 days have elapsed after the fuel assembly was discharged from the reactor; (iv) Waste (other than irradiated fuel) shipped from the reactor is in the form of packaged, solid wastes; and (v) Unirradiated fuel is shipped to the reactor by truck; irradiated fuel is shipped from the reactor by truck, rail, or barge; and waste other than irradiated fuel is shipped from the reactor by truck or rail."

616. Both the Applicants and the Staff testified that the design and operation proposed for Pilgrim 2 will fall within the scope of 10 CFR §51.20(g). Applicants' witness Rosen,

pp. 5-6, following Tr. 3651; Staff witness Barker, pp. 2-3, following Tr. 2537.

617. The Intervenor Cleetons have failed to establish by cross-examination of Applicants and Staff witnesses any condition or specific circumstance which would lead to a conclusion that the transportation risks specified in Part 51 of the Commission's regulations are not sufficient to define the transportation risks associated with the operation of Pilgrim Unit 2.

618. The Board finds that the transportation risks including risks from accidents specified in Summary Table S-4 of 10 CFR §51.20(g) are applicable to define transportation risks associated with the operation of Pilgrim Unit 2.

L. Risk of Theft and Sabotage

619. The Board admitted into controversy a contention advanced by the Commonwealth (Contention 9) asserting that the advantage of the nuclear option, as opposed to alternative methods of electrical generation, is overstated by understating the risk of theft and sabotage, the cost of which would cause the overall cost of the facility to outweigh its benefits. Board Memorandum and Order (February 18, 1975), at 6-7.

620. The Commonwealth sought to present testimony on this contention by Dr. George W. Rathjens, which testimony consisted

of the Preface and Chapters 1 and 9 of the Report of the Massachusetts Nuclear Safety Commission. Both the Applicants and the Staff objected to the scope of the testimony. The Applicants took the position that Appeal Board decisions have ruled out theft and sabotage against the plant as a NEPA issue in a construction permit proceeding, and argued that Commonwealth Contention 9 must be interpreted as limited to the risk of theft and sabotage in the transportation of nuclear materials to and from the plant. The Staff took a similar position, except that the Staff offered the limited testimony of John Sears, to which Applicants also objected covering the costs of the security system to protect against sabotage by something less than an armed band of trained saboteurs.

621. The risk of the threat of theft and sabotage to a nuclear plant as a consideration to be factored into the NEPA cost benefit analysis has been ruled beyond the scope of these proceedings by the Appeal Board. Long Island Lighting Co (Shoreham Nuclear Power Station) ALAB-156, 6 AEC 831, 851 (October 26, 1973); Potomac Electric & Power Co. (Douglas Point Nuclear Generating Station, Units 1 and 2), ALAB-218, 8 AEC 79, 81 n. 7 (July 15, 1974). Moreover, the adequacy of the Applicants' security plan is not subject to review at the construction permit state but will be considered at the operating licensing stage. Consolidated Edison Co.

(Indian Point Station Union No. 2) ALAB-174R, 7 AEC 826, 830 (April 25, 1974). Therefore, the Board has limited the consideration of Commonwealth Contention 9, as an environmental issue, to the risks of theft and sabotage to nuclear materials in transit to and from the plant.

622. The Commission document WASH-1238, Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants, and NUREG-75/038, Supplement 1 to WASH-1238, present the Staff's analysis of the environmental impact of the transportation of radioactive materials to and from nuclear power plants. The report encompasses an analysis of the probabilities of occurrence and the potential consequences of transportation accidents. The conclusions of this analysis are incorporated into NRC regulations in 10 CFR §51.20(g), Summary Table S-4. The consequences of sabotage of shipments of radioactive material would not be significantly different from those described and analyzed in the assessment of accidents in WASH-1238. Staff witness Barker, pp. 2-9, following Tr. 2275; Tr. 2280-81.

623. The Staff analysis for spent fuel, based on NUREG-0194 ("Calculations of Radiological Consequences from Sabotage of Shipping Casks of Spent Fuel and High-Level Waste"), conservatively estimates that the worst case effects that could be expected from maximum potential releases associated with sabotage of a rail cask by high-velocity anti-tank,

recoiless rifle, rocket-fired anti-tank shaped charges and other surface-to-surface and surface-to-air missiles to be no early deaths and about 10 latent cancer fatalities for 100 people per square mile population conditions Affidavit of Kasun and Hodge, p. 2, and Attachment following Tr. 8459, and for sabotage using large amounts of high-explosives, expertly employed with proper design and placement of the charge, less than 1 early death and about 38 latent cancer fatalities, Affidavit of Kasun and Hodge, pp. 3-4, and Attachment following Tr. 8459.

624. Cesium is the primary component of the volatile inventory that would be subject to release. The cesium release as a result of sabotage is estimated to be a factor of 2 higher than that estimated for very severe accident conditions. However, according to the Staff Analysis, a massive rupture of a spent fuel cask is essentially impossible. Affidavit of Kasun and Hodge, pp. 4-5, following Tr. 8459.

625. Applicants' witness Rodger concluded that the potential consequences of sabotage of radioactive wastes would be comparable to those analyzed for accidents involving low-level waste during transportation, Applicants' witness Rodger, pp. 9-10, following Tr. 2024, and that, for the transportation of spent fuels, in the extremely unlikely event a saboteur would succeed in breaching the cask and causing a significant release of radioactivity from within

the fuel rods, the maximum effect on people or the environment is most unlikely to be more than an order of magnitude greater than the maximum effects of the worst accident considered in WASH-1238. Applicants' witness Rodg[illegible], pp. 1, 16, following Tr. 2024.

626. With respect to transportation of radioactive waste, Commonwealth witness Rathjens testified that, "(t)he threat to the public from the possible theft or dispersal of radioactive waste in transit is not serious". Commonwealth witness Rathzens, p. 6, following Tr. 4380. Dr. Rathjens testified that the Massachusetts Nuclear Safety Commission had evaluated the potential for dispersal of radioactive materials from spent fuels in transit and that a scenario had been drawn in which a shaped charge would be utilized to rupture a spent fuel cask and that, "a substantial and sustained fire or something else like that would be needed in order to disperse the material", Tr. 4397-4398; and that, "just to break open a case,...my judgment would be that there would be a lot of alarm and, in effect, the levels of damage would not be great". Tr. 4398. He further stated that "(i)f you really want to disperse the material, it can only be done, I think, as a result of very high temperatures, such as could be produced in the meltdown of a nuclear reactor," and that "we are talking of thousands of degrees". Tr. 4419. Moreover, while gaseous materials might be released due to an explosive rupture, it would be much more difficult for there to be any real dispersal of the fuel elements

themselves Tr. 4398-99. Dr. Rathjens testified that the Massachusetts Nuclear Safety Commission did not evaluate the levels of radiation associated with the amount of gases released in the more likely scenario; however, he believed, "that such amounts as would be released would be diluted in the atmosphere; that, in fact, the real hazard to anybody any significant distance from the cask would really be quite small." Tr. 4399-4400.

627. The desirability to saboteurs of nuclear materials in transit is small due to the form of the material and of the packaging, the uncertainty of the consequences of a successful act of sabotage, the hazard to the saboteurs, the cost of the attempt, the technical knowledge and skills required, and the lack of immediate effect. Applicants' witness Low, pp. 9, 13-15, following Tr. 2024; Staff witness Barker, p. 9, following Tr. 2275. Other materials available to terrorists/saboteurs are more readily amenable to cause quick, lethal effects, such as explosives and chemical agents. Other transported hazardous materials, such as propane, chlorine, liquefied natural gas, biological agents, and etiologic agents, are more readily available and more potentially effective than radioactive wastes. Commonwealth witness Rathjens, Tr. 4404-06, 4417-19; Staff witness Barker, p. 9, following Tr. 2275.

