p.70

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC UTILITIES

RE: BOSTON EDISON COMPANY'S CONSTRUCTION PROGRAM AND CAPACITY NEEDS, DPU 19494

COMMONWEALTH OF MASSACHUSETTS
ENERGY FACILITIES SITING COUNCIL

RE: BOSTON EDISON COMPANY'S SUPPLEMENT A-2 TO THEIR LONG-RANGE DEMAND AND ENERGY FORECAST, E.F.S.C. NO. 78-12

JOINT TESTIMONY OF PAUL L. CHERNICK AND SUSAN C. GELLER ON BEHALF OF THE ATTORNEY GENERAL

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TABLE OF CONTENTS

I. QUALIFICATIONS

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

A: My name is Paul Chernick. I am employed by the Attorney General as a Utility Rate Analyst. My office address is One Ashburton Place, 19th Floor, Boston, Massachusetts, 02108.

Q: Please describe briefly your professional education and experience.

A: I received a S.B. degree from the Massachusetts Institute of Technology in June, 1974 in Civil Engineering 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 Applications to Diverse Conditions, Report 77-1, Technology and Policy Program, Massachusetts Institute of Technology. During my graduate education, I was the teaching assistant for courses in systems analysis, for which I prepared course notes and taught classes in regression and other topics in modeling. My resume is attached to the end of this testimony as Appendix A.

Q: Ms. Geller, would you please state your name, position, and office address?

A: My name is Susan C. Geller. I am employed full-time as a utility rate analyst in the Utility Division of the Massachusetts Attorney General's Office. My office address is One Ashburton Place, 19th Floor, Boston, Massachusetts, 02108.

Q: Would you please briefly describe your education and employment background.

A: I graduated from Harvard University in June 1974, with a B.A., magna cum laude, in Economics. In addition, I have a Master's Degree in Public Policy from the John F. Kennedy School of Government, Harvard University and I have completed the course requirements and passed the qualifying examinations for the Ph.D. in Public Policy. My work experience includes:

1. A summer internship at the Atomic Energy Commission in 1973 where I collected and analyzed data for the Nuclear Reactor Safety Study (the "Rasmussen Study");

2. A research assistantship at the Harvard Business School where I helped prepare a seminar for business executives and public officials on the problems of producing electric power for New England (summer 1974);

3. Volunteer consulting for the Region 1 Office of the Environmental Protection Agency (spring 1975);

4. A research assistantship at the Kennedy School of Government, dealing with issues of technological safety (summer 1975).

My resume is attached to the end of this testimony as Appendix B.

II. RESIDENTIAL TRENDING

Q. Do you have any comments to make on the methodology used in BECO's residential appliance number and housing mix forecasts on pp. II-20 to II-60?

A. Yes, I do. I would like to comment on:

1. the inconsistency in the choice of projection techniques;

2. the selection of variant techniques in similar situations, inadequately justified and often partially disguised, resulting in inflation of electric use predictions;

3. extrapolation of trends far beyond past experience and close to physical limits; and

4. reliance on trends which are not evident in the data.

Q. What comments would you like to make regarding the choice of projection techniques used in these forecasts?

A. In examining the forecasts, I have identified 26 factors which BECO (or Gilbert) projects for the next decade. Of these, 11 projections seem to be based on average historical values, another 11 apparently attempt to continue the historical trends, and the remaining four are derived from the most recent data (generally 1974 or 1975).

There may be valid reasons for selecting a trend, an average, or most recent data to use in projections. Some speculative examples may serve to illustrate the factors which can determine the choice of projection technique. It seems reasonable to suppose that sales of the new micro-electronic home toys will accelerate as performance improves and prices fall in this rapidly advancing field. The same is probably true for solar heating retrofit products for the same reasons. Penetrations of these devices may be appropriately projected by some form of trending. On the other hand, while the short-run ratio of clapboard to brick facing may vary with fluctuations in price and fashion, the underlying technology, economics and social preferences are probably fairly stable and the last decade's average ratio may be a respectable predictor for the next decade's average ratio.

However, BECO's forecast does not present a consistent set of criteria to be used in selecting the projection method for each of the coefficients used in the housing and appliance forecasts. Nor is any detailed justification given for the choice of projection technique for any particular parameter. As Mr. Petrello states in his testimony in reference to other portions of the forecast, such ad hoc, unsystematic approaches severely limit the reviewability of the forecast. If the forecast specified the assumptions made about the nature of the buyers, the sellers, the costs, and the technology of each appliance on housing type as well as describing the rules which would be applied to those assumptions to select a projection methodology, the appropriateness of each step could be examined. Hence, the sensitivity of the forecasts to various reasonable changes in the assumptions could be determined and crude confidence intervals could be established. In the absence of a consistent and comprehensive analytical framework, the value of these projections in a public document is limited to the reader's faith in the wisdom and impartiality of the authors. In the present case, I find little evidence for either of these characteristics in the preparation of the forecast.

Q. Do you perceive any other difficulties in the choice of projection techniques?

A. Yes, I do. Once a particular projection technique is chosen, the forecasts frequently apply some inadequately documented modification. In some cases, the average (or last year's) figure was gradually decreased to reach a specified value in 1985, without any explanation of the way in which the rate of decline was determined. In other cases, the data from only certain years is selected for averaging or trending. Neither the amounts by which the parameters are adjusted in each projected year nor the rationale for this pattern of change is specified. These undocumented and apparently inconsistent choices create problems of reviewability and confidence similar to those caused by the arbitrary choice of projection techniques, which both Mr. Petrello and I have discussed. These choices are also subject to imposition of the same type of structure and consistency as are the choices of technique, if the forecaster desires a reviewable product subject to confidence estimation.

Q. Please expand on your earlier statement that different techniques have been used in similiar situations, resulting in inflated electric use predictions.

A. The clearest examples of this problem are found where home and apartment penetration rates for the same appliance are projected in different ways. Specifically, I will discuss electric space and water heating penetration, which are quite similiar, and central air conditioning penetration.

In the discussions of heat and hot water penetration (pp. II-31 to II-45) there is no discussion of factors (other than past penetration data) that applies differentially to home use and apartment use. Therefore, since Gilbert apparently believes the same forces to be acting, penetrations for both housing types should be projected in the same manner. However, for both uses, home penetration projections are based on the average penetration over the last eight or nine years, while apartment penetrations are projected based on the data from the most recent year reported.

The average home penetration rates are not much different than the latest year's penetration rate; the particular choice of projection technique for homes for these appliances is less important than the subjective modification made in the projection. But the latest year's data for apartment heat and hot water penetrations are, respectively, 95 per cent and 42 per cent greater than the average values for those parameters. Thus, with no explicit justification, BECO or Gilbert has manipulated projection methods for these appliances so as to produce the greater initial electric penetrations. Even though Gilbert reduces these penetration projections somewhat over time, the projected apartment penetrations remain above historical averages throughout the forecast period.

Gilbert (or BECO) would seem to have had some inkling that this procedure was suspect. They attempt the following explanation with respect to space heating: "With regard to multi-family housing, it is evident that this segment of the market continues to utilize electric heat in greater than 60 per cent of the projects." (p.II-39). In fact this is not evident at all, since the penetration exceeded 60 per cent only once, in 1975, the year on which the projection was based.

For water heating, the approach is somewhat different; the forecast avoids mentioning the starting value for the projection. "With respect to new market penetration for apartments a steady long run decline is anticipated and they (Gilbert) project that by 1985 the new market penetration rate for electric water heat will be 35 per cent." (p. II-45). For most parameters, including all seven other parameters estimated for space and water heating, the starting value is specified, e.g. "new market penetration of electric water heat in homes will decline steadily from the historic average level of 30 per cent to around 21 per cent by 1985." (Ibid.)

The use of the latest year's data for space and water heating is particularly objectionable because of the genesis of the latest year figures. Over the last few years of the data set (1971-75), the estimated numbers of new apartments with electric heat and hot water stayed roughly constant, while the total estimate of new apartments fell sharply. The decrease in the estimate of new apartments may have been due to either survey problems or economic conditions. In any case, the penetrations in this period vary inversely with the estimated number of new apartments. If the number of apartments built increases, as BECO has forecasted, then these penetrations would be expected to fall. The penetrations may decrease in any case; for example, the approximately 2000 unit/yr. all-electric market may be a limited luxury market.

The central air conditioning projections (II-45 to II-50) are biased in a similiar, if more straight-forward, manner. Again, no argument is made that home and apartment penetration should be handled differently. Nonetheless, they are projected with completely dissimilar techniques. Home penetration is projected at the average of the last three years of the data set; these three numbers happen to be the highest values of that parameter in the data set. In contrast, the last three years of the apartment penetrations are three of the four lowest in the data set. The apartment projection is not based on this average at all, but instead is "trended" upward in some mysterious way to the highest value since 1966; it is implied, but not specified, that this "trend" starts with the last year penetration.

Thus, in central air conditioning, as in space and water heating, projection techniques have been arbitrarily tailored to produce high penetrations.

Q. How has the Forecast engaged in excessive extrapolation?

A. The Forecast projects linearly increasing penetrations or saturations of several appliances which reportedly have been rapidly increasing in popularity over the past decade. Among the statistics which show strong growth trends in the Forecast's data set are room air conditioner penetration, frost-free refrigerator sales percentage, dishwasher saturation and color television saturation. Without a more thorough examination of the factors driving consumer decisions, BECO's projection of these trends through the next decade is unreliable.

For example, BECO's data indicates that room air conditioner penetration increased from 55 percent in 1966 to 68 percent in 1974. Therefore, the portion of the new market population which did not buy room air conditioners decreased approximately 29 per cent in that period. Over the next decade, the Forecast projects that the penetration rate will rise to 85 per cent. The non-buying fraction of the market is thus predicted to decrease by 53 per cent from the 1974 level. This means that data gathered while a large non-buying population decreased by less than a third is being extrapolated to predict a decline of over one half in the current smaller non-buying population. Such a prediction obviously extends beyond past experience and the bounds of common sense.

Even more extreme examples can be found in the Forecast. The most striking case is the frost-free refrigerator percentage projection. Non-frost-free refrigerators lost less than one third of their market share in BECO's 1969-1975 data series. Yet, that trend extrapolated to 1985, predicts that the share will decline (90%)

in the next decade, with 96 percent of 1985 sales being frost-free. Continuation of the trend would result in 102 percent frost-free sales in 1988; Gilbert arbitrarily stops frost-free sales growth in 1985.

The Forecast lacks the clear and consistent intellectual scheme which would be necessary to justify either such far-reaching projections, or the modifications required to make the projections plausible.

This is particularly evident when one considers the Forecast's verbal justification for using these trends. For many appliances, the Forecast examines purchase price as a percentage of effective buying income. For example, for air conditioning the Forecast states:

> Gilbert has compared room air conditioner unit purchase cost against Effective Buying Income for the Boston Edison Company retail sales area as presented in Sales Management Magazine and have found that between 1970 and 1974 purchase cost of an average room air conditioning unit has decreased as a percentage of effective buying income. In 1974, the purchase cost of an average room air unit was only approximately 1.4 percent of total annual effective buying income. One can conclude, therefore, that neither income nor purchase cost should pose any detriment to the continuation of the historic trend in new market penetration. (p. II-46).

Several important points are ignored by this argument. First, appliances are purchased by a range of actual households, not by the average regional households. Second, for some of BECO's customers, the cost of a typical air conditioner is much more than 1.4 per cent of buying income, and increasing; for others, it is less and decreasing. Third, the most affluent consumers are probably already buying air conditioners for new dwelling units, and are so counted in the historic data. Fourth, the current non-buyers, in addition to being poorer than the present buyers, probably tend to have other reasons for not buying appliances. Highly mobile renters, such as students, may be averse to accumulating numerous heavy possessions. Many people, especially in apartments, may simply not have room for dishwashers, clothes washers, dryers, and the like. Locational factors, e.g., proximity to a laundromat or a nice cool lake, may affect individuals demand for such appliances as washer-dryer and air conditioners. Smaller households would be less likely to find it worthwhile to invest in many appliances which will always be underutilized by only one or two people. In short, people of the sort who have not bought particular appliances in the past probably have good reasons not to buy them in the future, even if the cost of the appliances stays constant or declines somewhat. The Forecast's cost argument supports penetration estimates at or near historical levels, but not at much higher levels.

