COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF PUBLIC UTILITIES

RE: Performance Standards for Boston Edison Company G.L. Ch. 164, §94G	D.P.U. 1048

Testimony of

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on Behalf of

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Q. Mr. Chernick, would you please state your name, position, and office address.

A. My name is Paul L. Chernick. I am employed by Analysis and Inference, Inc., as a Research Associate. My office address is 10 Post Office Square, Suite 970, Boston, Massachusetts 02109.

Q. Please describe briefly your professional education and experience.

A. I received a S.B. degree from the Civil Engineering Department of the Massachusetts Institute of Technology in June, 1974, and a S.M. degree from the same school in February, 1978 in Technology and Policy. I have been elected to membership in the civil engineering honorary society Chi Epsilon, to membership in the engineering honorary society Tau Beta Pi, and to associate membership in the research honorary society Sigma Xi. I am the author of

> Optimal Pricing for Peak Loads and Joint Production: Theory and Applications to Diverse Conditions, Report 77-1, Technology and Policy Program, Massachusetts Institute of Technology, September, 1977.
>
> Design, Costs and Acceptability of an Electric Utility Self-Insurance Pool for Assuring the Adequacy of Funds for Nuclear Power Plant Decommissioning Expense (NUREG/CR-2370), U.S. Nuclear Regulatory Commission, December, 1981 (with W. Fairley, M. Meyer and L. Scharff).

"An Improved Methodology for Making Capacity/ Energy Allocations for Generation and Transmission Plant", in Institute Award Papers: Proceedings of 1981 Annual Conference, Institute for Public Utilities, Michigan State University, 1982, in press (with M. Meyer).

My professional experience includes over three years as a Utility Rate Analyst for the Utilities Division of the Massachusetts Attorney General. In this capacity, I was involved in review and analysis of utility proposals on a number of topics, particularly load forecasting, capacity planning, and rate design. One of my first major projects for the Attorney General was an investigation of the 1977-78 maintenance outages and associated derating of the Pilgrim I power plant.

In addition to my work for the Attorney General, I have served as a consultant to the National Consumer Law Center for two projects: teaching part of a short course in rate design and time-of-use rates, and assisting in preparation for an electric time-of-use rate design case. I have also served as a consultant to the Northeast Solar Energy Center on rates for cogenerators and small power producers.

My current position with Analysis and Inference, Inc. has involved work on a number of utility-related subjects. These include a study of nuclear decommissioning insurance for the NRC, analyses of gas and electric rate designs, nuclear power cost estimation, and design of conservation programs.

Q. Have you testified previously as an expert witness?

A. Yes. I have testified a number of times before this Department and before the Massachusetts Energy Facilities Siting Council. In addition, I have testified before the Atomic Safety and Licensing Board of the Nuclear Regulatory Commission, and before the Public Utility Commission of Texas. My resume, which is attached as Appendix B to this testimony, lists my previous testimony.

Q. Please describe the subject matter and purpose of your testimony.

A. My testimony discusses what I believe to be certain weaknesses and failings of the performance standards proposed by Boston Edison Company (BECo.). First, I describe the principles and concepts upon which BECo.'s standards should be based, and I explain why BECo.'s standards are inappropriate to the purposes of this proceeding. Second, I propose some superior alternative standards for the use in the short term, and some methods for developing more acceptable standards for the next performance standard proceeding.

Q. How have the changes in the fuel clause statute, and particularly the introduction of performance standards, changed the nature of fuel clause regulation in Massachusetts?

A. Until recently, regulation of the fuel clause was entirely <u>positive</u> or <u>descriptive</u> in nature. That is, the

only questions addressed were those relating to what had actually occurred: Did the utility actually incur this expense? What were the expenditures for fuel or purchased power?

The Department's powers and responsibilities in fuel clause regulation have now been extended to normative or prescriptive issues. The Department must now address such questions as whether the utility has made "all reasonable or prudent efforts . . . to achieve the lowest possible overall costs." The focus has thus expanded from "did" questions to "should" questions.

This recent transformation of fuel clause regulation into a normative process brings fuel clause regulation into line with base rate regulation which has been normative for many years.

Q. Should the fuel clause performance standards be set on a positive basis or a normative basis?

A. In general, performance standards might conceivably be based on any one of a range of concepts ranging from the purely positive to the purely normative. Starting with the positive end of the range, and proceeding to the normative end of the range, some of the possibilities include:

(1) "It will do as well as it will do." (no standard)

(2) "It will do as well as the average (or the worst, or the best) that it has done in the past."

(3) "It will do as well as others like it have done."

(4) "It will do as well as similar ones, competently run, have done."