628. In 30 years of experience with the transportation of radioactive wastes and spent fuels, there have been no criminal acts or attempted sabotage directed toward the release or diversion of the radioactive materials. Applicants' witness Low, p. 9, following Tr. 2024, Tr. 2103-04; Staff witness Barker, pp. 3-4, following Tr. 2275. Moreover, the additional event probability due to the small potential for successful sabotage is small compared to the probability of accidents based on the numbers of shipments and historical accident rates. Staff witness Barker, p. 10, following Tr. 2275 , Tr. 2505-2509.

629. The Board finds that the additional risks associated with the potential for sabotage in the transportation of spent fuels and radioactive wastes from proposed Pilgrim 2 are small compared to the normal risks of transportation accidents involving spent fuels and radioactive wastes and are very small compared to the risks of sabotage and terrorist activities that could be otherwise directed at facilities and materials used in this technological society. This small additional risk does not reduce the advantages of nuclear power as compared to alternative sources of power.*/

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*/ The Commission in a recently promulgated "interim Final Rule" has established requirements for the protection of spent fuel in transit. 44 Fed. Reg. 34466 (June 15, 1979). This rule established

(footnote continued on following page)

630. The risk of theft of spent fuel and radioactive wastes is very small. Radioactive wastes have no intrinsic or other value which could be converted into an asset. Further, these wastes have little value for ransom or blackmail

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Footnote continued from previous page.

detailed requirements relative to equipment, routing, prior notifications, escorts, personnel training and the like for spent fuel shipments. 10 CFR §§73.1, 73.37; 10 CFR Part 73, Appendix D. The Commission noted in its notice accompanying the issuance that a recent study suggests, contrary to the conclusions of earlier studies, that the "sabotage of spent fuel shipments has the potential for producing serious radiological consequences in areas of high population density". The interim rule is contemplated to be "in effect until the results of confirmatory research are available and analyzed. 44 Fed. Reg. 34467. The Board notes that, while the recent, as yet unconfirmed study cited by the Commission has suggested that more serious consequences may ensue from acts of sabotage, the regulations promulgated by the Commission will act measurably to decrease the already low probability that such consequences may occur. When the probability of an event is extremely low, the costs associated with the event will be low even if the consequences are quite high. See "Nuclear Regulatory Commission Staff's Proposed Findings of Fact and Conclusions of Law to Authorize the Issuance of a Limited Work Authorization in the Form of a Partial Initial Decision on Environmental and Site Suitability Matters", (August 15, 1977) para. 63. Consequently the Board finds that its overall conclusion that the additional risks of sabotage of spent fuel in transit are acceptably small is not altered by the recent rule regarding additional protective measures for such spent fuel shipments.

because of the lack of potential effectiveness of the materials as a threat to persons or the environment. Applicants' witness Low, p. 8, following Tr. 2024. Spent fuel has a net intrinsic monetary value in the order of $20,000 per ton (less than $10,000 per truck shipment and about $45,000 per rail shipment) but to realize this value, it is necessary to recover the uranium and plutonium from the irradiated fuel. Such separation requires elaborate and expensive remotely operable equipment and facilities equivalent to reprocessing plant capabilities and a high degree of scientific knowledge and technical skills. Theft of spent fuel for ransom would be extremely difficult to perpetrate successfully. Applicants' witness Low, p. 14, following Tr. 2024.

631. The Board finds that the potential risk of theft of radioactive waste and spent fuel is insignificant in that the monetary value is small and the desirability of the materials as an item for theft is small. The advantage of nuclear power with respect to alternative sources of energy is, therefore, unaffected.

M. Effect of Unavailability of Reprocessing and Waste Disposal Facilities on Costs and Environmental Assessment

632. At the request of Intervenor Cleetons, the Board admitted into controversy a contention (Cleeton Contention K) that the delay in the licensing of reprocessing facilities and

in the availability of long-term waste disposal and storage facilities will preclude the availability of sufficient fuel for Pilgrim Unit 2, that longer storage at the site will increase the environmental impact of the facility, and that the additional economic costs will make the plant more expensive than comparable fossil facilities. Board Memorandum and Order (February 19, 1975) at 19. The Board overruled Applicants' objection to the admission of this contention. Board Memorandum and Order on Applicants' Objections to the Board's Order of February 18, 1975 Admitting Certain Contentions (April 2, 1975) at 10-11. The Cleetons introduced no direct evidence, but did engage in cross-examination of witnesses introduced by the Applicants and the Staff. Tr. 4697-4735, 4781-4832, 4859-4898, 4908-4946.

633. Reprocessing of spent fuel to recover slightly enriched uranium and fissile plutonium would eventually displace the need for 40% of the annual uranium ore and 20% of the enrichments requirements that would be needed to fuel Pilgrim 2 without reprocessing and recycle. Applicants' witness Stoller, pp. 4-5, following Tr. 4692.

634. With reprocessing of recovered uranium and plutonium, nuclear power plants which are presently committed will require approximately 1.0 to 1.1 million tons of $U_3O_8$ over their estimated 30-year operating lifetimes at 70% capacity

factors. Applicants' witness Stoller, p. 46, following Tr. 955; Staff witness Nash, p. 2, following Tr. 4853. Without recycle of uranium and plutonium, $U_3O_8$ requirements will increase to about 1.4 and 1.5 million tons. Staff witness Nash, p. 3, following Tr. 4853; Tr. 4742.

635. Estimates of uranium resources by ERDA indicate that approximately 1-3/4 million tons are presently identified as assured and probable reserves recoverable at less than $30/pound forward costs. Applicants' witness Stoller, p. 5, following Tr. 4853; Tr. 4742.

636. The Board finds that the deferral of reprocessing will not preclude the availability of sufficient uranium fuel for Pilgrim Unit 2.

637. The Applicants' fuel cycle analysis estimated that the cost penalty associated with the deferral of reprocessing would amount to approximately 1.0 mills/kwh. Applicants' witness Stoller, p. 13, following Tr. 4692; Applicants' witness Seery, p. 22, following Tr. 8207. The Staff fuel cycle cost analysis estimated that the cost penalty of a no-reprocessing, throw-away fuel option would amount to approximately 1.2 mills/kwh. Staff witness Nash, p. 10, following Tr. 4853.

638. The cost of longer storage of spent fuel at the plant, specifically the incorporation of high-density spent fuel

storage racks, is estimated to be about 2 million dollars, which adds about 0.06 mills/kwh to the total generating cost. Applicants' witness Stoller, p. 12, following Tr. 4692.

639. The total generating cost of electricity from Pilgrim Unit 2 is estimated by the Applicants to be approximately 50.2 mills/kwh in 1988 and, under comparable analyses, is approximately 68.1 mills/kwh from a hypothetical coal-fired alternative power plant assumed to have been constructed on a shore-line generating site owned by Boston Edison Company located to the north of the Pilgrim site. Applicants' witness Maroni, p. 7, following Tr. 8207.

640. The Board finds that the costs of the deferral of reprocessing, including permanent deferral and delays in the implementation of waste disposal, are small in comparison to the total generating cost and to the differential costs of a coal-fired alternative power plant and will, therefore, not increase the cost of electricity from Pilgrim Unit 2 so as to cause alternative sources of power to be economically preferable.

641. The long-term storage of spent fuel at the Pilgrim Unit 2 plant will add to the inventory of radioactivity at the plant after long-term operation of the plant. The thermal contribution of radioactivity sources can be used as a

measure of the radioactivity contribution of those sources. Contribution from the storage of 5 years worth of spent fuel from 1 to 6 years old is conservatively estimated to be approximately 5.7 million Btu/hr, approximately 0.07% of the total fission product radioactivity energy inventory of the operating plant. Applicants' witness Muckerheide, p. 8, following Tr. 4692.

642. The spent fuel pool at Pilgrim Unit 2 will be designed to accommodate 45 million Btu/hr radioactive decay heat load based on conservative assumptions of a full reactor core with 7 days decay after shutdown plus one-third of a core with 90 days decay. Applicants' witness Muckerheide, p. 9, following Tr. 4692.