In the case of air conditioning, the Forecast considers a social factor:

> This projection is based upon the view that air conditioning has become strongly imbedded in the customer's perceived need for comfort and that this perceived need will continue unabated throughout the forecast period. (p. II-46).

This common sense statement, which is based on general experience rather than specific data, may well be true. If so, it implies that people who have air conditioners will be reluctant to part with them. It may even mean that new customers, to the extent that they are like old customers, will tend to buy as much air conditioning as do current customers. But it does <u>not</u> imply that more people will purchase more air conditioning. The latter conclusion would require some more tenuous assumptions, which would require greater support. Either the cost of air conditioning must be projected to decline or its perceived value must be projected to increase, not just "continue unabated". The Forecast makes no argument which specifically justifies the continuation of the 1966-74 trends for any appliance.

Apparently, Gilbert recognized the impropriety of extending the historic trends, since some appliance statistics (such as freezer and color TV saturation) are projected to increase at less than the historic rate. (In the case of color TV, this is convenient, for the historic straight-line trend would yield a saturation in excess of 100 per cent by 1987, which would force the Forecast to estimate the fraction of sets which are second or third sets in a household and to estimate consumption independently for a household's first, second and multiple sets). The Forecast does not explain why these particular trends were modified nor how the size of the modification was selected. In fact, the projections are represented as if they were simply continuations of the historical trends. As I discussed earlier, such modifications should be handled explicitly and consistently.

Finally, if careful examination of the mechanisms of consumer choice and of the probable course of future costs and values did indicate that appliance ownership will increase, it would be important for the Forecast to consider separately the annual KWH consumption of the units owned by the new kind of marginal owner as the size and usage of such appliances may be expected to vary from mean historical data.

Q. Would you like to expand upon your earlier statement that certain of the trends used in the Forecast are not evident in the data set?

A. First, I feel it should be noted that virtually any desired projection can be derived from most data sets by selecting the data and the projection technique. As I noted previously, however, projection methodology should be selected in a clear, and consistent manner.

In many references to "trend", the Forecast clearly intends the common meaning of "linear least-squares regression with time as the independent variable"; the term is used in this sense with respect to frost-free refrigerator percentage (p. II-56), average refrigerator size (p. II-45) dishwasher and clothes washer saturations (p. II-57), and room air conditioner penetration (p. II-46). However, in other cases, the "trend" referred to is not the result of linear regression on the entire data set, at all, nor on any specified subset; examples include old market penetration of room and central air conditioning (p. II-49), as well as freezer, black and white television, and color television saturation (p. II-57). If any other projection techniques were applied to develop these latter "trends", the forecast does not discuss them.

The extreme cases of mysterious trending involve central air conditioning. Apartment new market penetration (p. II-48) shows a negative time trend, which would project a zero penetration around 1977 and a negative penetration (whatever that might mean) thereafter. Yet, the Forecast says that: "the past trend will continue and result in a new market penetration of approximately 12 per cent by 1985. . ." (p. II-46).

In contrast, trending the entire data series given for old market central air penetration (p. II-49) results in a 1985 prediction of 1.35 per cent, which is much higher than that used in the forecast: "they project a continuation of the historic trends which would result in an old market penetration rate. . . [of] approximately 0.75 per cent by 1985." (p. II-50).

Gilbert may have modified the historic trend for old market penetration to reflect the fact that the trend in the last few years (1971-1974) has been downward; this very weak trend would predict .59 per cent penetration in 1985. If Gilbert made such a modification to this trend or any other, or if they used another projection technique, the forecast should explain what was done and why it was done for some statistics but not others.

Q. Are there similar difficulties in the trending techniques used in sections of the forecast other than those concerned wtih housing mix and appliance number?

A. There are similar difficulties in the residential elasticity calculations and in the industrial section. I will shortly discuss the trending technique used in the elasticity analysis. It is merely one of the many deficiencies in that section of the forecast. Mr. Petrello addresses the industrial forecast projection techniques in his testimony. I agree with his criticism of the forecast's arbitrary and vague approach, which is similar to that used for appliance number.

III. ELASTICITY

Q. Are you familiar with the calculations performed by Gilbert Associates for Boston Edison Company concerning residential price elasticity for electricity, and presented on pp. II-183 to II-187 of BECO's 1977 forecast?

A. 'I am.

Q. Do you have any comments regarding the appropriateness of the technique utilized?

A. Yes. The approach that Gilbert utilizes is very naive. They estimate normal consumption on the basis of only three years' data, which is clearly inadequate for statistical purposes. In addition to the random annual variations imposed by data handling errors, weather differences and the vagaries of human behavior, many of the rate groups considered are so small that the average consumption may vary radically as large projects of higher than average or lower than average consumption come on line. For example, the customer number for rate C-1 increased by 2650 in 1974. (Forecast, p. II-33). As a result, the trend for each rate group's total consumption may contain serious distortions.

In addition, the analysis is overly simplistic in assuming that demand is determined only by the passage of time and by the current price of electricity. Gilbert's analysis makes no effort to study the impact of population, income or weather on electric consumption. Indeed, given the small data set, it would be very difficult to sort these factors out.

Finally, the trending of normal use seems to be based on at least four different techniques: average growth rate, linear best fit, exponential best fit, and inverse best fit. No rationale is presented for the choice of any particular technique nor does the Forecast explain why different techniques are used with different rate classes. Due to the small data set, it would seem to be difficult to distinguish between trending techniques on statistical grounds. Nevertheless, Gilbert should have explained the grounds on which they chose the trend for each rate class.

Q. Can any useful information be obtained from the approach utilitized?

A. Once the deficiencies of the method are recognized, it can be used with minimal investments in data collection and analysis to indicate whether the residents of BECO service area appear, at first glance and roughly speaking, to respond to electricity price as have the subjects of more thorough national and regional studies. To a certain extent, the distortions in the various rate groups will tend to average out, allowing some weak inferences to be drawn from the aggregate results.

Q. Is this technique, as executed by Gilbert for this forecast, properly applied to achieve these limited goals?

A. It does not appear to be. Gilbert's discussion of their technique refers to prices current in each test year, not to prices in constant dollars. The real price increase in high-inflation periods, such as 1974-75, is much less than the increase in current dollar price, since the dollars are worth less as time goes by. Since BECO's forecast uses a projected rate of electricity price escalation in constant dollars (p. II-65), it is particularly important that price elasticity be calculated in constant dollars. In addition, it is not clear that a price elasticity estimated in current dollars would have any meaning at all in a period of variable inflation.

Q. Have you corrected Gilbert's calculations to account for inflation?

A. I have. The correction is quite simple. They report for each rate class a value P, which is the percentage current-dollar price increase from the base year to the test year. Therefore, with a deflation factor $d = \frac{\text{CPI in base year}}{\text{CPI in test year}_i}$

$$\frac{\text{test year price}}{\text{base year price}} \text{ in current dollars } = \frac{100 + P}{100}.$$

$$\frac{\text{test year price}}{\text{base year price}} \text{ in constant dollars } = K = \frac{100 + P}{100} \times d_i$$

% constant-dollar price increase from base to test year = $P' = (K-1) \times 1($

Using the consumer price indices from 1973, 1974, and 1975, respectively, for the base year, test year 1 and test year 2, the deflators are

$$d_1 = \frac{133.1}{147.7} = .901$$

$$d_2 = \frac{133.1}{161.2} = .826$$

Applying this correction to the example given on p. II-186 for rate B-020,

$$P'_1 = (1.3213 \times .901 - 1) \times 100 = 19.05$$

$$P'_2 = (1.4965 \times .826 - 1) \times 100 = 23.61$$

Hence, for test year i, the elasticity e_i is

$$e_1 = \frac{-6.25}{19.05} = -.328$$

$$e_2 = \frac{-9.56}{23.61} = -.405$$

These elasticity coefficients are respectively 69% and 110% higher than Gilbert's incorrect results.

I have recalculated the elasticities for all the rates analyzed by Gilbert. My results are attached as Table 1. Note that the average elasticity calculated for the first five rates is about .33, considerably higher than the .2 used in the forecast. For the remaining rates, which Gilbert considers less subject to short-run control, the average calculated elasticity is above .16.

Q. Are these corrected elasticity estimates of .33 for easily controllable use and of .16 for less controllable use reasonable and useful for the purpose to which they are applied in the forecast?

A. No, they are not. As Gilbert makes clear in their discussion (p. II-183, p. II-186), these are short-run elasticities. Whatever significance the numbers have applies to only the consumers' immediate reaction to a price change. Unlike either cross-sectional studies, which examine the effects of established differences in price across space, or sophisticated time series studies which directly estimate the lagged effects of price changes over time, this "snapshot" approach to elasticity estimation captures only those effects which are felt in a year or less. For example, the water heating rate groups (L controlled and L uncontrolled) would not be expected to quickly adjust to higher rates, since many of the hot water conserving actions they might take (water-saving showerheads, water heat and pipe insulation, etc.) would require some time, labor and expense. Over a longer period of time, say a decade, both behavioral patterns and ownership patterns can change much more than they do in a year or two. Hence, a thorough time-series studies of electric price elasticity will generally find that long-run elasticity is

TABLE I

ELASTICITY RECALCULATION

RATE	TEST YEAR	Q	CORRECTED P (%D)	CORRECTED E
B020	1	6.25	19.07	-.328
	2	9.56	23.56	-.405
B021	1	5.81	26.95	-.216
	2	9.02	36.51	-.247
B022 (2)	1	7.42	29.64	-.250
C	1	.56	-7.97	___ (1)
	2	3.11	8.21	-.379
C-1	1	14.51	33.98	-.427
	2	13.26	40.82	-.325
D	1	9.78	49.92	-.196
	2	15.68	69.83	-.225
J	1	6.02	32.71	-.184
	2	4.62	43.51	-.106
L-c	1	4.89	37.06	-.132
	2	8.14	57.79	-.141
L-u	1	3.92	31.36	-.125
	2	9.42	49.53	-.190
G1-011	1	13.13	49.28	.266
	2	15.41	52.55	.293
G1-012	1	14.26	58.10	.245
	2	11.83	75.93	.156

Notes: (1) e>0; excluded from average.
(2) Year 2 not given in Forecast.

much higher than short-run elasticity. For example, Baughman and Joskow found a short-run residential elasticity a bit lower than BECO's result, about .19, but a long-run elasticity of 1.00. Using a short-run elasticity, even if properly estimated, as if it were a long-run elasticity represents a major distortion of reality. Yet, this is precisely what BECO does, by extrapolating Gilbert's .2 elasticity estimate out to 1987. This extrapolation of a short-run elasticity completely ignores the long-run demand impacts of the tremendous price escalation since 1973, as well as of the price increases projected for the next several years.

A more appropriate approach would recognize that the price effect in a particular year is a function of the price in the current and past years, moderated by the corresponding long or short-run elasticities.

Q. Have you applied such an approach to BECO's residential forecast?

A. Yes, I have. Developing a model of the impact of electricity price on electricity consumption requires answers to three distinct questions:

1. What are appropriate long and short-run elasticities?

2. How does a short-run effect evolve into a long-run effect as time passes?

3. How do the prices in various past years combine to produce a total price impact in the current year?

In answering these questions, I make no claim to having determined the precise nature of the price reactions of BECO's residential customers. The data which would be required to specify that behavior simply does not exist, if indeed human decision making can be mathematically modelled at an aggregate level in an accurate manner. I have striven to define a reasonable approach to the present problem; that is, to correct certain grievous oversights in BECO's projection of residential electric consumption in the year 1987. I have avoided excessive complexity, which would not be justified in this case, given the limited data available and the simplicity of the model which is being corrected. For example, I have not attempted to model the effects of personal income, prices of alternative goods, lifestyles or social values since these are complicated issues beyond the scope of the original model.