(5) "It will do as well as has been promised for it."

(6) "It will do as well as it could do."

Except for some special purposes (such as encouraging under-achieving school children), performance standards should generally be based on the normative concepts from the second half of the preceding list. For example, it makes very little sense to hold a utility only to the level of its previous performance, without first determining whether that performance was very poor, very good, or somewhere in between.

The performance standards to be set in this proceeding serve a particular function. The standards will not establish the performance level at which the utility will automatically incur a penalty for any operation of its system which falls below the standard. Instead, the standards will simply flag performance which requires some scrutiny or explanation. Thus, a higher standard would be appropriate for this screening purpose than might be appropriate if there were automatic financial consequences when the utility failed to meet the standard.

Q. On the positive-normative scale you have discussed, where does BECo.'s proposal for setting performance standards lie?

A. BECo.'s proposed performance standard methodology appears to be of the second type in my list, above. Each standard for each plant is based exclusively on data from the plant's performance in certain months of the last three years. However, the standard applied is not even the mean of past performance, but a 95% "confidence interval"[1/] around the mean. By definition, this 95% confidence interval is the range in which 95% of the observations are expected, with the remaining 5% being higher or lower than the range. Thus, only about 2½% of the observations would be expected to fall below the lower limit of this interval, as illustrated in Figure 1. Since BECo. defines its standard on an annual basis, this implies that only for about one year in forty (2½%) would the performance be so low as to justify scrutiny. Thus, this standard will generally be lower than even the worst actual performance in any comparable historical period, and only longest-lived plants would be expected to "fail" the standard (i.e., trigger scrutiny) even once.

However, for availability, equivalent availability, and capacity factors (AF, EAF, and CF), BECo. is proposing an even weaker standard than the worst expected performance in forty years, which I have described. The Company incorporates in the published standards (Exh. BE-8) for these factors an adjustment to reflect the anticipated maintenance schedule: if the maintenance allowance were properly selected, this adjustment could introduce a

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[1/] The problems in the calculation of this "confidence interval" are discussed below.

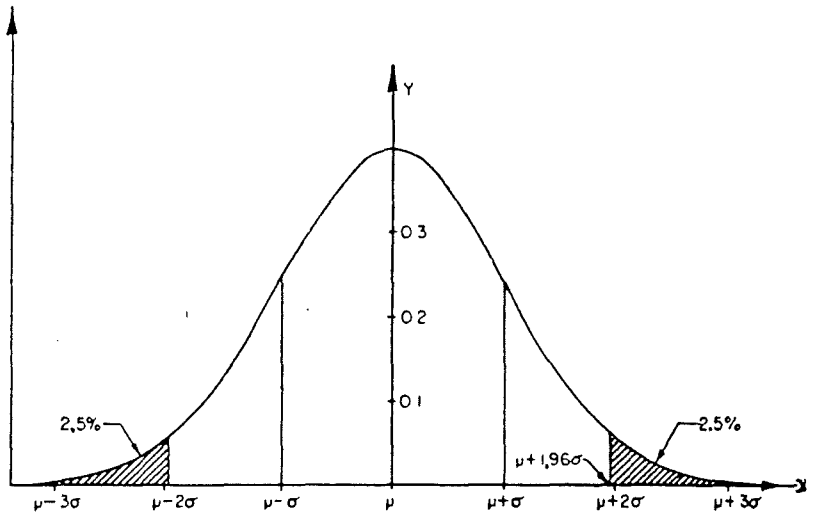

Figure 1: Normal distribution with mean μ and standard deviation σ; the shaded areas comprise 5% of the total.

Source : Snedecor, GW, and Cochran, WG, Statistical Methods (Iowa State University: Ames, Iowa) Sixth Edition, 1967, p. 33.

normative aspect to BECo.'s standard-setting methodology. However, it does not matter how the adjustments were performed, since BECo. has indicated that its standards will change retroactively to reflect outages. As Mr. Zimbone warns on p. I-17 of his testimony "Any changes in the Company's overhaul schedule . . . could have a significant impact on the Company's performance target ranges." This disclaimer is repeated twice in the footnotes in Ex. BE-7. Thus BECo.'s performance standards for AF, EAF, and CF are so adjustable in fact as to be essentially meaningless.

Q. Given that BECo.'s proposed standards are so weak as to be essentially meaningless, how should performance standards be set?

A. There are at least three ways in which standards could be set. First, each unit's performance can be compared to a <u>self-referent</u> standard, based on the unit's past performance. This is the general approach BECo. has taken, to the extent that BECo. has proposed standards. Since self-referent standards are inherently stricter for those units with good performance histories than for those with poor past performance, they are not useful in identifying "efficient and cost-effective operation", and I will not discuss self-referent standards further at this point.