643. The normal operating condition is the removal of one-third of the reactor core per year which contributes an estimated 7.9 million Btu/hr with 15 days decay. The normal operation heat load design capability of the spent fuel pool is 14 million Btu/hr. The addition of 5.7 million Btu/hr from long-term stored spent fuel to the heat load contribution of freshly discharged spent fuel with 15 days decay results in a total heat load less than the design capability of the spent fuel pool. Applicants' witness Muckerheide, p. 9, following Tr. 4692.

644. In addition to the reduction by decay of the total radioactivity energy inventory in long-term stored spent fuel,

the radioactive sources which remain in the spent fuel are longer-lived radionuclides with generally lower-energy radiation. Therefore, the penetrating ability of the resultant reduced inventory of radioactivity and hence the hazard potential of that source of radioactivity will have decayed away much more rapidly than the total energy contribution of that source. The incremental source of radioactivity from such long-term stored spent fuel would be completely dominated by sources from freshly discharged spent fuel. Applicants' witness Muckerheide, p. 10, following Tr. 4692.

645. The contribution to the total offsite exposure of the population from direct radiation from spent fuel stored in the spent fuel pool and radioactivity in spent fuel pool water is very conservatively calculated to be less than 0.02 millirem per year. Staff witness Parsont, p. 3, following Tr. 4906. The gaseous releases from the fuel pool are insignificant and lead to an even smaller dose than the direct dose. Affidavit of Staff witness Parsont, p. 3, following Tr. 7835.

646. The environmental impact evaluations of accidents that can be expected to affect spent fuel stored and transferred in the spent fuel pool are performed assuming minimum reasonable decay times to maximize the consequences of such evaluations. The consequences of such accident analyses are

dominated by short-lived radioactivity sources which will have decayed away in fuel subject to long decay times. The consequences of such accident analyses envelope the consequences of accidents affecting older spent fuel. Applicants' witness Muckerheide, p. 11, following Tr. 4692.

647. The effect of long-term storage of spent fuel at the plant can only reduce the potential environmental effects of the transportation of spent fuel since by longer decay the sources of radioactivity and, therefore, the heat generation rate in the fuel being transported will have been reduced. Applicants' witness Muckerheide, pp. 11-12, following Tr. 4692. The Board finds the environmental impact with respect to the potential for longer term storage of spent fuel at the plant to be insignificant.

N. Effects of Accidents

648. In accordance with the standard accident assumptions and guidance which were issued by the Commission as a proposed amendment to Appendix D of 10 CFR Part 50 on December 1, 1971—*/, the environmental effects of potential accidents have been assessed by the Applicants and have been independently evaluated by the Staff, ER, §7; FES, §7. Both the Applicants and the Staff have evaluated a comprehensive spectrum of postulated plant accidents, varying in probability from trivial accidents with relatively high probability to highly remote events, such as the design

*/ 36 Fed. Reg. 22851.

basis LOCA. Each of these postulated events have been analyzed and the probable man-rem exposure calculated for an assumed individual at the site boundary, and the estimated integrated exposure of the projected population within 50 miles of the plant. Both the Applicants' and the Staff's calculations show that the man-rem exposures associated with any of these events is but a small fraction of the naturally-occurring exposure due to background radiation and, in fact, well within naturally occurring variations in the natural background. Id.

649. The Board finds that these estimated exposures, combined with the extremely low probability of occurrence for many of these accidents, make the environmental risks, due to postulated plant accidents, exceedingly small. ER, §7, Table 705; FES, §7, Table 7-2. The Staff also concluded, and the Board agrees, that the environmental risks due to postulated occurrences involving sequences of successive failures more severe than those required for the design basis of protection systems and engineered safety features, are exceedingly small. FES, §7.1.

O. Compliance with the Federal Water Pollution Control Act

650. By letter, dated June 20, 1977, the Massachusetts Division of Water Pollution Control, issued a certification pursuant to Section 401 of the Federal Water Pollution Control Act as amended (FWPCA) that the proposed discharges from Pilgrim Unit 2 will not violate Section 301, 302, 306, or 307 of FWPCA. Staff Exhibit 18A, following Tr. 8801. Accordingly, the Board finds that the requirements of Section 401 of FWPCA have been met.

## IV. SITE SUITABILITY MATTERS

### A. Geography

651. The proposed site for Pilgrim 2 is a 528-acre tract of land on the western shore of Cape Cod Bay located in the Town of Plymouth in Plymouth County Massachusetts approximately 4.4 miles east-southeast from the center of the town and approximately 38 miles southeast of Boston, Massachusetts. PSAR § 2.1.1; SER § 2.1. The site can be described generally as a rectangular-shaped piece of land approximately 0.45 by 1.8 miles, with the long axis oriented parallel to the Cape Cod Bay shore. On the northeast side of the site, the land rises from the shoreline to a maximum on-site height of approximately 280 feet above mean sea level. The dominant inland topographic feature is a ridge which extends from the site's northern shoreline boundary to the south for about 4 miles. The maximum height along this ridge beyond the site is about 400 feet above mean sea level. Open water constitutes approximately 60 per cent of the area within a 50-mile radius. PSAR, §2.1.2.

B. Exclusion Area

652. Applicants own all of the land within the site boundary with one exception. A private party, not Applicants, owns a triangular portion of land within the site boundary but such land is not located within the exclusion area. Applicants have the authority to determine all activities as required within the exclusion area. The minimum exclusion area boundary distance is 441 meters. Applicants own the mineral rights to all of the land within the exclusion area. Rocky Hill Road, a public road which provides access to Priscilla Beach, crosses the exclusion area. PSAR, § 2.1.2; SER, § 2.1. The Staff has calculated the offsite radiological doses for postulated design basis accidents and has concluded that Part 100 doses will not be exceeded at the boundary of the exclusion area. SER, § 2.1 and Table 15.2. At present, no activities are being conducted on the triangular portion of land which is owned by a private party and which is outside the exclusion area. Applicants are not aware of any activities planned for this piece of land. Although Rocky Hill Road traverses the exclusion area, Applicants have made arrangements with the Plymouth Police Department to barricade this road at the boundaries

of the site upon Applicants' request. PSAR § 2.1.2.1, SER, § 2.1. The Board finds that the Applicants have the authority to determine all activities within the exclusion area including the exclusion and removal of personnel and property from the area. The Board further finds that Rocky Hill Road is not so close to the proposed facility as to interfere with its normal operations and that the Applicants have made satisfactory arrangements for the control of traffic along this road at the site in order to protect the public health and safety. The Board finds that there is reasonable assurance that the exclusion area is of sufficient size that adequate engineered safety features can be provided to satisfy Part 100 dose guidelines.*/

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*/ Under the date of April 4, 1979 a "Board Notification" was directed to us enclosing a Staff memorandum entitled "Differences in Procedures for Estimating Atmospheric Dispersion Conditions at Inland and Coastal Sites". The Memorandum suggests that the adoption of the model contained therein may result in a general increase in short term accident exclusion area boundary X/Q values for coastal sites, in that heretofore there has been a difference between coastal and inland sites in the selection of the meteorological data base used for the calculation of X/Q values. The memorandum points out that the X/Q values calculated for inland sites are based on dispersion conditions for all wind directions, while, at coastal sites, only the dispersion conditions when wind is blowing onshore have been considered.

(Footnote continued on next page.)