Q. What elasticity values did you use, and how did you select them?

A. There is a general consensus in the literature that the short-run own-price elasticity for electricity is around -.1 or -.2. For long-run elasticity, there is more variation (-1.0 to -1.9), but most of of the studies (including all of those which look specifically at the New England or Northeast region) indicate a value between -1.0 and -1.2.

We base this choice of values on a set of 12 studies, summarized in Table 2. These studies employ a variety of models and statistical methodologies and different data sources. They come up with consistent estimates of price elasticities. We have reviewed all recent studies considered important enough to be included in three surveys of the literature, Taylor (1975), Levy (1973), and Sharefkin (1974).

TABLE 2

SUMMARY OF DEMAND ELASTICITY STUDIES [1/]

STUDY	TYPE OF MODEL: Level of Aggregation	TYPE OF MODEL: Cross-sectional (CS) or Time Series (TS)	PRICE ELASTICITY: Long Run	PRICE ELASTICITY: Short Run
Houthakker & Taylor (1970)	States	TS	-1.8926	-0.1289
Wilson (1971)	SMSA's	CS	-1.33	
Anderson (1973)	States	CS	-1.12	
Levy (1973)	New England utility co. service areas	CS	-1.1162 (range of -0.804 to -1.262)	
Lyman (1973)	Utility co. service areas	Pooled CS and TS	Elastic	
Mount, Chapman, & Tyrell (1973)	States	Pooled CS and TS	-1.20	-0.14
Houthakker, Verleger, & Sheehan (1974)	States	Pooled TS and CS	(a)-1.0 (b)-1.2 (c)-0.45	-0.089 [2/] -0.094 -0.029
Baughman & Joskow (1975)	States	Pooled TS and CS	-1.003	-0.187
Halvorsen (1975)	States	Pooled TS and CS	-1.0 to -1.21	
Houthakker (1975)	New England States	Pooled TS and CS	-1.0	-0.106
F.E.A. (1976)	States	//	-1.043	

1/ This table is a modification of Table 4 in Taylor (1975), p. 101.

2/ Houthakker et al. estimated their equation using three definitions of the elasticity price variable. For result (a), the rate per KWH

Q. What studies look specifically at the New England or Northeast region?

A. We can cite three such studies. Halvorsen (1972) reports a long-run elasticity for the Northeast of -1.15. This figure exceeds Halvorsen's estimate of the national average of -1.13 as well as the estimates for all three of his other regional subdivisions: -1.05 for the Southeast,-0.7 for West North Central, and -1.08 for the West. A higher elasticity for the Northeast is consistent with the finding of Mount, Chapman, and Tyrell (1973) that demand elasticity increases with price. Houthakker re-ran the Houthakker, Verleger and Sheehan (1974) model with state data for the six New England states and in his testimony before the N.R.C. in 1975, reported an estimated elasticity of almost -1.0. The third study, Levy (1973) is the only one of these three to use data disaggregated to the level of the utility company service area. His best fit gives an elasticity of -1.116. He fits a number of functional forms of the demand equation and applies both two-stage least squares and ordinary least squares. He obtains a range of estimates of -0.8 to -1.26.

Q. How long is the long run? Do these long run elasticities apply to the time frame of BECO's demand projection?

A. In contrast to the estimates of the long run elasticities, the statistical evidence on the time frame for the long-run is in considerably less agreement.

The regression analyses of time series data cited here produce an estimate of the length of the long run by imposing a functional relationship between the short run and long run. This relationship is derived from specific assumptions about consumer behavior.

Basically, such models assume that consumers adjust gradually over time to a given price change and that as time passes, the response to that price change declines asymptotically to zero. Under this simplified model, complete adjustment takes an infinite number of years, but the total price response will come arbitrarily close to the long run elasticity in some finite number of years. An example of this type of model is Houthakker and Taylor's (1972) logarithmic flow adjustment model. They assume that in each year the ratio of this year's consumption to last year's is proportional to the ratio between desired and actual (last year's) consumption. Desired consumption is a function of price and other variables:

$$\text{DESIRED CONSUMPTION} = (\text{CONSTANT}) \times (\text{PRICE})^{x_0} \prod_i (\text{OTHER VARIABLES})^{x_i}$$

These two relations combine to give the following regression equation:

$$\ln q_t = a \ln p_t + b \ln q_{t-1} + \sum_i c_i \ln (\text{other variables}) + \text{error term}$$

where q_t = consumption in year t

p_t = price of electricity in year t

The coefficient a is the short run price elasticity (measuring the response to the price change that occurs within the first year), and the coefficient b is the "lag adjustment factor". Using these two numbers and the model of the demand adjustment process, we can derive the long run elasticity as well as elasticities for any finite time period. For simplicity, consider a once-and-for-all price change for year 0. In year n the elasticity is $(1 + b + b^2 + . . . + b^{n-1})a$. This geometric series sums to $\frac{a(1-b^n)}{1-b}$ in n years, and converges to $\frac{a}{1-b}$, is the long run elasticity. Table 3 demonstrates the adjustment path for a representative sample of values for the adjustment factor.

TABLE 3: PERCENTAGE OF ADJUSTMENT COMPLETED

AFTER n PERIODS $(1-b^n)$

Number of Years Elapsed Since Once-and-for-All Price Change	Lag Adjustment Factor, b		
	.873 1/	.888 2/	.913 3/
1	13	11	9
5	49	45	37
10	74	70	60
15	87	83	74
20	93	91	84

1/ from Houthakker and Taylor (1972)

2/ from Houthakker's testimony (1975)

3/ from Houthakker, Verleger, and Sheehan (1974)

The adjustment speed is sensitive to the estimate of the adjustment factor, but in general, these time series models predict a fairly low rate of adjustment. According to these models, it takes 15 to 20 years for the system to be 90 per cent adjusted.

Another approach to estimating demand elasticities is the multi-equation system model. The PIES model comes out with a 5 to 6 year time frame for a long run elasticity of -1.043 (an elasticity figure consistent with the simple time series models).

A third approach to estimating long run demand elasticities, the use of cross-sectional data, cannot provide any estimate of the time frame. Cross-sectional studies employ data from different locations in a given year. This data cannot be used for modeling adjustment dynamics. Underlying the interpretation of the price coefficients as long run elasticities is the assumption that there is substantial variation in cost conditions that has persisted over time (for example, in the case of regions serviced by hydro power versus regions that have had to depend on expensive fossil fuels) and thus, cross-sectional differences in price and consumption have been stable for a long period of time.

A time period somewhere in between the two estimates, 10 to 15 years, is certainly reasonable. Ten to fifteen years is the lifetime of most home appliances, and it is a long enough time for people to realize that prices have changed, to learn about different consumption options, and to alter their behavior.

Q. How did you model the effect of these elasticities on residential electricity consumption?

A. We used two separate approaches. Method 1 is simply a refinement of BECO's elasticity technique, while Method 2 is an application of the lagged-adjustment technique used in estimating elasticities.

Q. Please explain BECO's technique, on which you based Method 1.

A. Essentially, BECO allowed for the residential price elasticity effect in 1987 by multiplying their no-price-effect result by

$$\prod_{t=1979}^{1987} (1 - \Delta P_t \cdot e_t)$$

where $\Delta P_t = \dfrac{\text{(price in year t) - (price in year t-1)}}{\text{price in year t-1}}$

and e_t = effective elasticity in year t

BECO further assumed that ΔP_t was .03 in all years and that e_t was .2 in all years, yielding a total 1987 price effect of

$$(.994)^9 = .947$$

which reduces the projected consumption by 5.3 percent.

Q. How is BECO's elasticity technique deficient?

A. The technique is deficient in two ways. First, the effect of all price increases prior to 1979 are ignored. Second, a short-run elasticity value is used throughout, whereas a long-run elasticity value or some intermediate values which combine short-run and long-run elasticity effects would be appropriate in estimating the effect of price changes which occurred several years prior to the year under scrutiny, in this case 1987.

Q. How have you corrected the BECO approach?

A. First, we extended the analysis back to the price hikes of the middle 1970's. Some of the consumption effects of those price increases had already been felt in 1975, which is about the latest year from which substantial data is incorporated in the residential Forecast. While most of BECO's estimates for appliance saturation and electricity consumption are based on even earlier data, we decided to assume that the short-run price effects of the early 1970's were already implicitly incorporated in BECO's no-elasticity demand estimates.

Second, we used a short-run elasticity value for the effect of 1987 price on 1987 consumption, used a long-run elasticity value for the effect of 1974 price on 1987 consumption, and interpolated linearly to find the effect of intervening years' prices on 1987 consumption. Thus, the cumulative price effect in 1987 is

$$PE_{1987} = \prod_{t=1974}^{1987} \left[1 - P_t \cdot \left[e_s + (e_L - e_s) \frac{1987 - t}{1987-1974}\right]\right]$$

and the price effect in 1975 is

$$PE_{1975} = \left(1 - \Delta P_{1975} \cdot e_s\right) \cdot \left(1 - \Delta P_{1974} \cdot \left(e_s + \frac{e_L - e_s}{13}\right)\right)$$

where e_s = short-run elasticity

e_L = long-run elasticity

The net price effect is $\frac{PE_{1987}}{PE_{1975}}$

which is then multiplied by the consumption calculated without price effects, such as that presented in columns two through four on p. II-66A of the forecast. Alternatively, the PE_{1987} figure can be used as a net price effect if it is assumed that the Forecast is based on pre-1974 trends and prices. "Price effect" in this context is defined as:

$$\frac{\text{consumption predicted given price changes}}{\text{consumption predicted given no price changes}}.$$

Q. Why did you use a linear interpolation for the elasticities between short and long-run?

A. Basically because little work has been done on the time-path of price effects and because linear interpolation was arithmetically simpler than the alternatives. Linear interpolation and several alternatives are illustrated in Figures 1 to 5.

Q. What is the significance of this choice of linear interpolation?

A. Accelerated adjustment to price (Figure 3) would result in higher elasticities in intermediate years and hence a higher total price effect then would occur under a linear price adjustment. But the 1974 price effect on 1975 consumption would be increased as well. To the extent that BECO has captured the 1975 adjustment, this would tend to balance out the other differences from the linear assumption, since the 1974 increase is so large. Delayed elasticity change would have exactly opposite effects.

More irregular elasticity transition patterns are possible. For example, the function shown in Figure 4, as compared to the linear assumption, would tend to emphasize the 1974 effect on 1975 consumption but de-emphasize the 1974 effect on 1987 consumption resulting in a lower net price effect. The pattern of Figure 5 would have the reverse effect.

While time series studies yield estimates of short-run elasticity, and cross-sectional studies yield estimates of long-run elasticity, little or no research has been done to define the time-path of the elasticity transition. Reasonable arguments can be made for many patterns. Therefore, Occam's razor would suggest the use of the simplest transition path, i.e., linear interpolation.