Second, standards can be based on <u>comparative</u> analyses, which aggregate the experience of many units.

The comparisons may simply average data from a set of units with some similar characteristics, or they may involve more complex statistical analysis. The latter approach has been taken in several regression analyses of coal and nuclear capacity factors (Komanoff, 1978; Perl, 1978; Easterling, 1979, 1981; Joskow and Rozanski, 1979). Regression techniques are advantageous for these screening purposes, in that they permit several descriptive variables to be incorporated simultaneously, which facilitates the merging of data from a greater variety of units.

Third, standards may be based on absolute measures of proper performance. Examples of sources for absolute standards include industry standards, power pool assumptions or recommendations, and reports of the unit's performance prepared by the utility for other purposes. For BECo., absolute standards might be based on the performance data reported in BECo.'s filings in response to PURPA §133, and DPU 535; in BECo.'s documentation of its production costing model used for DPU 19494; in the NEPOOL reports presented by BECo. in DPU 19494; and in BECo.'s preoperational representations regarding the performance of its units.

Q. What are the major shortcomings in BECo.'s proposed performance standards and in the methodology on which they are based?

A. Fundamentally, BECo.'s proposed standards are inadequate because they fail to address the apparent purposes of the new fuel clause statute. The problems with BECo.'s proposed standards can be divided into two general groups (data sources and applications), in addition to a set of miscellaneous problems.

There are at least four general problems with the data sources BECo. uses:

A1. Only data from the specific unit under study is used, so the analysis is totally self-referent. No basis is established for identifying efficient operation. In addition, most of the relevant data for establishing historical baselines would come from other units and from earlier years of performance by the particular unit; this data is discarded by BECo. Even for BECo.'s multiple units (i.e., New Boston 1 and 2, and Mystic 4, 5, and 6), performance standards are developed separately for each unit, without reference to the performance of sister units.

A2. No other normative feature is incorporated to compensate for the totally positive nature of the underlying data. In particular, BECo. does not refer to the performance levels it assumes for the same units for other purposes, nor to NEPOOL or industry standards.

A3. BECo. uses only three years of data. Thus, BECo. discards most of the meager data left after the deletion of all other units. More than half the available data on each unit was discarded in this step: for Mystic 4, over 80% of the data is discarded. The basis for choosing these three years is not clear, and raises at least the theoretical possibility of sample bias.

A4. BECo. uses only certain months in the past three years. Again, the basis for classifying a particular month as "major overhaul" is not clear, and again there is the possibility of sample bias.

Once BECo. has collected its data, it commits four basic errors in application:

B1. BECo. incorrectly assumes that the observed sample mean and variance are equal to the true population mean and variance. The numerical effects of this error may very well be inconsequential, because BECo. has used such poor data, and because BECo. does not apply its results in a reasonable manner. Nonetheless, this error is important for two reasons: it allows BECo. to ignore the complete inadequacy of using only three years of data and it indicates that BECo. has not thought through its proposal carefully.

B2. BECo. assumes that sequential monthly performance results are serially independent. This assumption is incorrect in many situations, such as Pilgrim's 1977 derating and Yankee Rowe's turbine failure. Further, the existence of the Heat Rate Improvement Program suggests that BECo. believes that heat rates can vary systematically over time. Assuming independence again allows BECo. to ignore the fact that its data set for each standard consists of only three years, no matter how finely the data is subdivided.

B3. BECo. sets each performance goal two estimated standard deviations below the estimated mean of the distribution. Thus, ignoring BECo.'s other errors, and accepting BECo.'s assumptions, only about 2½% of data would even trigger review. Presumably, not all of this worst 2½% of data would be found to result from unreasonable behavior: thus, BECo.'s exposure to regulation (and its customers' resulting protection is minimized. In fact, unreasonable, inefficient, and suboptimal behavior on BECo.'s part could still produce performance near or even above the mean (of an appropriate distribution), if other conditions are favorable.

B4. For availability factor, equivalent availability factor, and capacity factor, BECo. in effect asks to be excused from any performance standard altogether. BECo. proposes to exclude "overhaul periods" (to be defined retrospectively by BECo.) from the standard. Thus, a year in which Pilgrim has a 10% capacity factor may meet the standard (if BECo. declares 11 months to be overhaul months), while a year with an 80% capacity factor could conceivably fail the standard (if BECo. declares no overhauls). This procedure not only produces absurd results; it also gives BECo. some very perverse incentives. If a Unit has been performing poorly, BECo. may improve its chances of meeting the performance standard by taking it out of service entirely, so that it may be declared to be an "overhaul", and thus excluded from the performance calculation BECo. should be allowed to demonstrate that low capacity factors were justifiably caused by necessary outages, but it should do so by proving that the outages were justified and efficient (or by preventing them), not by retroactively declaring certain time periods to be excluded from scrutiny as "overhaul" periods.