C. Population Density

653. The estimated 1972 resident population within 5 miles of the proposed site is slightly over 9,000. There is a seasonal population (within 5 miles of the proposed site) of slightly over 7,000, some of which occupy summer cottages at Priscilla and White Horse Beaches. Moreover, approximately 800,000 to 1,000,000 tourists visit the Plymouth area each year. Tr. 11,471. Applicants have estimated that the total peak seasonal

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The model discussed in the memorandum is a significant assumption in a new meteorological model published by the Staff in August 1979, Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." This is a new direction dependent model which can be used to calculate exclusion area distances. The Board is of the belief that insofar as the Staff intends to modify its determination with respect to the Applicants' exclusion area as set forth in SER §2.1, Table 15.2, (see, Staff's Memorandum, August 17, 1979, Summary of Meeting to Discuss Exclusion Area and Emergency Planning), that in light of Regulatory Guidel.145, only the Cape Cod Bay segment of the Applicants' exclusion area perimeter stands to be affected, thus leaving in place all prior determinations with respect to the land portion of the Applicants' exclusion area. SER Table 15.2.

population within 5 miles of the site will be slightly over 25,000, but that this peak, when properly weighted to reflect occupancy on an annual basis, totals approximately 4,300. PSAR, § 2.1.3.4 and Table 2.1-2a; SER, § 2.1. The Staff has estimated that the 1980 projected resident population density within 30 miles of proposed site will be approximately 350 persons per square mile. Even when the projected seasonal population is added to this figure on a weighted basis, the population density is less than 500 persons per square mile, SER, § 2.1. The Staff estimated the cumulative 1985 population to be 438 persons per square mile. FSFES, p. 4-4. The Board finds that the population density surrounding the proposed site for the facility is suitable from a population density standpoint.

D. Low Population Zone

654. Applicants have selected a low population zone (LPZ) surrounding the exclusion area with a radius of 2.3 miles from the proposed reactor unit. The 1975 population of the LPZ is approximately 3,000 with an estimated population projection of approximately 8,300 in the year 2020. Applicants' PSAR, § 2.1.3.3 and Table 2.1-1; SER Supplement No. 4, p. 2-1.

655. The Applicants initially identified Brockton, Massachusetts, which is approximately 23 miles from the Pilgrim 2 unit, as the population center with more than 25,000 residents. Applicants have now identified the Town of Marshfield, which is approximately 10 miles from the Pilgrim 2 unit as a potential population center, since it is projected to have a population in excess of 25,000 and a population density of greater than 2,000 persons per square mile by the year 2020. Applicants have further identified the contiguous areas of Plymouth Center, North Plymouth and Kingston Center as a potential population center (there are no official boundaries within the Town of Plymouth) since the population in these areas is projected to increase to about 16,000 by the year 2020. The closest distance from the reactor to a densely populated area of this population center (Plymouth Center) is 3-1/2 miles. Thus, all three population centers identified by the Applicants are at a greater distance than 1-1/3 times the distance from the reactor to the outer boundary of the LPZ 2.3 miles. PSAR, § 2.1.3.5. The Staff has selected the contiguous communities of Plymouth Center, West and North Plymouth and Kingston Center as the population center since these communities are projected

to have a population in excess of 25,000 by the year 1990. The Staff has looked at the population densities and boundaries of the census enumeration districts to determine the closest point of the population center to the reactor. The Staff concluded that the population center should include some, but not all, of the Census Enumeration District No. 1198. The population center distance which reflects this inclusion is 3.1 miles. Based upon the guideline in 10 CFR Part 100 that the distance to the population center shall be at least one and one-third times the Low Population Zone radius, the Staff found the 3.1 mile population center distance to be consistent with the 2.3 mile LPZ. SER Supp. Nos. 3 and 4, § 2.1.

656. The Board finds that assuming, without deciding, that the communities of Plymouth Center, West and North Plymouth and Kingston Center are considered as the population center for purposes of Part 100, and that the closest distance from the reactor to the population center (Plymouth Nursing Home) is 3.1 miles, and that the LPZ is 2.3 miles as described in SER Supp. Nos. 3 and 4, § 2.1, the distance to the population center from the reactor is at least 1-1/3

times the distance from the reactor to the outer boundary of the LPZ. The Board finds that from a population standpoint, there is reasonable assurance that the proposed Pilgrim 2 site is a suitable site for the location of a nuclear plant of the general type and size proposed by the Applicants.

E. Nearby Industrial, Transportation and Military Facilities

654. There are no nearby industrial, transportation or military facilities which would affect the suitability of the proposed Pilgrim 2 site. PSAR, § 2.2.1; SER § 2.2; SER Supp. No. 3, § 2.2. There are no military bases military firing ranges, missile sites, chemical plants, chemical storage facilities, or gas pipelines within a five-mile vicinity of the proposed site. SER, § 2.2. There are no major manufacturing firms within a five-mile vicinity of the proposed site. SER, § 2.2. A petroleum products storage facility lies 4.1 miles from the Pilgrim Unit 2 site. SER Supp. No. 3, § 2.2. The materials that can be stored there are diesel fuel, fuel oil, gasoline and propane. Id. The Applicants performed an analysis which demonstrated that the effects of postulated accidents at this storage facility do not require any special design considerations for Pilgrim Unit 2. NRC Staff reviewed the assumptions and methodology used by the Applicants and concluded that they were conservative. Id. NRC has performed a similar analysis for another nuclear facility, and they applied the knowledge acquired therein to the

Pilgrim 2 review. They concluded that the resultant overpressure due to a postulated propane or other fuel explosion resulting from an accident at the petroleum products storage facility would be significantly less than the external overpressure for which all Pilgrim 2 safety related structures will be designed to safely withstand. The Staff concluded that no special design considerations need to be considered for Pilgrim Unit 2 because of the presence of the petroleum products storage facility. Id. State Highway No. 3A (a two-lane undivided paved highway) runs approximately 0.7 miles west of the site, and State Highway No. 3 (a six-lane divided highway) runs approximately three miles west of the proposed site. Neither of these highways is used for the transportation of extraordinary quantities of hazardous materials. Boats which use Plymouth Harbor pass two to three miles north of the station, and ships which use Cape Cod Canal pass about four or more miles east of the station. PSAR, § 2.2.1, 2.2.2; SER, § 2.2.

F. Aircraft Hazards

659. Intervenor Cleetons have raised the contention that the Applicants and Staff have failed to consider adequately the health, safety and environmental risks of locating the proposed Pilgrim 2 facility in the proximity of a major descending flight path to Logan Airport and the risk of potential impact of aircraft descending to Logan on the proposed Unit 2 site. The Cleetons claim that a consideration of such risks would lead to the selection of a site more suitable from a health, safety and/or environmental viewpoint. Both the Applicants and the Staff have evaluated aircraft flights within the proximity of the proposed Pilgrim 2 site in order to ascertain the necessity of performing an aircraft hazard analysis. According to testimony presented by the Applicants and the Staff, there are (1) no Federal airways or airport approaches which pass within two miles of the proposed facility, (2) no airports located within five miles of the proposed facility, (3) no airports with projected operations greater than $500d^2$ movements per year within 10 miles of the proposed facility or greater than $1000d^2$ beyond 10 miles (d equals the distance in miles from the proposed facility) and (4) no military installations or airspace usage which might present a

hazard to the site. Applicants' Witnesses Larson and Merlino, at 4-6, following Tr. 4577 and Staff Witness Fontecilla, at 1-3, following Tr. 4654. Boston's Logan International Airport is located approximately 37 miles from the proposed facility and had approximately 295,070 movements in 1975. This number represents approximately 22% of the number of movements required before a hazard analysis is required. Applicants' Witness Larson, pp. 5-6, following Tr. 4577. Both the Weymouth Naval Air Station and the Plymouth Airport are located at distances greater than five miles from the proposed facility and neither has movements greater than $500d^2$. Staff Witness Fontecilla, Tr. 4665-4666. The Cleetons' rebuttal Witness Frieden agreed that the Plymouth Airport was more than five miles from the proposed site. Tr. 8424-8425. Therefore, according to Staff guidance, Regulatory Guide 1.70, Revision 2, NUREG 75/094, it was not necessary to perform an aircraft hazards analysis. Id., at 2. However, in response to Intervenor Cleetons' contention, the Applicants and Staff have evaluated the movements from Logan Airport and the flight patterns within the vicinity of the proposed facility. A Federal Airway, known as V-141 which is used primarily

for flights between Logan Airport and Hyannis and Nantucket, passes approximately 3.6 miles from the proposed facility. The Applicants used an average of 70 flights per day along V-141, and based upon the formula set forth in the NRC Standard Review Plan, calculated that the probability of an aircraft using V-141 crashing into the proposed facility was $5.2 \times 10^{-8}$ per crash year or less than one in ten million annually. Applicants' Witness Merlino, pp. 8-10, following Tr. 4577. The Staff chose to use an average of 40 flights per day for 365 days a year since these flights represent the number of flights by Air New England and because the remainder of the flights would be by small aircraft which would cause no significant damage even if they crashed into the proposed facility. Based upon the NRC Standard Review Plan formula, the Staff calculated that the probability of an aircraft using V-141 crashing into the proposed facility would be less than $3 \times 10^{-8}$ per year or approximately one in 33 million. Staff Witness Fontecilla, p. 3, following Tr. 4654; Tr. 4670.