FIGURE 1: LINEAR ELASTICITY TRANSITION

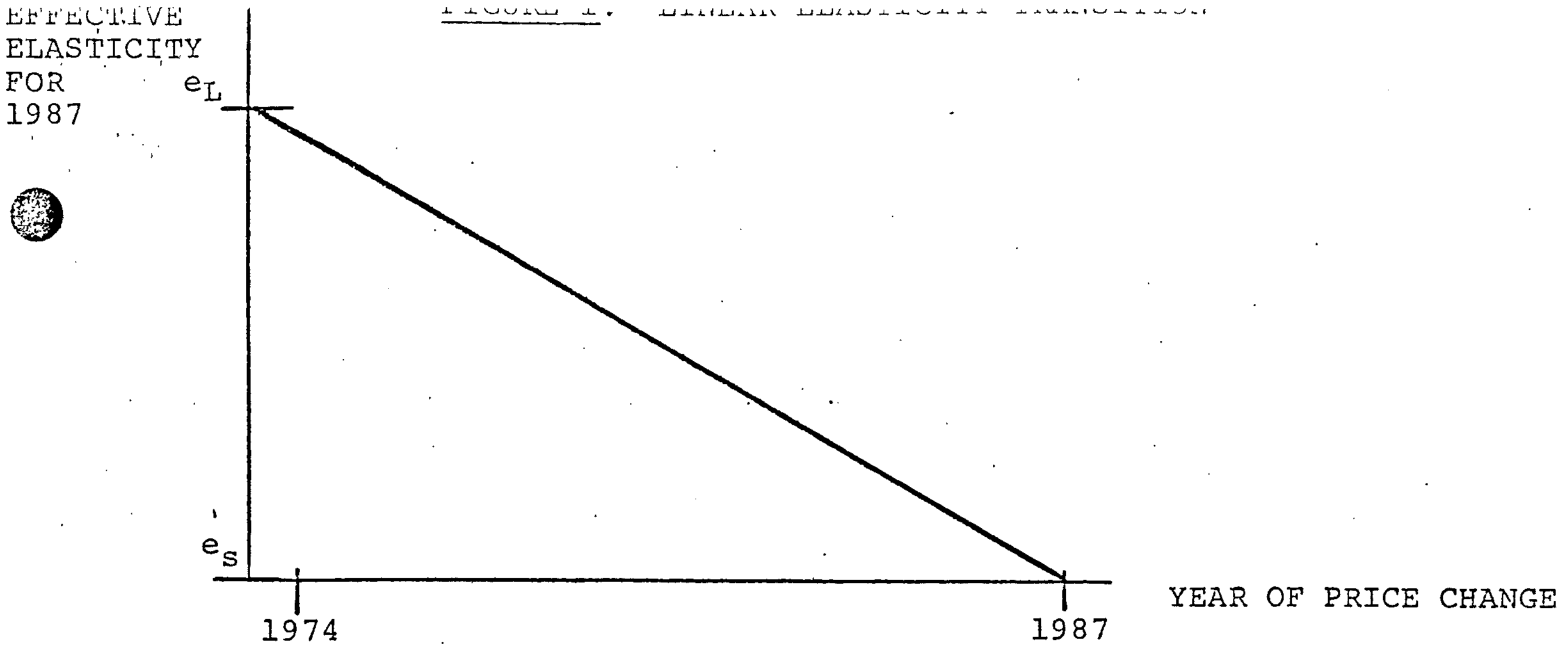


FIGURE 2: DELAYED ELASTICITY TRANSITION

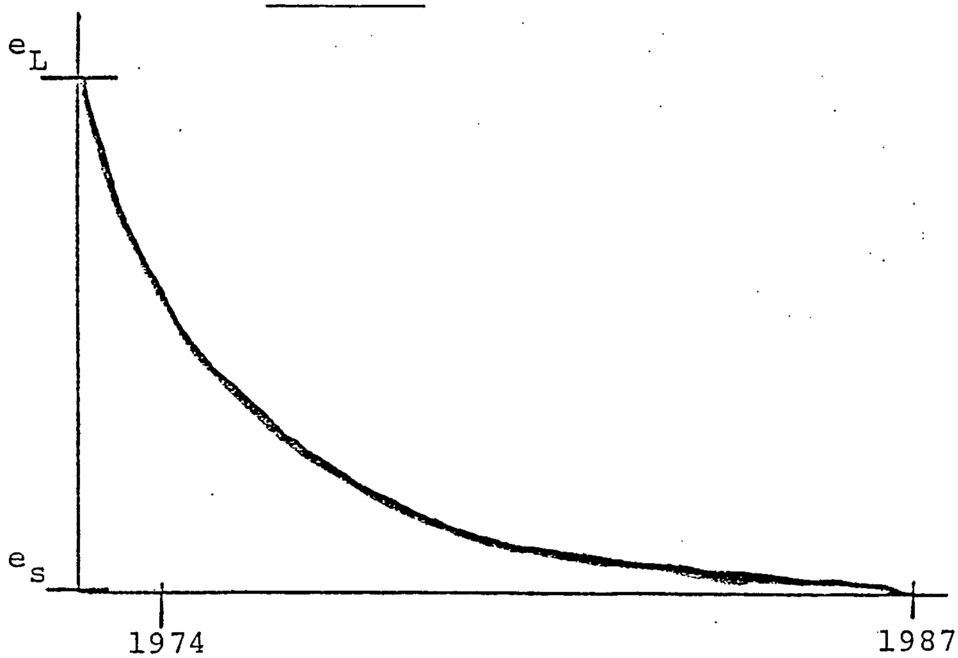


FIGURE 3: ACCELERATED ELASTICITY TRANSITION

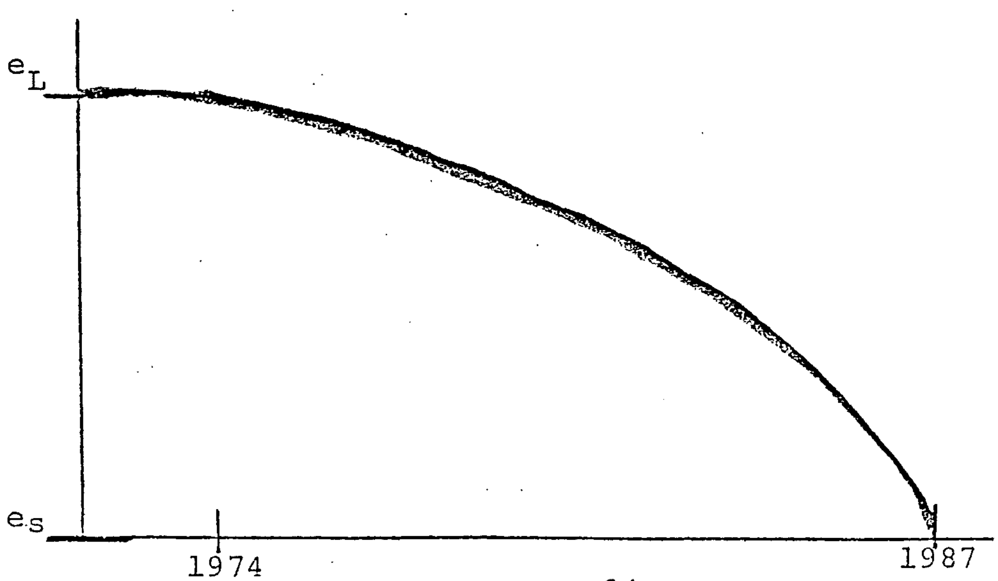


FIGURE 4: ELASTICITY TRANSITION CONCENTRATED AT BEGINNING AND END OF PERIOD

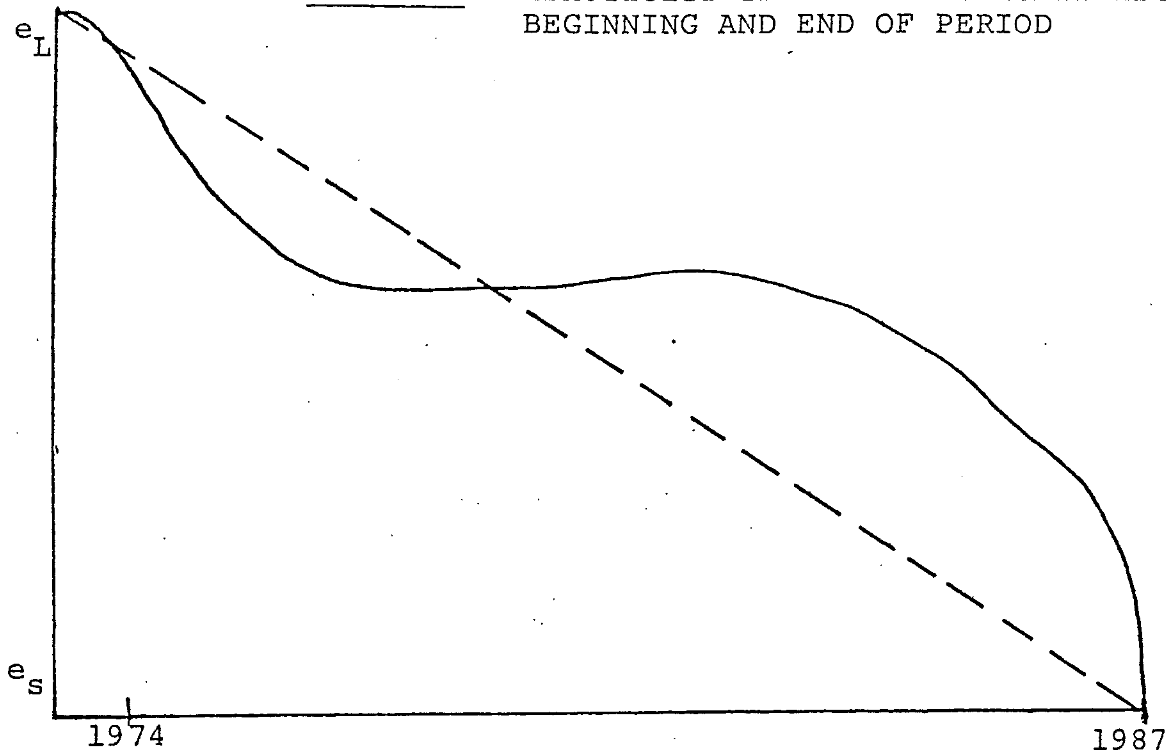
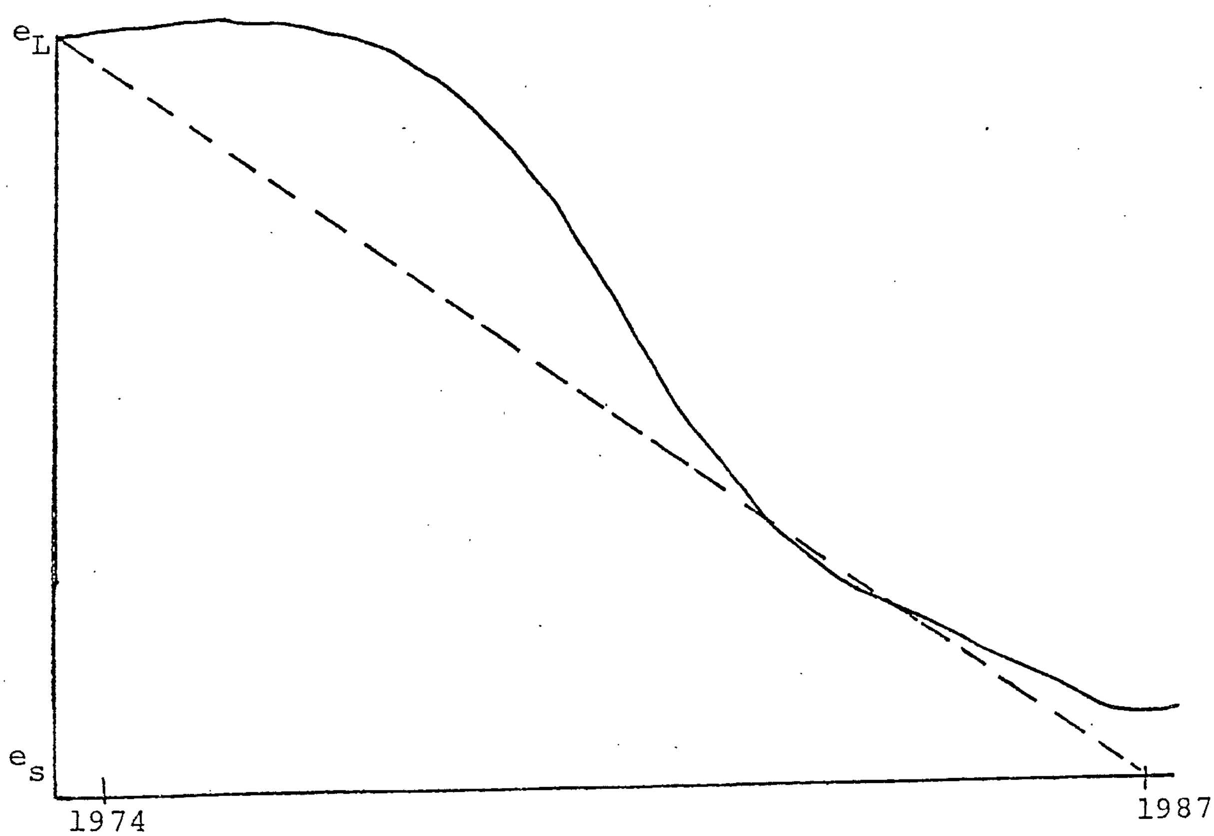


FIGURE 5: ELASTICITY TRANSITION CONCENTRATED IN MIDDLE OF PERIOD



Q. What were your data sources for your calculations?

A. To find BECO's residential real price increases in 1974 and 1975, we took BECO's 500 KWH/monthly bill for 1973, 1974 and 1975 from the corresponding year's Typical Electric Bill publication by the F.P.C. and then deflated by the January Consumer Price Index as reported in the same publication (see Table 4). The 500 KWH bill is the tabulated consumption level closest to BECO's 1976 average residential consumption of 451 KWH/month.