Finally, there are five special problems with BECo.'s proposals, each of which affects only a subset of units or standards:

C1. BECo. averages the heat rates for New Boston 1 and 2, and for Mystic 4, 5, and 6. BECo.'s filings with NEPEX indicate that the heat rates for the individual units can and are calculated separately, and that efficiencies do vary between similar units. Thus, plant heat rates would be expected to vary with the capacity factors of the individual units: if Unit 2 is out of service, for example, New Boston's heat rate would be expected to vary with the capacity factors of the individual units: if Unit 2 is out of service, for example, New Boston's heat rate would be expected to rise.

C2. The calculation of the Mystic 7 heat rate standard assumes the availability of a fixed quantity of gas next summer. In fact, the quantity of gas burned will not be known until after the fact. Therefore, a variable target which reflects the higher stack losses from gas-fired boilers is far more appropriate, such as

$$HRS = HRSO\ (1 + .05\ X)$$

where HRS = the heat rate standard for Mystic 7

HRSO = the standard if Mystic 7 burns only oil, and

X = the fraction of Mystic 7 fuel input which is gas.

C3. BECo. does not propose standards, or even provide historical data, for any of its units for which it is not the sole owner. I can see no reason for exempting any of these units from the standard-setting process. Once a variance has occurred, and in prescribing relief, this Department may wish to recognize the nature of BECo.'s entitlement in the unit as shareholder (the Yankee plants), joint owner (Wyman #4), life-of-unit buyer (Canal #1), or short-term buyer (Coleson Cove, Potter, and Pt. Lepreau); the nature of the variance, the size of and value of the entitlement, BECo.'s efforts to warn or assist the operator, and the relative size and expertise of the parties (perhaps BECo. should provide greater support to Braintree than to larger partners). In order for any regulatory action to be taken, however, standards first must be set so that variances can be detected.

BECo.'s failure to supply data on units operated by others is inconsistent with the public nature of much of this data (particularly heat rate and capacity factor), and BECo.'s ability

to supply data on the units in other cases (e.g., the cogeneration filing of 9/14/81). BECo. should have already possessed at least the NEPEX Form NX-12, FERC Form 1, and NRC "Gray Book" (NUREG 0020) data on the applicable units.

C4. BECo. averages monthly data on heat rates to set a standard for annual heat rate. In general, the months with the lowest capacity factors will show the highest heat rates, since the unit will be operating at less efficient levels. Thus, the simple average of monthly heat rates will generally be larger (and hence more lenient) than the output-weighted annual heat rate.

C5. BECo. has changed the rated capacity of some units without adequate explanation. This tactic renders the capacity factors (CF) of the affected units nearly meaningless, and has a similar but lesser effect on EAF. For example, derating the New Boston units in 1981 from 380 to 355mw increased the reported capacity factors by 7%: if the derating had been to 248mw, CF for unit 2 would have been reported as 100%, rather than 69.8%. Similarly, part of the "improvements" in performance at Mystic 4 and 5, following their overhauls, apparently results from their deratings from 146mw to 135mw.

Q. In general, how should plant performance standards be set?

A. I will describe four methodologies for setting plant performance standards: two absolute approaches and two comparative approaches. For long-lived oil plants (and Yankee Rowe), a self-referent comparison to a long period of the plant's previous operation may be feasible; I will not elaborate further on that option.

Q. Please describe the first of the two absolute approaches.

A. Plant performance can be held up to two absolute standards: the promises made for the plant before it was built, and the utilities' current assumptions about the unit.

Using pre-operational promises to set performance standards is intrinsically appealing: if a utility builds a plant to operate in a particular manner, it is only fair to expect that the plant operate as advertised. This approach helps to tie together planning and operation, and gives the utility greater incentives to extract accurate projections and adequate performance from its suppliers.

Standards may most reasonably be based on prior projections for plants for which cost-effectiveness issues were extensively studied, and for which a reasonable amount of relevant experience with previous plants was available. Both of these conditions certainly apply for the large units under construction or planned in New England. If BECo. chooses to buy into Seabrook, Millstone 3, or Sears Island, it should be held to the performance levels it uses in justifying the purchases. For any of these new large units, I would recommend that failure to achieve the promised performance level should not just trigger review: any additional costs should not be paid by the ratepayers, except in special circumstances.