659. The Board finds that the risk of an aircraft using V-141 crashing into the proposed Pilgrim 2 facility

is sufficiently small so that it does not affect the suitability of the proposed Pilgrim 2 site. The Board further finds that the Applicants and Staff have adequately considered the risks of a potential impact on the proposed Pilgrim 2 facility by an aircraft descending to Logan Airport. The Board finds that there are no nearby industrial, transportation, military or commercial facilities which would cause the proposed Pilgrim 2 site to be an unsuitable one for the general type and size of reactor proposed by the Applicants.

G. Hydrology

660. The Pilgrim 2 unit is located on Cape Cod Bay which is a broad, open-mouthed body of water facing northward, and having a surface area of approximately 365,000 acres. The Pilgrim Unit 2 site is in a localized rectangular drainage basin with an area of 330 acres and whose long axis runs approximately parallel to the shoreline. This drainage basin is divided into three areas. The immediate plant area of 50 acres is flat and gently slopes toward Cape Cod Bay. This area will be drained by a system of catch basins and culverts flowing directly into the

Bay The western area of the basin, approximately 60 acres in size, drains directly to the bay of the west of the plant. The remaining 220 acres drains in a northerly direction to a marshy area which flows into a peat bog south of the switchyard and parking area. PSAR, § 2.4.1.1., SER, § 2.4.1. The grade elevation at the site of the proposed Pilgrim 2 structures is approximately 22.5 ft. above mean sea level (MSL). Except for the intake structure, all of the exterior accesses to safety-related areas are at or above the elevation of 23 ft. MSL. PSAR, § 2.4.1.1; SER, §2.4.1. The Applicants and the Staff have evaluated the site and safety-related structures for protection against potential flooding. The analysis of flooding from the probable maximum precipitation at the site shows that water levels would reach to 23.5 ft. MSL. This is about one-half foot above the floor grade on the turbine building site. If such flooding were to occur, there could be some water seepage around a small door of the auxiliary building and around four doors leading into the turbine building area. This leakage, however, would be small and would be more than accommodated by the in-plant draining system, including the sump pumps

located in the turbine building basement. PSAR, § 2.4.10 1; SER, § 2.4.2.

661. The Board finds that the proposed plant grade elevation of 22.5 ft. above MSL for Pilgrim 2 will provide adequate protection against the potential for flooding from the maximum probable precipitation.

662. The Applicants and the Staff have further analyzed the potential for flooding due to a maximum probable hurricane with the concurrent wind and wave effect. If such were to occur, water could reach the auxiliary building, resulting in a maximum runup on the building of approximately 3 feet. However, the auxiliary building will be waterproofed to protect against possible damage. The maximum leakage around closed doors is estimated to be 20 gpm for each door. Leakage will be handled by the floor drainage system and will be well within the capacity of sump pumps. PSAR, § 2.4.10.2, SER, § 2.4.1.

663. Therefore, the Board finds that the proposed plant grade elevation of 22.5 ft. above MSL for Pilgrim Unit 2 will provide adequate protection against potential for flooding from the maximum probable hurricane with concurrent wind and wave effect.

664. The intake structure for the proposed plant will be protected by two breakwaters which serve to reduce plant site flooding. The intake structure is designed for the maximum hurricane surge level of 14.7 MSL (19.5 feet MLW). A reinforced concrete superstructure which houses the service water pumps and the substructure will be designed for the static and dynamic effects of surge level and waves. PSAR, § 2.4.10.2.

665. The Board finds that the safety-related equipment in the intake structure will be protected againt the maximum probable flood. Moreover, drawdown of water at the intake structure may occur due to wind stress of offshore winds. The Applicants have estimated and the Staff agrees that the probable maximum drawdown of water at the intake structure due to a hurricane will be -10.1 ft. MSL. PSAR, § 2.4.11.2; SER, § 2.4.3.

666. The Board finds that the predicted minimum low water level elevation of -10.1 MSL will be above the intake structure which will be -23 MSL and therefore, will not affect the dependability of the water supply to safely shut down Pilgrim Unit 2.

667. There is a small ground-water basin under the proposed Pilgrim 2 site which is not generally used by public or private users. The hydraulic gradient of this ground water is toward Cape Cod Bay and, therefore, there can be no contamination of public or private wells caused by accidental releases of radioactive materials into the groundwater. Moreover, the Applicants will not use any groundwater for the operation of proposed Pilgrim Unit 2. PSAR, § 2.4.13.1; SER, § 2.4.4. The Board finds that the potential for groundwater contamination will have no effect on nearby wells. The Applicants intend to use water from Cape Cod Bay to shut down the proposed Pilgrim 2 facility under normal and emergency conditions. Since the loss of water from Cape Cod Bay is virtually impossible, there will be an adequate supply of water for safety-related purposes. SER, § 2.4.3.

668. The Board finds that with respect to hydrology, the Pilgrim Unit 2 site is a suitable site for reactors of the general type and size proposed.

H. Meteorology

669. The weather in eastern Massachusetts can be characterized as varied and changeable. The region experiences various types of storms including intense

thundershowers, snow and ice storms and severe storms such as hurricanes and "nor'easters." Nor'easters are extra tropical coastal cyclones which occur during the winter. They are characterized by high winds and intense rainfall activity. Hurricanes with high winds and intense rainfall occur occasionally. The "Great New England Hurricane" of September 21, 1938 approached approximately 120 miles from the proposed Pilgrim site and recorded sustained winds of 121 mph and gusts of 183 mph (at Blue Hill Observatory, Milton, Massachusetts). Only limited damage was sustained in Plymouth. PSAR, § 2.3.1, 2.3.2; SER, § 2.3.1, 2.3.2.

670. The Board finds that none of these natural phenomena precludes the site of the proposed Pilgrim Unit 2 from being a suitable site for the general type and size of reactor which is being proposed by the Applicants.

671. Local meteorological data has been collected at the Pilgrim site since May 1968, when a 220 ft. meteorological tower was placed in operation. In April 1974, new equipment was placed on this tower, and, in addition, a new 160 ft. tower was erected in order to collect the necessary data for the proposed Pilgrim 2

facility. PSAR, § 2.3.3; SER, § 2.3.3. Based upon the data gathered from these meteorological sources, the Applicants and the Staff have evaluated the atmospheric dispersion conditions of the proposed site. This information was used by the Applicants and the Staff in the calculation of offsite doses which might result from releases of radioactivity due to postulated accidents. In a comparison with about eighty other sites, the Staff has found that the dispersion conditions at the proposed Pilgrim 2 site are better than about 70 percent of these other sites. PSAR, § 2.3.4; SER, § 2.3.4; Site Suitability Report, at 5, following Tr. 7466.

672. The Board finds that with respect to expected atmospheric dispersion conditions, the site is suitable for the general type and size of reactor which is being proposed by the Applicants.

I. Geology and Seismology

673. As required by the provisions of the Commission's regulations set forth in 10 CFR, §§50.34(a)(1) and 100.11(c)(1), and Appendix A to 10 CFR Part 100, the Applicants have submitted extensive information to the NRC Staff relating to the geology and seismology of the proposed site and relating to foundation engineering for the proposed facility. PSAR, §2.5 and Appendices.