We used BECO's projection of a 3 per cent annual real price increase beyond 1975. Without explicitly saying that it does so, the forecast omits all price effects from 1976 through 1978, perhaps reflecting an unstated belief that prices would remain stable in that period or perhaps reflecting an oversight. The projection of price increases through a period which (hindsight tells us) did not experience such increases would be equivalent to assuming that total growth in the decade would average out to a 3 per cent effective rate, despite the slow start, which is not inconceivable. We determined the price effect both with and without price increases over these three years. We called these cases "high price" and "low price" respectively.

We used two sets of elasticity figures. "Low elasticity" was defined as .1 short-run and 1.0 long-run, while "high elasticity" was defined as .2 short-run and 1.2 long-run.

Q. What were your results for Method 1?

A. We derived eight net price effects from the various combinations of high or low price growth, high or low elasticity, and 1973 or 1975 base year. The calculations are shown in Table 5. The eight price effect results are circled in Table 5 and vary from .543 to .687, or a price-caused reduction of 31.3 per cent to 45.7 per cent, depending on the assumptions.

TABLE 4

YEAR	TYPICAL ELECTRIC BILL[1] (500 KWH/MONTH)	JANUARY CONSUMER PRICE INDEX	PRICE (CONSTANT) JANUARY 1973	ΔP[2]
1973	14.17	127.7	14.17	---
1974	17.56	139.7	16.05	.133
1975	22.91	156.1	18.74	.168

CONSTANT DOLLAR PRICE CALCULATIONS

Notes: (1) from Typical Electric Bills, F.P.C., various years

(2) from Typical Electric Bills, F.P.C., 1977

(3) $\frac{P_t - P_{t-1}}{P_{t-1}}$

TABLE 5: METHOD 1 ELASTICITY CALCULATIONS

EFFECT YEAR	PRICE YEAR	ΔP	HIGH ELASTICITY e_t	HIGH ELASTICITY $1-\Delta P \cdot e_t$	LOW ELASTICITY e_t	LOW ELASTICITY $1-\Delta P \cdot e_t$
1987	1974	.133 (1)	1.20	.840	1.00	.867
	1975	.168 (1)	1.12	.811	.93	.844
	1976	.03	1.05	.969	.86	.974
	1977	.03	.97	.971	.79	.976
	1978	.03	.89	.973	.72	.978
	1979	.03	.82	.976	.65	.980
	1980	.03	.74	.978	.58	.982
	1981	.03	.66	.980	.52	.985
	1982	.03	.58	.982	.45	.987
	1983	.03	.51	.985	.38	.987
	1984	.03	.43	.987	.31	.991
	1985	.03	.35	.989	.24	.993
	1986	.03	.28	.992	.17	.995
	1987	.03	.20	.994	.10	.997
	PE_{1987} (high price) (3)			.543		.614
1975	1974	.133 (1)	.28	.963	.17	.977
	1975	.168 (1)	.20	.966	.10	.983
PE_{1975}				.931		.961
$\frac{PE_{1987}}{PE_{1975}}$	(high price) (4)			.583		.639
PE_{1987}	(low price) (2)			.591		.660
$\frac{PE_{1987}}{PE_{1975}}$	(low price) (2)			.635		.687

Notes (1) from Table X
(2) deletes 1976 to 1978 price increases
(3) 1973 base year
(4) 1975 base year

Q. How large an effect does this correction in residential elasticity methodology have on BECO's forecasted 1987 sales?

A. BECO forecasts 1987 residential consumption of

2598	GWH non-heating
697	GWH heating
298	GWH C, C-1, and K
3593	GWH TOTAL

Correcting for a price effect of .700 (less drastic than any Method 1 result) from 1975, as opposed to the .947 BECO uses, yields 3593 x .700 ÷ .947 = 2656, GWH or a reduction of 937 GWH in 1987 sales. The 1976 residential sales were

2146	non-heating
343	heating
275	C, C-1, K
2744	

Hence, the corrected 1987 sales figure would actually represent a decline in residential sales from 1976 to 1987. A reduction of 937 GWH in the projected 1987 sales would equal over 25 per cent of the projected 1976-1987 increase in territory output requirements of 3662 GWH. In addition, losses would be 106 GWH lower due to reduced residential sales; even the smallest reasonable correction of BECO's method would eliminate nearly 30 per cent of the projected output increase. These are, then, sizable differences.

Q. Would you please explain your second method for calculating price effects?

A. Method 2 is based upon the lagged-demand model for estimation of elasticities from time series data. These models are generally of the form

$$Q_t = k \cdot P_t^{a} \cdot B_t^{c} \cdot Q^{b}_{t-1}$$

where Q_t = sales in year t

B_t = various non-price variables in year t

b = lagged adjustment factor $(0 < b < 1)$

a = short-run price elasticity

Applying this formula recursively yields

$$Q_t = P^a_t \; P^{ab}_{t-1} \; P^{ab^2}_{t-2} \; \ldots \; \cdot k' Q_o^{b^t} \prod_{i=0}^{t} B_i^{cb^{t-i}}$$

If the sales in year t were estimated at some constant price level P_o, sales would be

$$Q_t = P_o^a \; P_o^{ab} \; P_o^{ab^2} \; \ldots \; k' Q_o^{b^t} \prod_{i=0}^{t} B_i^{cb^{t-i}}$$

An estimate based on constant prices can then be corrected for price changes by multiplying a factor of

$$\frac{P_t^{a} \; P_{t-1}^{ab} \; P_{t-2}^{ab^2} \ldots P_o^{ab^t}}{P_o^{a} \; P_o^{ab} \; P_o^{ab^2} \ldots \; P_o^{ab^t}}$$

Development of a factor of this form constituted Method 2.

Q. What data did you develop for this method?

A. The "a" coefficient is simply the short-run elasticity, for which we used both -.1 and -.2 values. We selected the "b" lagged adjustment values to yield the desired long-run (14 year) price elasticity effect from a one-time increase. With a -.1 short-run elasticity and a lagged adjustment factor of .93, the 14 year effect is equivalent to an elasticity of -0.911. A -.2 short-run elasticity and a .85 lagged adjustment factor gives a long-run elasticity of -1.196. These elasticity cases, therefore, represent consistently lower long-run elasticities than do the elasticities used in Method 1. In the low-elasticity case, the difference is about 9 percent.

Again, we used BECO's price-increase assumptions beyond 1975 (both with and without increases in 1976 to 1978), and the real 1973 dollar prices for 1974 and 1975. Unlike Method 1, this second approach uses total prices, which are tabulated in Table 6.

Finally, we had to determine the base price on which the original forecast was based. The price regime reflected in the current BECO Forecast is not quite clear, as previously noted. By and large, the low pre-embargo prices seem to dominate the residential trends, so the 1973 price should generally be used for P_o. As an extremely conservative position, it could be assumed that the Forecast was totally based upon 1975 conditions in which case P_o should be set at the 1975 price. As in Model 1, we explored the effect of using both 1973 and 1975 base price levels.

Q. What were your results from Method 2?

A. Generally speaking, the results of Method 2 were similar to those of Method 1, although there was greater sensitivity to varying assumptions. Price effects range from .428 to .838, with an average of about .640, as compared with the Method 1 average of .620. The major portion of the variation in the price effect is due to the base price

TABLE 6: PROJECTED RESIDENTIAL ELECTRIC PRICES
500 KWH/MONTH 1974-1987

YEAR	PRICE: HIGH PRICES WITH INCREASES IN 1976-1978	PRICE: LOW PRICES WITHOUT INCREASES IN 1976-1978
1974	16.05 ~~17.56~~ (1)	16.05 17.56 (1)
1975	18.74 ~~22.91~~ (1)	18.74 22.91 (1)
1976	19.30 23.60 (2)	↓ 22.91 (3)
1977	19.88 24.31	↓ 22.91 (3)
1978	20.48 25.03	↓ 22.91 (3)
1979	21.09 25.79	19.30 23.60 (2)
1980	21.72 26.56	19.88 24.31
1981	22.38 27.36	20.48 25.03
1982	23.05 28.18	21.09 25.79
1983	23.74 29.02	21.72 26.56
1984	24.45 29.89	22.38 27.36
1985	25.18 30.79	23.05 28.18
1986	25.94 31.71	23.74 29.02
1987	26.72 32.66	24.45 29.89

Notes:
(1) from Typical Electric Bills, F.P.C.
(2) this and succeeding years experience 3 per cent real price increases
(3) no increase projected
(4) all prices in 1973 dollars

TABLE 7: METHOD 2 LOW ELASTICITY CASE

i	$e_i = -.1(.93)^i$	$(P_o)^{e_i}$ low base (1)	$(P_o)^{e_i}$ high base (2)	$(P_t)^{e_i}$ low price (3)	$(P_t)^{e_i}$ high price (3)
13	-.039	.9019	.8922	.8976	.8976
12	-.042	.8950	.8845	.8845	.8845
11	-.045	.8875	.8764	.8764	.8753
10	-.048	.8796	.8678	.8678	.8653
9	-.052	.8711	.8585	.8585	.8546
8	-.056	.8621	.8487	.8473	.8432
7	-.060	.8526	.8383	.8354	.8309
6	-.065	.8424	.8272	.8225	.8178
5	-.070	.8316	.8156	.8089	.8039
4	-.075	.8201	.8031	.7943	.7891
3	-.080	.8080	.7900	.7788	.7733
2	-.086	.7951	.7761	.7623	.7565
1	-.093	.7815	.7614	.7449	.7388
0	-.100	.7671	.7460	.7264	.7200
		.08926	.06919	.06230	.05811

Notes: (1) P_o = $14.17 = Typical [illegible] Bill, [illegible] 0 KW[illegible]
(2) P_o = ~~$22.91~~ 18.74 = Typical [illegible] c Bill [illegible] 00 [illegible]
(3) P_t from Table 6; year = 1987 - i
(4) all prices in 1973 dollars

TABLE 8: METHOD 2 HIGH ELASTICITY CASE

i	$e = -.2(.85)^i$	$(P_o)^{e_i}$ low base(1)	$(P_o)^{e_i}$ high base(2)	$(P_t)^{e_i}$ low price(3)	$(P_t)^{e_i}$ high pric
13	-.024	.9379	.9316	.9351	.9351
12	-.028	.9274	.9200	.9200	.9200
11	-.033	.9151	.9066	.9066	.9057
10	-.039	.9009	.8910	.8910	.8889
9	-.046	.8844	.8731	.8731	.8695
8	-.054	.8655	.8524	.8510	.8469
7	-.064	.8437	.8287	.8256	.8209
6	-.075	.8188	.8017	.7963	7910
5	-.089	.7904	.7710	.7630	.7580
4	-.104	.7582	.7364	.7252	.7185
3	-.123	.7221	.6977	.6827	.6753
2	-.145	.6818	.6548	.6355	6274
1	-.17	.6372	.6076	.5837	5749
0	-.2	.5885	.5565	.5276	5184
		.04194	.03002	.02509	.02274

Notes: see table 7

TABLE 9: METHOD 2 NET PRICE EFFECTS

ELASTICITY ASSUMPTION	BASE PRICE ASSUMPTION	PRICE FORECAST	PRICE EFFECT $\frac{\pi P_t^{e_i}}{\pi P_o^{e_i}}$	AVERAGE OF PRICE EF FOR EACH ELASTICITY ASSUMPTION
low	low	low	.698 ~~.584~~	.772 ~~.654~~
low	low	high	.651 ~~.545~~	
low	high	low	.900 ~~.768~~	
low	high	high	.840 ~~.717~~	
high	low	low	.598 ~~.472~~	.683 ~~.624~~ ~~.676~~
high	low	high	.542 ~~.428~~	
high	high	low	.836 ~~.838~~	
high	high	high	.757 ~~.760~~	

Note: results compiled from Tables 7 and 8 assumption, rather than the elasticity or the price forecast used. As previously noted, the trends and consumption figures used by BECO reflect the low and declining prices of the late 1960's and early 1970's, with little allowance for the price changes of 1974 and 1975. Hence, even the low base price assumption may overestimate the effective prices incorporated into the zero-elasticity forecast. Certainly, averaging the price effects for the two base price assumptions should at least adequately represent the effective incorporated price.