For Pilgrim 1, the situation is somewhat different. The high reliability that was expected of nuclear units while Pilgrim was being built has simply proven unachievable. Hence, when BECo. provides the early projections for Pilgrim's performance, it should be afforded an opportunity to explain why those projections were over-optimistic.

For Point Lepreau, the performance standard should be set with reference to the performance levels which BECo. uses to justify the purchase. In the event of a variance, the Commission may wish to take account of the limited amount of data on heavy-water reactor performance, and BECo.'s limited control over the New Brunswick Electric Power Commission's operation of the plant, but BECo. should not be completely insulated from risks and responsibility in committing its customers to major capacity purchases.

Q. You have described the applicability of the performance promises to standard setting for Pilgrim, new large units, and Pt. Lepreau. Would the same approach be appropriate for BECo.'s oil-fired units?

A. I believe that the use of performance promises generally would be appropriate for oil-fired units. Several decades of data on oil-fired steam generation were available when BECo.'s oil plants were built. It seems reasonable to expect BECo. to have carefully assessed the tradeoffs between construction cost, heat rate, availability, and load-following capability, and to have accumulated the data required for projecting these parameters. However, I am not familiar with the nature of the predictions made by BECo. or its suppliers while the oil plants were being planned and constructed, so I cannot currently suggest specific sources or values for standards based on this approach.

Q. Please describe the second absolute approach.

A. Performance standards can also be set by reference to recent and current projections of plant performance used by BECo. and NEPOOL for other purposes, such as assessing reliability, planning capacity additions, estimating marginal costs, and setting rates for small power producers. Table 1 displays equivalent forced outage rates (EFORs) and maintenance requirements (MR) as reported in recent NEPOOL and BECo. documents, and calculates equivalent availability factors (EAF's) from these parameters. Table 1 also computes the EAF which would be expected from the most recent projections, where EAF = $(1 - M/52) \bullet (1-EFOR)$. These values may reasonably be used as performance standards, in the meaning of the new fuel clause statute. In addition, any deviation between capacity factor and EAF for nuclear units should be fully explained.

Q. Can similar sources be used for setting heat rate standards?

A. Yes. Heat rate curves have been provided by BECo. or NEPOOL in:

a. GTF (1977);

b. BECo.'s responses to Information Requests AG-1500-13 and 14 in DPU 19494;

c. BECo. (1980);

d. BECo. (1981); and

e. BECo.'s filing in this case.

Two tasks must be fulfilled before this data can be used in standard-setting. First, one of the many heat rate projections (or a variant thereon) must be selected as the basis for the standard. Early or generic projections would be preferable.

Units	Equivalent Forced Outage Rates (%)			Maintenance Requirements (average weeks/year)			Equivalent Availability Factor %
	GTF (1977)	BECo. (1980)	BECo. (1981)	NEPEX (1979)	NEPLAN (1979)	BECo. (1980)	
	a	b	c	d	e	b	f
Pilgrim	9.1	17.3	17.3	6.0	8.5	6	73.2
New Boston 1, 2	9.0[h]	9.0	9.7	3.5	4.5	7	78.1
Mystic 7	7.5[i]	9.1	7.5	6.0	7.5	8	78.3
Mystic 4, 5, 6	3.6	3.6	20.0[j]	2.75	3.5	5	72.3
Wyman 4	9.1	9.1	7.5	6	7.5	9	76.5
Canal 1	7.5	--[g]	7.5	6	7.5	--	79.2
Yankee Rowe	5.2	--	5.2	6	8.5	--	79.3
Conn. Yankee	9.2	--	9.2	6	8.5	--	76.0
Potter 2	11.3	--	9.0	2[k]	--	--	87.5
Coleson Cove	9.0[h]	--	9.1	3.5	4.5	--	83.0

TABLE 1: NEPOOL and BECo. Standards for EFOR and Maintenance

Notes:
a. Generation Task Force Long Range Study Assumptions.
b. PURPA §133 Filing.
c. Congeneration Filing.
d. NEPEX Maintenance Standards, quoted in e.
e. NEPLAN Recommended Maintenance Cycles in Planning.
f. From most recent EFOR and maintenance projections.
g. Not given.
h. Assumed to be once-through; other oil-steam units assumed to be drum type.
i. If capacity over 600mw, EFOR = 9.1; ratings vary.
j. 100% for Unit 6.
k. Source A and actual 1977-78 maintenance; 1979-83 schedule (from DPU 19494) averaged 2.4.