674. In respon to the Staff's request, the Applicants have submitted further information to the Staff in support of its position on seismology, and in particular, on the question of determination of the safe shutdown earthquake (SSE) for the proposed Pilgrim 2 facility. Id. The Staff and its advisors, the U.S. Geological Survey and the U.S. Army Corps of Engineers reviewed the aditional material submitted by Applicants and, subsequent to the completion of this review, reached a conclusion with respect to the SSE. A design basis acceleration of 0.2 g at the ground surface was identified by the Staff. SER Supp. No. 4, §2.5. The Applicants have investigated the subsurface materials underlying the proposed Pilgrim 2 facility by having a total of 61 borings drilled into the subsurface and by excavating two test pits below foundation level. The purpose of

Applicant's investigation was to measure the in-situ density of the soils and to determine from undisturbed samples the properties of the soils for purpose of further evaluation. These investigations have shown that the soil consists of about 90 ft. of dense, poorly-graded to well-graded sands and gravely sands. The upper 20-30 feet of this soil contains layers of silt, silty clay, and sandy clay. Statified sandy glacial outwash, which is the main bearing stratum at the site, overlies bedrock. Over the outwash is a complex mass of glacial till which is about 20 ft. thick. Bedrock consists of contemporaneous igneous rocks, known as the Dedham granodiorite, and the bedrock surface under the foundation area lies between 58 and 80 ft. below MSL. PSAR, §§2.4.1.3.1; 2.5.1.3.3.1; 2.5.1.3.3.2; Site Suitability Report, at 8, following Tr. 7466. No faults or evidence of faulting has been mapped or detected in the site area. The nearest fault which has been mapped is located about 17 miles from the site, although the Staff indicates that a possibility of faulting exists about 10 miles from the site. PSAR, §2.5.1.2.3; Site Suitability Report, at 7.

675. The Board finds that there is no indication of faulting in the vicinity of the site which would affect the suitability of the proposed site.

676. The largest historical earthquake which has been recorded in New England, occurred in 1755 at Cape Ann, Massachusetts and is known as the 1755 Cape Ann Earthquake. This earthquake measured Intensity VIII on the Modified Mercalli scale. Applicants maintain that, for purposes of determing the SSE for the proposed facility, it is appropriate to apply an Intensity VII earhtquake at the Pilgrim site. PSAR, §2.5.2.4. According to the Applicants, the proposed Pilgrim 2 site is located in the southeastern New England platform. The Applicants believe that the Cape Ann earthquake is correlated with an anomalous geologic structure in the area of Cape Ann, Massachusetts, and in particular, with cylindrical mafic plutons of the middle Cretaceous Age. Therefore, the intensity of the Cape Ann earthquake could occur no closer to the Pilgrim 2 site than the nearest mafic intrusive body which is located approximately 50 miles north from the site. Applicants state that an Intensity VIII earthquake 50 miles from the site would result in an Intensity V-VI at the site. PSAR, §2.5.2.3; Site Suitability Report, p. 7, following Tr. 7466. In SER Supp. No. 3, the Staff discussed the results of its review of the additional information submitted by the Applicants. The Staff concluded that a safe shutdown earthquake of maximum Intensity VII would be assumed to occur at the site. SER Supp. No. 3, at 2-15. The Neumann and Trifunac-Brady methods were used to relate the intensity to

an acceleration, and an acceleration of 0.13g was identified. Because soil conditions at the site suggested some amplification could occur, an acceleration of 0.20g at the ground surface was identified by the Staff as appropriate for the Pilgrim 2 facility. SER Supp. No. 3, at 2-15 and 2-16.

677. The Board agrees with the Staff's analysis set forth in SER Supp. 3 and 4, and finds that for purposes of issuance of this Partial Initial Decision, an earthquake of an Intensity VII on the modified Mercalli scale occurring in the vicinity of the proposed site, will be assumed for the Pilgrim 2 facility.

678. The Staff concludes, based on past experience with the design of nuclear power plants, that reactors of the general type and size proposed can be, and have been, safely designed to withstand an Intensity VII event. Site Suitability Report, at 8, following Tr. 7466.

679. The Board concurs. Therefore, the Board finds that from a seismology standpoint, the proposed site is suitable for reactors of the general type and size as the proposed facility.

680. Assuming that an Intensity VII earthquake represents the maximum intensity earthquake which will occur at the proposed

site, and that an SSE of 0.20g ground surface acceleration is determined for this intensity earthquake, both the Applicants and the Staff agree that there is no indication of a potential for liquefaction at the site. Attachment A to testimony of Staff witness Kane, following Tr. 7470; Tr. 7478. The Staff concluded that there is an adequate safety margin against liquefaction for ground acceleration levels up to 0.25g. SER Supp. No. 3, at 2-19.

681. The Board finds that based upon the evidence in the record there is no liquefaction potential at the site of the proposed facility.

## V. COST-BENEFIT ANALYSIS

681. The Board finds that the principal economic and environmental costs of construction and operation of the Facility are summarized as follows:

A. The costs of the Facility will be approximately $2,037,500,000 (See Section II H, supra).

B. The plant, along with Unit 1 will occupy about 45 acres for all station facilities. Approximately 49 acres will be disturbed during construction (See Section III B, supra).

C. Operation of the plant cooling system will cause some adverse effects to aquatic life of Cape Cod Bay, as a result of impingement, entrapment, and passage of organisms through the plant cooling system, but these effects are not considered significant to the overall Cape Cod Bay ecosystem (See Section III C, supra).

D. Nuclear fuel will be consumed.

E. An insignificant amount of radiation will be received by the population within a 50-mile radius of the site, calculated to be 1.8 man-rems per year, as opposed to about 620,000 man-rems of annual background radiation now being received by this population (See FES, Table 10.4, Tr. 8803).

682. The Board finds that the benefits from construction and operation of the Facility are summarized as follows:

A. The Facility will be available to supply needed electrical power for the NEPOOL service area and to assure reliability of the NEPOOL System. See Section III H, supra.

B. The Facility will be available to supply electrical power in substitution for the power produced by imported ore. Such substitution will reduce New England's and the nation's dependency on imported oil and will act to reduce the nation's unfavorable balance of trade and is in furtherance of regional and national energy policies. In this regard, there will also be an economic benefit from the use of less expensive nuclear generating capacity, and there will be a savings of the more versatile fossil fuels. See Section III H, supra.

C. There will be secondary local benefits of increased employment during construction and operation of the Facility, and of the generation of additional taxes (See FES, Table 10.1).

683. Based upon the evidence in the record as of the date of this Partial Initial Decision the Board finds that the environmental and economic benefits from the construction and operation of the Facility will be greater than the environmental and economic costs incurred. Therefore, the Board finds that the balance between the benefits and costs involved in the construction of the

Facility as of the date of this Partial Initial Decision favors granting of the construction permit for the Facility.

684. Further, independently considering the final balance among conflicting environmental factors set out in the record of this proceeding as of the date of this Partial Initial Decision the Board finds that the appropriate action to be taken is to authorize the granting of the construction permit subject to further orders and directives of the Commission, if such action is deemed to be warranted, following completion of evidentiary hearings on the issue of emergency planning and of the full record of this proceeding.

## VI. CONCLUSIONS OF LAW

685. The Board has given careful consideration to all of the documentary and oral evidence presented by the parties. Based on our review of the entire record in this proceeding as of the date of this Partial Initial Decision and the foregoing findings and in accordance with the Notice of Hearing issued in the proceeding, 10 CFR Part 51 and the Commission's regulations, the Board concludes as follows:

A. The Application and the record of the proceeding, contain sufficient information, and the review of the Application by the Staff has been adequate to support the foregoing findings and following Conclusions and Order:

B. In accordance with 10 CFR 50.35(a):

(1) The Applicants have described the proposed design of the Facility, including but not limited to principal architectural and engineering criteria for the design, and have identified the major features or components incorporated therein for the protection of the health and safety of the public.