Q. Based upon your calculations, what would be a reasonable overall net price effect?

A. It would appear that the net price effect, using BECO's price projections and reasonable elasticities, lies in the .5 to .7 range implying that BECO's residential forecast (before elasticity effects) is 30 per cent to 50 per cent too high. } restate

Q. Does the Forecast adequately deal with elasticity in the commercial and industrial sectors?

A. The commercial forecast uses an overly simplistic approach. Essentially, Gilbert's model uses only a short-run (current year) elasticity. The change in consumption is a function of the change in price relative to the preceding year. The elasticity used (.777) is far too high to really reflect short-run effects, so it is evident that current price is serving as a surrogate for lagged price / ? effects. The total price effect is approximately .84 for the 8 year period to which this technique is applied on p. II-87.

Much less work has been done on the commercial price elasticity of electricity, but what has been done generally seems to indicate larger elasticity values than for residential use. Mount, Chapman and Tyrell (1973) for example, derived -.17 short-run and -1.36 long-run elasticities. Gilbert's .777 elasticity represents some sort of compromise between the short and long run. This elasticity might be adequate were it not that the long-run effects of the 1974-1975 price increases are neglected and that BECO's peculiar averaging process deletes all price effects in 1977-79 and dilutes such effects thereafter.

If Gilbert's commercial forecast is used alone, without averaging in the linear trend, the 1987 commercial sales prediction is 6,291,000 MWH. Deleting Gilbert's inadequate price effect produces a figure of 8,032,000 MWH. If a more reasonable, but still conservative, reduction of 30 per cent (a price effect of .7) is applied, the prediction would be 5,622,000 MWH. Subtracting BECO's estimate of MATEP's impact leaves 5,502,000 MWH as a more reasonable estimate for 1987 commercial sales. Bear in mind that this calculation is based on Gilbert's preferred model (with all its errors) and BECO's population and GNP projections.

With respect to the industrial forecast, the situation is far worse. BECO dismisses any consideration of price effects with the observation that "the trends would include the implicit elasticity that resides in the data points themselves." (p. II-3). However, BECO clearly indicates on pp. II-92 to II-94 that the forecasts relate to the output of the various industries nationally and in the service area, not to the efficiency of their energy use. Furthermore, except for altering the starting point, the post-1974 data rarely seem to affect the forecast. Generally speaking, the trends of the last decade are simply extrapolated into the next. In any case, the short-run price effects of the middle seventies were probably obscured by the effects of economic slump and recovery.

It is ironic that price effects were excluded from the industrial sector, since research has consistently indicated that elasticities are highest in that sector. For example, Taylor (1975) quotes five studies which place the value of long-run industrial elasticity between -1.25 and -1.94. The three lowest figures include an older study (Fisher and Kaysen, 1962), a British study (Baxter and Rees, 1968) and a study which does not completely distinguish long-run from short-run effects (Lyman, 1974). The most applicable study appears to be Mount, Chapman and Tyrell (1973) which yields a -1.82 long-run elasticity and a -.22 short-run value.

The informality of BECO's projection approach renders a detailed elasticity recalculation rather inappropriate. There is really no point in carefully refining a very carelessly produced forecast, unless the basic projections are to be reworked. This would clearly be a sizable undertaking. In addition, capital-intensive energy conservation measures may have been delayed by the recession, so estimating the extent of the price effect incorporated in the forecast is especially difficult.

However, one would eventually expect a price effect at least comparable to that of the residential sector, and perhaps quite higher. Applying a .7 price effect to BECO's 1987 industrial sales forecast yields sales of 1,567,000 MWH, or 112,000 MWH less than the 1975 sales to that class.

Q. What is the total impact of including price impacts in all three major classes?

A. The conservatively price-corrected sales forecast for 1987 would be:

2,307,000	MWH	residential heating
5,502,000	MWH	commercial
1,567,000	MWH	industrial
9,376,000	MWH	

Adding BECO's estimates for railroad and streetlighting (156,000 MWH) yields retail sales of 9,532,000 MWH.

Making the unlikely, but highly conservative, assumption that BECO's resale forecasts have accounted for price effects (a very difficult proposition to test due to BECO's limited discussion of the methodology used for this class) total territory sales in 1987 would be 572,000 MWH greater, or a total of 10,104,000 MWH. Losses would be: (See p. II-154 for loss ratios)

9,532,000 x .1137 =	1,084,000 MWH	retail
572,000 x .0233 =	13,000 MWH	resale
	1,097,000 MWH	total losses

Territory energy output requirements would then be:

10,104,000	sales
1,097,000	losses
11,201,000	MWH territory output

This 11,201 GWH estimate is still 2567 GWH or 18.6 per cent less than BECO's forecast (p. II-217) of 13,768 GWH.

IV. EFFECT OF PEAK LOADS ON PRICE

Q. Do you have any comments on the way in which price elasticity was handled in the peak-load section of the forecast?

A. Yes, I do. BECO simply assumes that "customers [demands] are [price] inelastic during peak-demand periods when creature comforts are threatened." On this basis, residential and commercial consumption are recalculated as if no price increase were expected after 1975; historical load factors are applied to these "adjusted" energy estimates to provide peak load estimates. There are at least four good reasons to believe that BECO's assumption is incorrect:

1. Higher prices will decrease electric consumption in all time periods, including peak periods;

2. Higher time-of-use prices during peak periods will particularly depress temperature-sensitive and other on-peak uses.

3. The cost of removing the heat generated by non-cooling appliances will further reduce their use during hot peak periods;

4. Direct load management techniques will lower consumption throughout designated peak periods and particularly at the time of the company peak.

Q. Please explain why generally higher prices will decrease peak demand.

A. Higher electricity prices encourage the purchase of fewer, smaller and more efficient electrical equipment, as well as greater care in the use of existing equipment. Even if the current rate structure were not radically changed, reduced commerical lighting levels, for example, would decrease consumption on the peak as well as off. BECO's assumption requires that customers maintain a stock of wasteful and inefficient equipment and bad habits, to be utilized only at the time of system peak.

Q. How would time-of-use prices affect peak loads?

A. Since prices will be highest at the time that demand is highest, appliances with a large on-peak demand will be particularly responsive to price effects. One would expect fewer air conditioners, better insulated refrigerators, and so on. The high price of electricity, both generally and on-peak, will tend to make building modifications such as attic ventilation, lighter-colored roofs, awnings, and reflective films more economical ways of maintaining comfortable temperatures than a corresponding investment in extra air conditioning equipment and the electricity to run it. Insulation and weather stripping will be promoted by the rising cost of energy for both heating and cooling. Rising electricity prices will also tend to encourage cogeneration plants which, among other things, can provide heat for absorbtion cooling; not only would the electric cooling load be reduced, but cogenerated electricity sales to the grid would tend to increase with temperature, satisfying part of the remaining demands for electric cooling.

Loads which are not temperature sensitive would also be expected to respond to peak periods prices. Greater care would be justified in using this equipment during peak periods, due to the higher costs of unnecessary use. In addition, usage will tend to be shifted to off-peak periods when electricity is cheaper.

Q. How will this effect be increased by waste-heat considerations?

A. In an air-conditioned building, each KWH used in running an appliance must be removed from the building. Some appliances, such as dryers, vent part of their heat to the outside, but most of the waste heat generated within air conditioned spaces probably stays there until the air conditioner pumps it out. An air conditioner with a coefficient of performance (COP) of 2.5 thus requires .4 KWH of extra cooling electricity for each KWH used in the building. Therefore, lighting, cooking, cleaning, office machines, and tools will cost 1.4 times the nominal KWH charge. BECO's current time-of-use pricing proposals use peak prices which are two to three times as high as current average summer prices (rates P and P-1, optional rate schedule). An extra 40 per cent increase on top of the peak-hour price should present a powerful inducement to conservation and load shifting at those times.

Q. How will direct load management measures reduce peak demand?

A. Some load management techniques, such as off-peak timed storage water heating, will simply automate the effects of peak-load pricing by shifting loads out of the designated peak hours without any regular customer intervention. Other load management techniques, however, will allow the interruption or limitation of demands at the actual time of system peak or at other times when demand threatens to exceed supply.

The D.P.U. has addressed the potential of load management and peak-load pricing in the generic rate case decision (D.P.U. 18810). BECO and other electric companies have begun to deal with these issues in their responses to that order. While BECO seriously underestimates the potential amount of interruptible load at summer peak, they recognize that there is considerable opportunity for such curtailable service.

Whether a particular demand is interrupted throughout the designated peak period, only during the actual peak hours, or on a rotating basis, the interruption will contribute to reducing the peak demand.

Q. Is there any empirical evidence to suggest that higher peak prices tend to depress peak demand?

A. First of all, in the Connecticut Peak Load Pricing Test, it was found that "The proportions of total daily electricity consumption occurring in the . . . June system peak (which are days of extreme temperatures) were nearly equal to the corresponding proportions on average. . . June weekdays. . . , indicating that the test customers responded similarly to the pricing 'signals' on extremely hot. . . days as on days of normal seasonal weather." (Final Report, May 1977, p. S-7). Furthermore, the summer coincident load factors for the test customers averaged 43.8 per cent higher than similar customers not on peak-load pricing. The clear implication is that peak-load pricing does reduce system peak load. BECO's assumption that peak demand is independent of price is seen to fail even in the short run, prior to any significant effect of appliance purchase decisions.

Second, Cargill and Meyer (1971) found that electric price response in a midwest industrial city was approximately equal in peak and off-peak hours. Unfortunately, this study corrected for seasonal effects, did not differentiate between user classes, and addresses only general increases in the average price level, rather than hour-specific prices. Nonetheless, the results are statistically significant and supportive of the general conclusion that peak-load elasticity is not much different than total consumption elasticity.

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Finally, Boston Edison's own data indicate that weather-adjusted peak load is growing more slowly than total sales. This contradicts their argument that it should grow more rapidly. BECO estimates that the system load for a "normal" hottest summer week day - a 96F degree high in July - would have been 1980 MW for 1977 (p. II-157). The estimated territory output for 1977 was reported to be 10,208 GWH (p. II-217). The temperature corrected load factor for 1977 is thus 58.9 per cent, whereas the actual load factor for 1976 was 58.4 per cent. Since the 1976 peak occurred on a relatively mild day (a June day, with a 95F degree high and 94F degree temperature at time of peak), weather adjusting the 1976 peak would presumably yield a slightly lower load factor. The difference between the 1976 and 1977 weather-adjusted load factors is due to the fact that normalized peak demand increased only .5 per cent while output increased 1.0 per cent. Thus, it would appear that peak demand is, if anything, more price responsive than sales.

Q. If in fact, peak load is as price responsive as is total consumption, how would this affect the forecast?

A. BECO uses summer peak factors (p. II-180) of

.260	residential
.203	commercial
.195	industrial
.120	railroads
.208	resale

which are the ratio between class contribution to system peak (MW) and annual class energy (GWH). Using BECO's energy estimates gives a 1987 summer peak of

energy		peak factor		peak sales
3295	x	.260	=	856.7
6146	x	.203	=	1247.6
2239	x	.195	=	436.6
18	x	.120	=	2.2
572	x	.208	=	119.0
				2662.1 MW

This is 6.5 per cent less than the Forecast's projection of 2846 MW.