Second, a heat-rate standard must be developed which accounts for unit loading, either in a simple way (e.g., as a linear function of CF/AF) or in a detailed way (e.g., by calculating fuel use if the heat rate curve standard were met, under actual loadings). This latter task should probably be undertaken regardless of the source of the heat rate estimates: efficiency targets are of limited significance if they are set without reference to load levels.

Q. Please describe the first of the comparative approaches.

A. A performance standard may be set with reference to a (generally small) set of very similar units. For Pilgrim, this set could be the other six BWR's between 500mw and 700mw. For Connecticut Yankee, the comparison set could be the other seven Westinghouse PWR's between 400mw and 650mw, or it could also include the other PWR in that size range, Fort Calhoun. In either case, the comparability of the units and their selection is debatable, especially as regards the inclusion of the smallest unit in each set. For Yankee Rowe, no comparable unit exists, at least in the U.S., so this technique is not applicable. I have not attempted to construct comparison groups for the oil plants.

Q. Have you established any comparative standards for Pilgrim and Connecticut Yankee from the experience of similar plants?

A. Yes. I have used data only through 1979 (more recent data is not readily available to me, but is published in the NRC Gray Books, NUREG 0020), and only for mature operating experience. I defined "mature" as starting with the fifth full calendar year of operation, following the conclusions of

Easterling (1981) and of GTF (1977). On this basis, the Pilgrim comparison group had 23 years of mature experience through 1979, and the Connecticut Yankee Westinghouse group had 25 years. Easterling (1981) provides capacity factors based on maximum generator nameplate (MGN) through 1979: for mature years, the two comparison groups have average MGN capacity factors of 68.9% and 71.1%. Expressed in terms of NEPOOL capacity measures, these averages convert to 69.7% for Pilgrim and 74.2% for Connecticut Yankee.

Similar analyses can be conducted for different comparison groups, different measures of capacity, and different performance measures. Specifically, capacity factor data based on design rating and dependable capacity, as well as availability factor and forced outage rate data are available from the NRC Gray Books and periodic compilations, such as the Annual Report series. In addition, EEI and EPRI compile data on several performance measures.

Q. Please describe the second comparative methodology.

A. A larger group of plants can be incorporated into the standard-setting, by the use of more sophisticated statistical analyses. Some studies which have taken this approach are listed earlier in my testimony. The most recent such study is Easterling (1981), which finds an expected MGN capacity factor for a mature BWR of 65.0%; for Pilgrim's 670mw rating this is equivalent to 65.8%. For Connecticut Yankee, the expected capacity factor would be 72.5% based on MGN, or 75.7% based on the 575mw NEPOOL rating.

Q. Do the regression studies you cited represent the most appropriate application of that technique to the purposes of this proceeding?

A. No. These studies only cover nuclear and coal plants, estimate only capacity factor, and neglect several explanatory variables which may be important in setting performance standards. Appendix A discusses further the design of regression studies of performance factors.

Q. What performance standards would you recommend imposing in this proceeding?

A. Since BECo. has not performed the necessary comparative or absolute analyses, or presented the prerequisite data (and has objected to providing much of that data), any decision made at this time should be quite preliminary, and not constrain subsequent investigations. In particular, uncertainties should be resolved by setting the important standards at the high end of the plausible range, to preserve the ability of the Commission and intervenors to pursue investigation of questionable performance.

Until a more rigorous analysis can be performed, I recommend using the performance standards from Table 1 for EAF, and thus for nuclear CF. Heat rates for oil units also deserve a thorough analysis; until such an analysis is available, I would suggest basing the performance standards on the best heat rates ever reported on the NEPEX NX-12 forms. Specifically, the target heat rate could be the value predicted for the load level equal to average load while operating, which can be estimated as the

observed capacity factor divided by the observed availability factor. Thus, for Mystic 7 in 1981, the standard would have been evaluated at 56.2/79.9 =70.3% of full load, or 397mw. Revision 2 of NX-12 (the earliest and most optimistic version BECo. has provided) predicts a heat rate of 9538 BTU/kwh for that loading. Of course, BECo. may be able to demonstrate that changes in fuel type, cooling water temperature, environmental restrictions, or other uncontrollable (or prudent) changes have reduced the achievable efficiencies at particular units, in which case the standard may be relaxed. Similarly, BECo. may be able to report hours of operation by load level, to facilitate a more precise comparison of BECo.'s claimed heat rates (in the NX-12's) with actual heat rates.

Q. You have suggested EAF standards for all BECo.'s steam plants or entitlements, CF standards for its nuclear plants, and heat rate standards for the oil-fired steam plants. Do you have suggestions for the other standards for steam plants and for the gas turbines?