(2) Such further technical or design information as may be required to complete the safety analysis, and which can reasonably be left for later consideration, will be supplied in the final safety analysis report.

(3) Safety features or components, if any, which require research and development have been described by the Applicants, and the Applicants have identified, and there will be conducted a research and development program designed to resolve any safety questions associated with such features or components.

(4) On the basis of the foregoing, there is reasonable assurance that (a) such questions will be satisfactorily resolved at or before the latest date stated in the Application for the completion of the Facility; and (b) taking into consideration the site criteria contained in 10 CFR Part 100, the proposed Facility can be constructed and operated at the proposed

location without undue risk to the health and safety of the public.*/

C. The Applicants are technically qualified to design and construct the proposed Facility.

D. The Applicants are financially qualified to design and construct the proposed Facility.

E. The issuance of a permit for construction of the Facility would not be inimical to the common defense and security or to health and safety of the public.

F. The environmental review conducted by the Staff pursuant to the National Environmental Policy Act of 1969 and set forth in the FES, FSFES and the Staff's Supplemental Testimony filed in this proceeding has been adequate.

G. The requirements of Section 102(2) (c) and (e) of the National Environmental Policy Act of 1969 and 10 CFR Part 51 have been complied with in this proceeding.

H. The Board has independently considered and decided all matters in controversy among the parties and has independently considered the final balance among conflicting factors contained in the record in the proceeding and determines that the appropriate action to be taken is issuance of the construction permit for the Facility, subject to the conditions for

*/ Subject to such further findings as are warranted following completion of evidentiary hearings on the issue of "emergency planning" and on completion of the full record in this proceeding.

protection of the environment which are set forth in subparagraphs a, b, c, d, and e of paragraph 7 of the Summary and Conclusions as appearing on pages iv - v of the FES.

I. The requirements of Section 401(a) of the Federal Water Pollution Control Act have been met.

J. Based upon the available information and review to date, there is reasonable assurance that the site for Pilgrim Unit 2 is a suitable location of a nuclear power reactor of the general type and size proposed from the standpoint of radiological health and safety considerations under the Act and the rules and regulations promulgated by the Commission pursuant thereto.*/

## VII. ORDER

In accordance with 10 CFR §§ 2.760, 2.762, 2.764, 2.785, 2.786, this Partial Initial Decision shall become effective immediately and shall constitute, with respect to the matters covered therein, the final action of the NRC forty-five (45) days after the date of issuance hereof, subject to any review pursuant to NRC's Rules of Practice. Exceptions to this Partial Initial Decision may be filed by any party within 10 (10) days after service of this Partial Initial Decision. Within thirty (30) days thereafter

*/ Subject to such further findings as are warranted following completion of evidentiary hearings on the issue of "emergency planning" and on completion of the full record in this proceeding.

(forty (40) days in the case of the NRC Staff) any party filing such exceptions shall file a brief in support thereof. Within thirty (30) days of the filing of the brief of the Appellant (forty (40) days in the case of the NRC Staff), any other party may file a brief in support of, or in oppostion to, the exceptions.

IT IS SO ORDERED.

THE ATOMIC SAFETY AND
LICENSING BOARD

_____

_____

_____

Issued at Bethesda, Maryland

this_____day of_____, 1979.

APPENDIX A

Applicants' Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| A | Applicants' Direct Testimony on Alternate Sources of Power | 899 | 955 |
| B | Qualifications of Abraham Gerber | 919 | 955 |
| C | Applicants' Direct Testimony on Alternate Sites | 1636 | 1656 |
| 1-A | Application | 901 | 906 |
| 1-B | PSAR, Vol. I | 901 | 906 |
| 1-C | PSAR, Vol. II | 901 | 906 |
| 1-D | PSAR, Vol. III | 901 | 906 |
| 1-E | PSAR, Vol. IV | 901 | 906 |
| 1-F | PSAR, Vol. V | 901 | 906 |
| 1-G | PSAR, Vol. VI | 901 | 906 |
| 1-H | PSAR, Vol. VII | 901 | 906 |
| 1-I | PSAR, Vol. VIII | 901 | 906 |
| 1-J | PSAR, Vol. IX | 901 | 906 |
| 1-K | ER, Vol. I | 901 | 906 |
| 1-L | ER, Vol. II | 901 | 906 |
| 1-M | ER, Vol. III | 901 | 906 |
| 1-N | PSAR Amendment 21 | 7586 | 7595 |
| 1-O | PSAR Amendment 22 | 7587 | 7595 |
| 1-P | PSAR Amendment 23 | 7587 | 7595 |
| 1-Q | PSAR Amendment 24 | 7588 | 7595 |

Applicants' Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 1-R | PSAR Amendment 25 | 7588 | 7595 |
| 1-S | PSAR Amendment 26 | 7589 | 7595 |
| 1-T | PSAR Amendment 27 | 7589 | 7595 |
| 1-U | PSAR Amendment 28 | 7590 | 7595 |
| 1-V | PSAR Amendment 29 | 7590 | 7595 |
| 1-W | PSAR Amendment 30 | 7591 | 7595 |
| 1-X (1) | PSAR Amendment 31 | 7592 | 7595 |
| 1-X (2) | Report on Fire Protection | 7592 | 7595 |
| 1-Y | PSAR Amendment 32 | 7592 | 7595 |
| 1-Z | PSAR Amendment 33 | 7593 | 7595 |
| 1-AA | PSAR Amendment 34 | 7593 | 7595 |
| 1-BB | PSAR Amendment 35 | 7594 | 7595 |
| 1-CC | ER Amendment 6 | 7594 | 7595 |
| 1-EE | Correspondence between BECo and the NRC | 9229 | 9379 |
| 1-FF | Letter dated 5/23/79 from BECo to O.D. Parr. | 9233 | 9379 |
| 1-KK | Financial Amendment No. 5 | 9599 | 9601 |
| 1-LL (1), (2) and (3) | Financial Amendment No. 6 (In 3 volumes) | 9600 | 9601 |
| 1-MM | Financial Amendment No. 7 | 9600 | 9601 |
| 1-NN (1), (2) and (3) | Financial Amendment No. 8 (In 3 volumes) | 9600 | 9601 |

Applicants' Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 1-OO | Financial Amendment No. 9 | 9600 | 9601 |
| 3 | Letter of 11/28/75 re NRC Inspection Report | 3919 | 3919 |
| 4 | Contract Provision: "I. Quality Assurance" | 3931 | 3931 |
| 5 | Report: "Events Affecting the Availability of Pilgrim 1 During January - July, 1974" | 3964 | 3964 |
| 6 | Letter re BECo's Response to Notice of Violation in Commonwealth Exh. 10 | 4375 | 4375 |
| 10 | UEC Report: "Rocky Point (Pilgrim) Site - An Evaluated Comparison of Site Alternatives | 5916 | 5916 |
| 11 | Letter of 6/29/76 re Testimony of Commonwealth Witness MacDonald | 6226 | 6328 |
| 12 | Letter of 6/30/76 re Testimony of Commonwealth Witness MacDonald | 6228 | 6328 |
| 13 | AFUDC over 90% earnings one sheet: "Salomon Brothers" (formerly exhibit 1-HH) | 9346 | 9379 |
| 14 (a), (b) and (c) | Boston Edison Co. siting study for Long Range Generating Capacity Expansion, 1975-2000 | 9610 | 9610 |
| 15 | Letters and Attachments from Boston Edison Co. to the NRC Concerning Alternate Siting, 1978 | 9637 | 9637 |
| 16 | Letter from Boston Edison Co. to the NRC and attachment (formerly Staff Exhibit 51) | 9672 | 9676 |