However, the sales figures are far too high, as previously discussed. If the price-corrected sales figures developed earlier in this testimony are used, the 1987 summer peak load would be:

2307	x	.260	=	599.8
5502	x	.203	=	1116.9
1567	x	.195	=	305.6
18	x	.120	=	2.2
572	x	.208	=	119.0
				2143.4 MW

This is 24.7 per cent less than the Forecast's figure. The price-corrected figure implies a compound growth rate from 1977 (weather adjusted to 1980 MW) to 1987 of .79 per cent, as opposed to the 3.69 per cent growth rate implied in the Forecast. In other words, even conservative price corrections, otherwise using BECO's overall methodology and assumptions (except for the linear trending of commercial sales), reduce the projected growth rate by nearly four-fifths and eliminate 81 per cent of the projected peak growth.

V. MISCELLANEOUS COMMENTS

Q. Do you have any further comments on the Forecast?

A. I would like to make two observations about the residential household projections discussed on P. II-20. First, the statement that the "methodology achieves good results" is not supported by the data provided. Second, this table presents an excellent example of the difference between prediction of a parameter and prediction of growth in that parameter.

Q. Please explain your statement that the household projection methodology does not appear to yield good results.

A. BECO supports their statement by observing that the difference between actual and projected residential households for the years 1970 to 1976 varies from .1 per cent to 3.3 per cent. While those differences appear small, they must be compared to the small actual variation in customer count over the period, which is only 6.7 per cent of the average customer count over the period. The average absolute error in the projection is 1.3 per cent, or about 19 per cent of the total variation in the period. A "projection" which was simply a constant 505155 households (the 1970 to 1976 average) would only have an average error of about 2.4 per cent. Thus, the Forecast methodology is not really predicting the changes in customer count very well.

In addition, the projection tends to lie on the high side of the actual figures. The algebraic average of the "variances" BECO reports is over .9 per cent, indicating that the projection tends to run about 5000 households too high.

Q. Could you expand on your second point about the household projections?

A. This point does not refer to the validity of this particular projection; rather, it illustrates the inappropriateness of the commercial model BECO uses, which is a demand growth model rather than a demand model.

To illustrate this difference, it is useful to examine the relationship between actual customer count and projected residential households in two different ways. First, if projected households number (P) is used to estimate actual household number (A), given the data on p. II-20 a linear regression yields

$$A = 114396 + 1.21554P \quad (r=.888)$$

indicating that actual household number increases with projected household number, which is apparent from cursory inspection of the table on p. II-20.

However, in commercial model 2, Gilbert determines the percentage annual growth in each variable and performs a regression on these growth figures. For the example above, the growth rates are shown below:

Year	Δ % Actual	Δ % Projected
1971	0.43	1.87
1972	2.54	.36
1973	1.88	.56
1974	1.48	.77
1975	.49	1.37
1976	-.05	1.47

Performing a regression on these figures yields:

$$\Delta\%A = 2.79 - 1.55\ \Delta\%P \qquad (r = -.922)$$

which indicates that higher projected household numbers will be associated with lower actual numbers, and that increases of over 1.8 per cent/year in the projected households will predict a decrease in actual households. This flatly contradicts both the first model and common sense.

This example simply illustrates a fundamental short-coming of growth-rate regression models. Due to randomness, measurement error, lag effects and excluded variables, the observed relationship between annual growth rates in various variables may be completely different than the long-term relationship between the variables. Specifically, regressions on "wavy" data sets like that presented on p. II-20 may be very sensitive to the lag structure assumed. If high-growth and low-growth years tend to alternate in dependent and/or independent variables, regression might yield a negative sign for an unlagged relationship, but a positive sign for a one-year lag. (Precisely this effect is apparent in Information Response AG III-35; unlagged RH growth has a -.807 coefficient in model 11, while lagged RH growth has a .706 coefficient in model 12, which is otherwise identical).

Correctly specifying the causal lags might not be very important, <u>if</u> the short-term patterning in the data remains consistent and <u>if</u> that pattern can be predicted into the future. However, the first condition is unlikely to be met and the second is not likely to be possible. Certainly, BECO makes no attempt to predict electric price or GNP in detail; they simply assume a constant growth rate throughout the forecast period. While a constant growth rate may be a reasonable assumption for total consumption model, it is highly problematical for this type of growth rate model.

Q. You mentioned that specification of lag structure is particularly important in growth rate regression models. Did Gilbert adequately examine lag effects in either the growth rate or total consumption models?

A. From the forecast and BECO's response to the Attorney General's Information Request AG III-35 (April 18, 1978), it appears that they did not. First, no causal logic is presented regarding the lagging of any variable. Surely the search for an appropriate specification should be guided by a sense of the likely relationships. At the very least, models selected on statistical grounds should be examined to insure that the specified lags are reasonable. But the forecast presents no justification for lagging residential households in Model 2 and not lagging it in Model 1, nor for not lagging the other variables.

Secondly, the examination of lags is incomplete. The variable most likely to have a delayed effect is price, as discussed in this testimony with regard to elasticity. Yet Gilbert apparently failed to test even a single growth rate model incorporating lagged prices. Residential household number may have some delayed effects as Gilbert apparently concludes, yet it is not lagged in any total consumption model which also includes a price variable. Also, GNP, which seems as likely as household number to have delayed effects, is not lagged in <u>any</u> model.

The combination of inadequate justification and inadequate examination of lag effects makes it difficult to conclude that the commercial model was developed in a thorough and professional manner.

Q: Are there any errors in the forecast's handling of the master-metered apartment rate groups, which have traditionally been counted in the commercial sector, but are really residential use?

A: BECO forecasts growth corresponding to these rate groups as part of residential sales, while leaving base sales (projected 1978 master-metered sales) in the commercial class (p. II-65). Problems arise in three areas: first, the commercial forecast is biased by the inclusion of master-metered sales; second, master-metered sales are counted in both the commercial and the residential sectors; and third, average residential consumption is biased upward by inclusion of master-metered apartments.

Q: Please explain how the master-metered apartment rates bias the commercial forecast?

A: The three master-metered rates which the forecast discusses - rates C, C-1, and K - were not deleted from sales data before Gilbert's regressions were performed (Information Response AGIII-36). Therefore, the estimated coefficients in Gilbert's models are based in part on changes in C, C-1, and K sales over the period studied. The annual sales to these 3 rates increased from 39.9 GWH in 1961 to 259.4 GWH in 1975, at a compound growth rate of 14.31%/yr. (this data taken from BECO annual returns to Department of Public Utilities). In the same period, other commercial sales increased from 1351.3 GWH to 3665.0 GWH annually, at a rate of 7.39%/yr. Thus, the inclusion of the master-metered rates in the regression data will tend to increase the coefficients of those explanatory variables which correlate with time. Thus, GNP and residential households will appear to generate more commercial sales than they should, and electric price will tend to have less impact than would be observed if master-metered sales were omitted from the regression data.

Q: How are master-metered sales double-counted?

A: Both the base use of 296 GWH/yr. and growth in C, C-1, and K are double-counted, although in different ways. The master-metered sales are counted in Gilbert's commercial projection, but subtracted from BECO's linear-trend. Hence, one-half the C, C-1, and K sales are represented in the "average" column on p. II-87. BECO then adds in the 296 GWH base sales, so the base use is counted one and one-half times in the commercial sector.

The growth corresponding to these apartment rate classes is included in the residential forecast, as previously noted. But half of that growth is also included in the commercial forecast, without any allowance for energy efficiency improvements. Therefore, growth in sales corresponding to present master-metered apartments is counted at least one and one-half times.

Q: Are there other master-metered rate classes which similar problems arise, other than rate classes C, C-1, and K?

A: Yes, some of the J class, which is master-metered, is used for apartment buildings. These sales (both base and growth) are apparently completely counted twice, in both the commercial and the residential sectors. In addition, sales to the residential portion of the J class (from Info. Response AGIII-22) increased from 23.2 GWH in 1970 to 35.2 GWH in 1975 (8.71%/yr.) while non-master-metered commercial sales only increased from 2765.5 GWH to 3629.8 GWH (5.59%/yr.). Thus, inclusion of the J-class residential sales in the commercial model also biases the overall prediction upwards.

Q: How does inclusion of master-metered apartments distort average residential consumption?

A: It is well known that master-metered apartments use more electricity than otherwise equivalent apartments, since the residents have no incentive to conserve. I have seen an FEA estimate that master-metered units use about 25% more electricity than individually-metered apartments. BECO's figures indicate that apartments on the master-metered C-1 and J rates use between 13% and 164% more space heating energy than do units on the individual rate B023 (Information Response AGIII-22, p. 5). The same data indicate that the master-metered rate groups were not only included in determining average apartment heating consumption, but that they dominated the average. In fact, 1975, the first year with considerable numbers of B023 units, was deleted from the average. Yet, those B023 apartments would seem to be typical of future construction, both because they are entirely new units and because the master-metered rates are closed. Certainly, then, electric apartment heating (and probably other uses) consumption for new units is upwardly biased.

In addition, conversion of some 20,000 existing master-metered apartments to individual metering (which landlords may well undertake) could reduce their consumption by as much as 50%. The same would apply to some extent in master-metered sales to shopping malls, office buildings, and other commercial establishments.

Q: Are there any other problems with the calculations performed on p. II-87, the "Final Method Commercial Forecast 1977-1987", besides the double-counting of master-metered sales?

A: First of all, BECO has no justification for arbitrarily using a linear time trend -- a thoroughly discredited technique -- in place of an econometric model which (were it properly derived) could incorporate the effects of changes in prices, economic activity, population, and the like. If BECO really believes that Gilbert's work was no better than trending, they are essentially saying that they do not have a competent forecast of commercial sales.

Furthermore, BECO does not simply average two results which they might consider equally reliable. Rather, they use linear growth alone until 1980, when Gilbert's growth rate exceeds the linear rate. At that point, they apply Gilbert's growth rate to the linear-trend results for 1979, rather than to Gilbert's lower 1979 prediction thus increasing the 1987 total prediction by 112 GWH. In short, BECO picks and chooses techniques to achieve the highest possible "average".

Finally, the electricity use of the "Harvard Complex" (MATEP) was included in the data from which both commercial models (linear and Gilbert) were derived. Hence, some of the growth in commercial sales is an extrapolation of growth in sales to MATEP customers. But these customers will almost certainly be disconnected from BECO within a few years and their growth, if any, will presumably occur within MATEP. Therefore, the MATEP share of growth should be subtracted from commercial sales. This may be a larger than average share, since the hospitals were presumably adding many energy-intensive treatment and research facilities in the period on which the forecast is based.

Q: Do you have any additional comments on BECO's selection of a commercial model?

A: Yes. I wish to note two more examples of inconsistent and arbitrary methods. First, Gilbert uses a highly unorthodox procedure of fitting the data set to the model by varying the study period, rather than fitting the model to the data. The forecast fits Model 1 to data from the years 1960 to 1976 but it fits Model 2 to data from the years 1963 to 1972. According to Information Response III-35 Gilbert did fit Model 2 to a more complete data set, 1963 to 1976, (labelled Model 12 in the Information Request). The result is a much poorer fit. The Adjusted Index of Determination is 0.294, compared to 0.602 for the smaller data set. Altering the data set does produce very different values for the parameter estimates (*see* Table 10).

Table 10.
Comparison of Regression Statistics
for Model 2 Fit to
Two Different Study Periods

	Study Period 1963-1976	Study Period 1963-1972
Independent Variables		
X_1	0.706	2.629
X_2	0.424	0.334
X_3	-0.314	-0.777
Intercept	0.234	-1.164
Adjusted Index of Determination	0.294	0.602

If Model 2 does not work well for the recent years - where we see the start of rising real prices and slower growth in sales, it may be an indication that the model fails to capture the causal relationships that will exist in future years. This is simply one more of the many defects in the design of the commercial forecast; by itself, this arbitrary manipulation of the data is sufficient to call into question the validity of the entire commercial model.