A. The other standards can be divided into three groups. First, nuclear heat rates have a direct financial effect on rate-payers, but the effect is smaller (for an equal percentage change) than the factors discussed above. Appropriate comparative or absolute analyses can and should be used to set standards for nuclear heat rates, but the level of scrutiny may reasonably be lower. I would expect that somewhat less effort would be expended in setting these standards (e.g., the comparative analyses may be simpler), and that request for variance hearings would be rarer.

The second group of "other standards" are those for steam plant performance factors which have little direct economic consequence: these are AF, FOR, and for oil plants, CF. It is useful to have data on these performance factors, to help in identifying problems. For example, a 70% annual EAF may appear reasonable in itself, but not in conjunction with a 25% FOR, which may indicate that scheduled maintenance was deferred to produce a high EAF. Also, if CF (an objective, observable factor) falls dramatically relative to EAF (a partially judgmental factor), some explanation is required. Therefore, these factors should be reported, and performance standards should be set for them. Most variances in these factors, unless accompanied by variances in heat rate or EAF, will probably be easily explained and not lead to hearings.

The third group of supplementary standards relates to the gas turbine units. I agree with Mr. Zimbone that CF and heat rate are not currently important with respect to these units and the standards may be set arbitrarily. If he is correct in asserting that the turbines do not operate derated, then EAF is equal to AF and need not be separately reported. Availability factor is important, since the great value of gas turbines is that they provide inexpensive, reliable capacity. Even under conditions of considerable excess capacity, such as in New England now and for the foreseeable future, turbines are useful in meeting sudden changes in load, major plant failures, and transmission outages.

Events of these types have caused periodic customer disconnections, especially in Southeastern New England, even in the post-embargo period. In addition, the time pattern of availability is important, so it would be useful to know how much of the loss in AF is due to forced outages, as opposed to scheduled maintenance. Unfortunately, FOR, as currently defined, is not a useful measure of forced outage contributions to unavailability, since the denominator does not include all non-maintenance hours in the period. Thus, both AF and FOR may be close to 100%. A better measure of contribution of forced outages to unavailability would be most useful in judging the performance of the gas turbines. Comparative or absolute standards should be developed for both AF and a revised forced outage measure. GTF (1977), BECo. (1980), and BECo. (1981) all report 20% FOR for jet turbines; GTF anticipates 2 weeks of annual maintenance while BECo. (1980) expects 12 weeks. These parameters produce annual AF's of 61.5% to 76.9%. Therefore, reasonable standards would be 61.5% for AF and 20% for FOR, defined as a fraction of non-maintenance hours in the period.

Q. Do you have any other suggestions regarding the definitions of standards?

A. Yes. Regarding Mr. Zimbone's comments on "modifications . . . to the recommended procedures . . . for calculating one of the performance factors" (SP3, pp. I-12, I-13), I agree

that EAF should recognize all deratings. As for the definition of capacity rating, I see no objection to any of a number of ratings, so long as three conditions are met. First, it must be clear what rating is being used and why; it is not clear whether BECo. used the same capacity in defining performance standards (and historic EAF) that it did in calculating historic CF, or what other capacity rating may have been used. Second, the capacity rating used must be consistent with those used in the data: at least for New Boston and Mystic 4 and 5, rated capacities have changed since 1979, so this condition may not hold for BECo.'s data set. Third, BECo. must refrain from changing the rated capacity of its units for these purposes, except for good cause and with a complete explanation; as noted above, manipulation of rated capacity can totally obstruct the purposes of performance reviews.

Mr. Zimbone does correctly observe that the random variation in performance standards tends to decrease as the time period of observation increases (SP-3, p. I-15). While BECo. has oversimplified this point (as I explained previously), the general principle is valid. Literally any capacity factor may be reasonable for one month, or even one quarter, while a much narrower range of factors is expected over a year. The range continues to narrow over time, so that five year average capacity factors are more reliable measures of performance than one year capacity factors. This is particularly true for nuclear units, which probably display negative serial correlation between years, due to the timing of refueling outages. It is therefore

appropriate to review performance over the long term, and to evaluate this quarter's performance both on its own merits and in the context of the last year, or the last five years. In addition to permitting more definitive identification of inferior or superior performance, the longer view should result in fewer compliance hearings: the Department and intervenors need not take action in every quarter in which a performance factor is weak, but may wait until a definite and significant pattern of operating problems emerges. Thus, the quarterly target can be thought of as

$$t_q = t_l(n + 1) - \sum P_i$$

where t_q = standard this quarter

t_l = long-run standard

n = number of previous quarters considered

p_i = performance in previous quarter i.