Applicants' Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 17-A | Letter from Boston Edison Co. to Averill Laundon, Esq. (6/20/78) | 10,350 | 10,353 |
| 17-B | Letter from Boston Edison Co. to Peter V. Lacouture, Esq., Tillinghast, Collins and Graham (6/21/78) | 10,350 | 10,353 |
| 17-C | Letter from Boston Edison Co. to Lewis Segal, Esq., Murtha, Cullina, Richter and Pinney (6/22/78) | 10,350 | 10,353 |
| 17-D | Letter from Boston Edison Co. to Joseph Ransmeier, Sulloway, Hollis, Godfrey and Soden. (8/2/78) | 10,351 | 10,353 |
| 18 | Package of letters attached to letter to Mr. Regan of the NRC (8/2/78) | 10,352 | 10,353 |
| 19 | Applicants' Revised Supplemental Testimony on the Need for Pilgrim 2 | 10,427 | 10,430 |
| 20-A | NEPOOL Forecast for New England, 1979 - 1989 | 10,740 | 10,740 |
| 20-B | Report of the NEPOOL Load Forecasting Task Force on the NEPOOL Model-Based Forecast of New England Electricity and Energy and Peak Load, 1979 - 1989 | 10,740 | 10,740 |
| 20-C | New England Load and Capacity Report, 1978 - 1989 | 10,740 | 10,740 |

Staff's Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 1 | Attachment A to Testimony of Staff Witness Barker: "Environmental Effects of Transportation of Radioactive Materials To and From Nuclear Power Plants" | 2535 | 2537 |
| 2 | Attachment B to Testimony of Staff Witness Barker: WASH-1238, December 1972, "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants" | 2536 | 2537 |
| 3 | Attachment C to Testimony of Staff Witness Barker: NUREG-75/038, Supplement One to WASH-1238, "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants" | 2536 | 2537 |
| 4 | Safety Evaluation Report (SER) | 3717 | 3717 |
| 5 | SER, Supplement No. 1 | 3717 | 3717 |
| 6 | NRC Letter of 3/5/1975 re Findings of the Inspection of the In-Service Inspection Program | 4237 | 4250 |
| 6-a | Inspection Report No. 50-293/75-05 | 4237 | 4240 |
| 6-b | BECo Letter of 6/19/75 Responding to NRC Inspection Findings | 4237 | 4240 |
| 6-c | NRC Letter of 7/10/75 re BECo Position re NRC Inspection Findings | 4237 | 4240 |
| 7 | SER, Supplement No. 2 | 5393 | 5394 |
| 7 | Supplemental Testimony of M. A. Parsont re MWF Contention 2(C) | 6431 | 6432 |
| 8 | Affidavit of Dr. R. L. Gotchy | 7436 | 7437 |

Staff's Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 8-A | Corrected Affidavit of Dr. R. L. Gotchy | 7818 | 7820 |
| 9 | NRC Site Suitability Report | 7462 | 7466 |
| 10 | FES Revised Section 5.5 and Revised Table S-3 | 7603 | 7607 |
| 11-A | FES Section 4.6: "Radiological Effects: | 7822 | 7828 |
| 11-B | FES Section 5.3: "Radiological Impacts" | 7822 | 7828 |
| 11-C | FES Section 6.1.4.1: "Preoperational Programs" | 7823 | 7828 |
| 12 | Affidavit of M. Parsont | 7834 | 7835 |
| 13 | FES Section 10.4.2: "Economic Costs" | 8307 | 8308 |
| 14 | FES Section 6.1.4: "Radiological" | 8537 | 8538 |
| 15 | FES Section 6.2: "Operational Programs" | 8359 | 8540 |
| 16 | Staff's "Environmental Analysis of Proposed Modified Site Utilization Plan for Pilgrim Unit 2" | 8542 | 8542 |
| 17 | Fig. 1 of Wetland Identification and Mapping Study | 8542 | 8542 |
| 18-A | 401 Certificate | 8801 | 8801 |
| 18-B | Letter of 3/11/77 Transmitting NPDES Permit to Applicants, as modified by Letter of 3/25/77 | 8801 | 8801 |
| 18-C | Federal Permit No. MA0025135 | 8801 | 8801 |
| 18-D | Amendment to Permit No. MA0025135 | 8801 | 8801 |

Staff's Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 19 | FES Table 10.4: "Summary Environmental Costs" | 8803 | 8803 |
| 21 | SER, Supplement No. 3 | 8921 | 8921 |
| 22 | Letter, ACRS to Hon. Joseph M. Hendrie, 10/12/77; subject: "Report on Pilgrim Nuclear Generating Station, Unit No. 2 | 8922 | 8922 |
| 50 | SER, Supplement No. 4 | 9509 | 9509 |
| 52 | Letters from Mr. Butler to Mr. Regal dated 4/13/78 with attachment; 5/20/78 with attachment; 8/2/78 without attachment; 8/11/78 with attachment and 8/18/78 with attachment | 9622 | 9622 |
| 53 | Supplemental Testimony to FES | 9847 | 9852 |
| 60 | A document entitled "Regional Econometric Model for Forecasting Electricity Demand by Sector and by State" | 11,232 | 11,234 |
| 66 | 4 Tables and Text | 11,444 | 11,451 |

1353 088

Commonwealth of Massachusetts' Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 2 | Resume and Testimony of A. O. Converse | 1540 | 1540 |
| 3 | AEC Letter of 4/23/71 to BECo | 3846 | 3846 |
| 4 | AEC Letter of 7/6/71 | 3846 | 3846 |
| 5 | AEC Letter of 1/7/72 | 3846 | 3846 |
| 6 | AEC Letter of 10/18/73 BECo | 3846 | 3846 |
| 7 | AEC Letter of 1/31/74 | 3846 | 3846 |
| 8 | NRC Letter of 3/6/75 | 3846 | 3846 |
| 9 | AEC Letter of 3/29/74 | 3858 | 3860 |
| 11 | Documents re Ultrasonic Reading Violation | 3949 | 3950 |
| 12 | AEC Letter of 4/18/72 | 4296 | 4299 |
| 14 | "BECo's Supplement to Long-range Forecast, 1977 through 1986" | 7908 | 7911 |
| 16 | Report "Nuclear Plant Performance/Update" | 8754 | 8755 |
| 100 | BECo Pilgrim 2 Financial Analysis of Comparative Studies, 7/17/78 | 9268 | 9270 |
| 101 | BECo Board of Directors Meeting, 7/27/78, Report on Pilgrim 2 Project | 9275 | 9275 |
| 102 | Testimony R. M. Kelmon, BECo, Exh. No. BE-100 | 9276 | 9276 |
| 103 | Pilgrim 2, Current Est., 1/31/79 | 9319 | 9322 |

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Commonwealth of Massachusetts Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 104 | Pilgrim 2, Detailed Capital Cost Chronology, 1/31/79, p. 1 of 2 | 9320 | 9389 |
| 105 | DPU 19494, Inf. Request, 1/31/79, p. 2 of 2 | 9321 | 9389 |
| 106 | Pilgrim 2, Estimate No. 4 | 9323 | 9389 |
| 109 | USGS 7.5 min. quadrangle on set, MA, dated 1967 | 10,112 | 10,113 |
| 110 | Letter from W. E. Gordon, NOAA, to USNRC, 11/28/77. | 10,158 | 10,159 |
| 110 | The New England Energy Policy Alternative Study, dated October 1978, Final Report, (Admitted for Impeachment Purposes Only) | 10,698 | 10,708 |
| 111 | Letter from Mr. Landry, EPA, to N.E. Utilities Service Co., to Mr. B. Fox (undated) | 10,161 | 10,161 |
| 112 | SECY 78-137 from E.G. Case dated 3/7/78 | 11,537 | 11,539 |

1353 090

Cleetons' Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 1 | Map of Massachusetts | 8414 | 8457, 8557 |
| 2 | NPDES Permit Hearing Notice | 8801 | 8801 |

Massachusetts Wildlife Federation Exhibits

| No. | Description | Identified (Tr) | Received (Tr) |
|---|---|---|---|
| 1-A | Settlement Agreement Between MWF and Applicants | 6460 | 6460 |
| 1-B | Proposed Technical Specifications for Pilgrim 1 Monitoring Program | 6460 | 6460 |

1353 092