Secondly, a low t-statistic is insufficient justification for rejection of the MST variable. If it seems reasonable a priori that temperature should have an effect on consumption, a low t-statistic may be an indication of modeling or data problems. In particular, Annual Cooling Degree Days may be a better explanatory variable than MST. Note also that Gilbert does not reject the GNP variable from Model 2 even though that regression coefficient has a lower significance level (74.45%) than does the coefficient of MST in Model 7 of Information Response AG III-35 (78.46%).

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Research Experience

12/77-present:	Utility Rate Analyst, Massachusetts Attorney General. Responsibilities include reviewing and commenting on demand forecasts and proposed peak-load rate structures, as well as other electric utility issues involving planning, modelling, and evaluation.
9/76-9/77:	Thesis research on pricing policy as an optimization technique. Considered peak-load and joint-production problems, effects of technological factors on optimal pricing structure, and value judgements underlying the analysis. Published as Technology and Policy Report 77-1.
2/76-1/77:	Liquefied Natural Gas as a public safety problem. Compared analytical techniques for public evaluation and decision-making. Developed paper into proseminar project assignment, guided student groups, critiqued final reports.
9/73-5/74:	Transportation and Community Values Project, MIT. Worked in Cambridge and San Francisco preparing examples of regional transportation plans for California Department of Transportation. Developed data display and comparison techniques.

Education

1968-1970;1973-1974	Massachusetts Institute of Technology. S.B. in Civil Engineering, June 1974.
1972-1973	University of Maryland. Mathematics Education.
1974-1977	Massachusetts Institute of Technology. Civil Engineering and Technology and Policy. S.M. in Technology and Policy, February 1978.

APPENDIX A

General Background

6/77-10/77: Research Assistant to Ben Snyder, Director, Education Division, MIT. Compiled annotated bibliography of case studies and related materials on organizational adaptation. To be published in conference proceedings.

9/74-6/77: Teaching Assistant to Richard de Neufville, Civil Engineering Dept., MIT. Taught systems courses for undergraduates and graduates, covering: marginal analysis, constrained optimization, regression, math programming, social decision-making, sensitivity analysis, utility theory, cost-benefit and decision analysis. Wrote course notes, supervised student graders, taught sections, gave some lectures. Accompanied Prof. de Neufville to Berkeley to start similar courses there.

9/71-1/73: Teaching Assistant, University of Maryland. Team-taught 6 sections of Math for Elem. Ed. majors; small-group methods. Assisted in course design, wrote teaching materials. Taught and wrote materials for junior high and high school.

1968-1970: Various summer and term jobs; computer programmer, lab assistant.

Honorary Societies

Chi Epsilon (Civil Engineering)

Tau Beta Pi (Engineering)

Sigma Xi (Research)

RESUME OF SUSAN C. GELLER

Education

1974-present — PUBLIC POLICY PROGRAM KENNEDY SCHOOL OF GOVERNMENT, HARVARD UNIVERSITY

Passed Ph.D. Qualifying Examinations Spring 1977

Received Master's Degree in Public Policy in June, 1978. First year coursework included Analytic Methods, Economics, Statistics, Political Analysis, and a workshop applying analytical techniques to specific policy problems. Second year coursework in advanced micro- and macroeconomic theory, decision theory and operations research. Also, seminar on the politics of the use and support of science and technology. Master's Thesis: "Employment Discrimination Against Epileptics." Focuses on implications of the probabilistic nature of the disability.

Teaching Assistantships:

Spring 1975	With Prof. F. Bator for first-year course in Economic Theory.
Fall 1976	With Prof. M. Roberts and T. Schelling for course on Analytic Methods and Public Policy.
Fall 1976 through Fall 1977	With Prof. H. Brooks and Dean D. Price for a seminar on science, technology, and public policy.

1970-1974 — RADCLIFFE COLLEGE, HARVARD UNIVERSITY

Received B.A., magna cum laude, in Economics, June, 1974. Honors Thesis: "Incentives for Nuclear Safety: A Policy Framework." Drawing on knowledge of the technology, examined distortionary incentive effects of government subsidy and regulatory mechanisms. Other coursework included advanced courses in econometrics, public finance, and decision analysis.

Work Experience

March, 1978- Present	UTILITIES SECTION, MASSACHUSETTS ATTORNEY GENERAL'S OFFICE. Utility Rate Analyst. Deal with economic and statistical issues in electric and telephone ratemaking.
Summer 1975	PUBLIC POLICY PROGRAM, KENNEDY SCHOOL OF GOVERNMENT Research Assistant for Professor William Fairley. Examined safety issues raised by proposals to transport liquified natural gas into city harbors. Helped prepare discussion outline and syllabus for seminar on catastrophes (low probability, severe consequence events).
Spring 1975	EPA REGION I, ENVIRONMENTAL IMPACT OFFICE Volunteer Consultant. Evaluated current and evolving policy regarding secondary impacts of the EPA Wastewater Treatment Plan Grants Program.
Summer 1974	HARVARD BUSINESS SCHOOL Research Assistant. Helped prepare seminar for business executives and public officials on the problems of producing electric power for New England. Responsibilities included conducting interviews with business executives, public officials, and environmentalists, gathering source materials, and generating topics for discussion.
Summer 1973	ATOMIC ENERGY COMMISSION, NUCLEAR REACTOR SAFETY STUDY Summer Intern. Worked on the "Rasmussen Study", a controversial attempt to apply the technique of fault tree analysis to the estimation of probabilities and consequences of serious nuclear power plant accidents. Collected and analyzed data on component failure rates and repair times.

Joint Testimony of Paul L. Chernick
and Susan C. Geller: Errata Sheet

1. Page 1, lines 16-17: the correct title of the report is: Optimal Pricing for Peak Loads and Joint Production: Theory and Applications to Diverse Conditions.

2. Page 12, line 27: "conditioing" should read "conditioning."

3. Page 13, line 5: insert a comma after "convenient."

4. Page 26:
after "Houthakker and Taylor" add "(1970)" and change "States" to "National";
after "Levy" add "CS" in column 3;
after "Mount, Chapman, Tyrell" add "(1973)";
after "FEA" add "States" in column 2 and "Pooled TS and CS" in column 3.

5. Page 28, line 24: the beginning of the line should read "for year 0."

6. Page 28, line 26: omit "is".

7. Page 33, line 23: "cross-sectioned" should read "cross-sectional".

8. Page 38: note 3 should read:

$$\frac{P_t - P_{t-1}}{P_{t-1}}$$

9. Page 40:
line 6: "298" should be "296";
lines 7 and 10: "3593" should be "3591";
line 10: "2656" should be "2655".

10. Page 42:
line 24: "from .428 to .900" should read "from .542 to .900";
line 25: ".640" should read ".728".

11. Page 50, line 12: after "sales" add "forecast for 1987".

12. Page 52, line 1: title of §IV should read: "EFFECT OF PRICE ON PEAK LOADS" (this should also be changed in the Table of Contents, p. i).

13. Page 70, line 10: "111-35" should read "III-35."

14. <u>General Comments.</u>

It should also be noted that Gilbert has revised its elasticity calculations, which we correct on page 21. It does not appear that their revisions affect the validity of our criticism; therefore, we have not repeated our calculations on their new estimates.

On the last line of page 47, our statement that BECO's estimates are "30% to 50% too high" is not clear. Since our revisions are 30% to 50% lower than BECO's figures, it would be clearer to say that we believe that BECO's estimates are 43% to 100% too high.

On page 48, lines 6-9, it should be additionally noted that the growth-rate model does not allow for any direct connection between current price and lagged prices. Therefore, the capture of lagged-price effects by the current price growth variable would appear to be fortuitous.

On page 42, lines 1-2, it would be more appropriate to list the 13-year effects, rather than the 14-year effects, since a 13-year time span (1974-87) is the longest period effect used in our calculations. With this modification, the value "-0.911" on line 2 should read "-0.872" and the value "-1.196" on line 4 should read "-1.172".

Finally, recomputed Tables 6-9 are attached. These were previously supplied to BECO in response to an information request. Also, a corrected p. 41 is attached; the original p. 41 omitted some exponents and superscripts in the equations.

TABLE 6: PROJECTED RESIDENTIAL ELECTRIC PRICES
500 KWH/MONTH 1974-1987

YEAR	PRICE: HIGH PRICES WITH INCREASES IN 1976-1978	PRICE: LOW PRICES WITHOUT INCREASES IN 1976-1978
1974	16.05(1)	16.05(1)
1975	18.74(1)	18.74(1)
1976	19.30(2)	18.74(3)
1977	19.88	18.74(3)
1978	20.48	18.74(3)
1979	21.09	19.30(2)
1980	21.72	19.88
1981	22.38	20.48
1982	23.05	21.09
1983	23.74	21.72
1984	24.45	22.38
1985	25.18	23.05
1986	25.94	23.74
1987	26.72	24.45

NOTES:
(1) from Typical Electric Bills, F.P.C.
(2) this and succeding years experience 3 per cent real price increases
(3) no increase projected
(4) all prices in 1973 dollars

TABLE 7: METHOD 2 LOW ELASTICITY CASE

i	$e_i = -.1(.93)^i$	$(P_o)^{e_i}$ low base(1)	$(P_o)^{e_i}$ high base(2)	$(P_t)^{e_i}$ low price(3)	$(P_t)^{e_i}$ high price(3
13	-.039	.9019	.8922	.8976	.8976
12	-.042	.8950	.8845	.8845	.8845
11	-.045	.8875	.8764	.8764	.8753
10	-.048	.8796	.8678	.8678	.8653
9	-.052	.8711	.8585	.8585	.8546
8	-.056	.8621	.8487	.8473	.8432
7	-.060	.8526	.8383	.8354	.8309
6	-.065	.8424	.8272	.8225	.8178
5	-.070	.8316	.8156	.8089	.8039
4	-.075	.8201	.8031	.7943	.7891
3	-.080	.8080	.7900	.7788	.7733
2	-.086	.7951	.7761	.7623	.7565
1	-.093	.7815	.7614	.7449	.7388
0	-.100	.7671	.7460	.7264	.7200
		.08926	.06919	.06230	.05811

NOTES: (1) P_o = \$14.17 = Typical Electric Bill, 1973, 500 KWH, in all year
(2) P_o = \$18.74 = Typical Electric Bill, 1975, 500 KWH, in all year
(3) P_t from Table 6; year = 1987 - i
(4) all prices in 1973 dollars

TABLE 8: METHOD 2 HIGH ELASTICITY CASE

		$(P_o)^{e_i}$		$(P_t)^{e_i}$	
[illegible]	$e = -.2(.85)^i$	low base (1)	high base (2)	low price (3)	high price (3)
13	-.024	.9379	.9316	.9351	.9351
12	-.028	.9274	.9200	.9200	.9200
11	-.033	.9151	.9066	.9066	.9057
10	-.039	.9009	.8910	.8910	.8889
9	-.046	.8844	.8731	.8731	.8695
8	-.054	.8655	.8524	.8510	.8469
7	-.064	.8437	.8287	.8256	.8209
6	-.075	.8188	.8017	.7963	.7910
5	-.089	.7904	.7710	.7630	.7570
4	-.104	.7582	.7364	.7252	.7185
3	-.123	.7221	.6977	.6827	.6753
[illegible]	-.145	.6818	.6548	.6355	.6274
1	-.17	.6372	.6076	.5837	.5749
0	-.2	.5885	.5565	.5276	.5184
		.04194	.03002	.02509	.02274

NOTES: see table 7

TABLE 9: METHOD 2 NET PRICE EFFECTS

ELASTICITY ASSUMPTION	BASE PRICE ASSUMPTION	PRICE FORECAST	PRICE EFFECT $\frac{\prod Pt^{ei}}{\prod Po^{ei}}$	AVERAGE OF PRICE EFFECT FOR EACH ELASTICITY ASSUMPTION
low	low	low	.698	
low	low	high	.651	
low	high	low	.900	.772
low	high	high	.840	
high	low	low	.598	
high	low	high	.542	.683
high	high	low	.836	
high	high	high	.757	

NOTE: results compiled from Tables 7 and 8