If the Commission does not allow full cost recovery in some quarter due to an inadequate performance factor, the p_i used in future reviews should be the allowed performance, not the actual performance.

Q. Do you have any comments on the calculation of system average performance?

A. Yes. While average system heat rate or EAF is not a tremendously meaningful figure, there is no harm done in calculating such averages. However, they should be calculated in the most relevant manner possible. BECo.'s kwh weighting is basically appropriate, but the weights should be based on BECo.'s sources of energy, not on generation at BECo.-owned plants. Thus, the

average should include BECo.'s entitlements in major units operated by other utilities, and exclude the unit sales from Pilgrim.

Q. Do you have any comments on the data that should be included in BECo.'s annual and quarterly filings?

A. Several types of data should be added. First, standards should be set, and data reported, for BECo. entitlements not operated directly by BECo., particularly the Yankee plants, Pt. Lepreau, and Canal. It would certainly make sense for one utility to take responsibility for presenting standards and data for each plant, and for the other owners (or holders of entitlements) to accept the results of the lead utility's standard-setting proceedings and quarterly reviews. Thus, BECo.'s proceedings might set standards and reach conclusions on the reasonableness of Pilgrim performance which would be applied to Eastern Edison and Commonwealth Electric, and the results of Commonwealth cases for Canal could apply to BECo. Table 2 lists the units in which both BECo. and other utilities possess entitlements, and suggests lead utilities for each. In addition to the units listed in Table 2, lead utilities should be designated for the Maine and Vermont Yankees, New Haven Harbor, and Canal 2.

Second, to allow accurate comparison of actual heat rates to appropriate standards, the number of hours each unit spent at each load level should be reported. This data, combined with heat rate curves, allows the setting of heat rate standards which incorporate the effects of

Unit	Suggested Lead Utility for Performance Standards
Pilgrim I	BECo.
Canal 1	Commonwealth
Yankee Rowe	MECo.
Connecticut Yankee	WMECo.
Wyman 4	MECo.
Pt. Lepreau	BECo.
Potter 2	BECo.
Coleson Cove	MECo.

Table 2: Suggested Lead Utilities for Performance Standards.

actual operation.

Third, any deviation of EAF from CF for a nuclear unit of more than one percentage point should be fully explained. As indicated in BECo.'s response to the Attorney General's information request 1-15, small differences may result from round-off errors. Larger differences are more likely to result from over-estimates of EAF, or from details of the EAF definition which reduce the usefulness of EAF as a reliability measure. It is important for the Commission and intervenors to understand how well BECo.'s estimates of EAF fare as proxies for potential capacity factor.

Fourth, the MW rating of units used in evaluating performance should not be changed without adequate explanation. Initially, the rated capacity should be the highest values reported to date until reductions are justified.

Fifth, the data used in setting standards should be compatible with the data collected for review. I have previously discussed this problem for heat rates, for which BECo. mixed monthly averages and kwh averages, and for capacity ratings.

Sixth, so that the Department and intervenors may estimate the importance of each outage, BECo. should report kwh and payments for scheduled and unscheduled outage by unit. This data should be available from NEPEX's billing program, which dispatches BECo. units and entitlements on a full-availability, stand-alone basis and charges different rates to BECo. for units which were not run, depending on the type of outage (economy, scheduled, or

unscheduled).

Seventh, BECo. should file periodic reports on its efforts to lower average system heat rate through co-generation, particularly, although not exclusively, with BECo.'s own steam system. New cogeneration equipment, supplying steam, hot water, or other forms of thermal energy to BECo.'s steam system or to other entities, would probably have heat rates in the 5000-6000BTU/kwh range, and thus reduce average system heat rates. In addition, if New Boston provides cogenerated steam to BECo.'s steam system, then the heat rates for those units will also improve. The same is true for sales of heat from Mystic station. If there are good reasons for BECo. to have no cogeneration on its system, now that L Street no longer cogenerates, BECo. should provide those reasons; otherwise, an aggressive cogeneration development program should be part of the Heat Rate Improvement Program.

Eighth, BECo. should report projected and actual burn uprates for its nuclear units. Nuclear fuel use efficiency is a function of heat production per ton of uranium (usually expressed as megawatt-days thermal per metric ton of uranium, or MWD(t)/MTU), as well as of kwh per BTU of heat production (heat rate). Unlike fossil fuels, uranium fuel is removed and discarded before all of the available energy is extracted; the Commission should know how refueling schedules affect burn up.

Ninth, and most importantly, BECo. should design performance standards based on reasonable comparative or absolute analyses.

Q. Does this complete your testimony?

A. Yes.

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