APPENDIX A

Financial Impact Upon Ratepayers

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I. The City's Projection Of Reduced Job Growth Is Unverifiable, Speculative And Grossly Overstates The Economic Impact of PECO's Proposed Rate Increase.

The City has attempted to quantify the potential economic impact of the electric rate increase proposed by PECO in this proceeding through the testimony of Dr. Arie P. Schinnar (City Sts. 1 and 1A). Dr. Schinnar's testimony presents the results of a complex econometric computer model that he has developed, known as the "STARLOC". The results of Dr. Schinnar's model indicate that PECO's rate proposal would reduce job growth in the Philadelphia area by 19,196 jobs. The model includes "nearly two-hundred equations and over one thousand parameters [or intermediate calculations]" (City St. 1, p. 4). STARLOC consists of a large number of components, including submodels, which have all been hooked together into one large, overall model (City St. 1, p. 38).

In order to understand and evaluate this complex model, PECO retained two outside modeling experts to review STARLOC and consider its results. PECO Witness Dr. George Schink is the Vice President for Research and Development at Wharton Econometric Forecasting Associates, Inc. ("WEFA"), and is "responsible for the development, enhancement, specification and maintenance of the WEFA econometric models" (PECO St. 38, p. 1). PECO Witness Dr. William W. Hogan, is a professor of Political Economy at the

Kennedy School of Government, Harvard University, and is the Director of the Energy and Environmental Policy Center at Harvard University (PECO St. 37, p. 1). Both PECO experts have doctorates in Economics and have extensive modeling experience and backgrounds constructing, evaluating and working with large economic models like STARLOC.

Although enshrouded with mathmatical complexity, Dr. Schinnar's STARLOC model actually is presented in only a preliminary and incomplete form. The results derived from his model, therefore, are deserving of little, if any, weight in this proceeding. Dr. Schinnar's model is incapable of satisfying even the minimum requirements for public validation and consideration in this proceeding because: (a) Dr. Schinnar has not documented the procedures used to construct his model; (b) Dr. Schinnar has not made available to the other parties to this proceeding or this Commission the intermediate calculations which are essential to validate and test his model, (c) Dr. Schinnar has not documented or replicated his purported testing of the model; and (d) Dr. Schinnar has modified the program for his model at least twice in response to concerns raised by PECO's experts, underscoring the preliminary nature of STARLOC.

Even operating within these validation constraints on the process, however, PECO modeling experts Dr. Hogan and Dr. Schink were able to identify significant conceptual and structural flaws and modeling errors in STARLOC. As a result of

these errors alone, the STARLOC model has been shown to overestimate significantly the economic impact of PECO's rate proposal.

A. Dr. Schinnar's Model Is Presented And Documented In A Form That Is Incapable Of Validation.

Before Dr. Schinnar's model, or any other model, can be relied upon for policy-making purposes, the model must be open to public scrutiny, must be capable of validation, and must undergo sufficient testing to warrant the consideration of policy makers and the public. The documentation of Dr. Schinnar's model in its present form, however, is unable to satisfy even the most rudimentary requirements of public validation.

PECO Witness Dr. Schink, who has been involved in the process of public validation of econometric models, including those he has prepared for WEFA, has explained the importance of public validation of computer models:

> "If policy makers are to use information produced by these models as input into their decision-making process, then these models must be open fully to public scrutiny and review.... If a model's output is to be used in the policy making process, then the model builder must provide detailed model documentation and must allow access by reviewers to all final and intermediate model calculations. This documentation and access is essential for public validation of the model. Such public validation is critical if a policy maker is to rely on the model's results with any degree of confidence".

(PECO St. 38, pp. 4-5) (emphasis added)

PECO's experts, including Dr. Hogan (PECO Sts. 37 and 37A) and Dr. Schink (PECO Sts. 38 and 38A) undertook to validate and test the structure and results of the STARLOC model. They found that the STARLOC model, as presently constructed and documented, is in a form that is incapable of public validation within the time frame of this proceeding.

B. Dr. Schinnar Has Failed To Document The Procedures Used To Construct His Model.

PECO's efforts to validate the STARLOC model and its results were thwarted by Dr. Schinnar's failure to document, for purposes of review and validation, the steps he and his assistants undertook in constructing the model to this point. Dr. Schinnar has produced only two types of documentation: (a) the draft of a Technical Report, outlining generally the mathematical specifications and estimated parameters of STARLOC (PECO Exhibit 22), and (b) certain workpapers that were made available to PECO sufficiently close to the close of the record in this proceeding that they were not useable. Besides being in draft form or too late to be useful, this documentation is woefully incomplete and provides only a brief glimpse of the STARLOC model.

1/ The draft Technical Report states on its cover that the final version will be out in March, 1980. No final version has been presented to PECO or the other parties to this proceeding.

1. The Technical Report Is Only A Draft and Is Only The First In a Series of Reports To Be Issued At Some Unspecified Time In The Future Detailing Key Aspects Of STARLOC.

The Technical Report is only in draft form and refers to several future reports that are intended to document, with greater specificity, various aspects of STARLOC.[1] Moreover, the draft Technical Report indicates that a series of six STARLOC technical reports ultimately will be forthcoming, of which the draft Technical Report is the first version of the first such report (PECO Exhibit 22, pp. 3-4). The other STARLOC reports will include details on the following key aspects of the STARLOC model:

"STARLOC Report 3: Employment Multipliers and Elasticities of the Philadelphia Economy (and Other Data of the Philadelphia STARLOC Model)

STARLOC Report 4: Residential Energy Demand Elasticities by Region and Income: Electricity, Gas and Fuel Oil

STARLOC Report 5: Government Energy Demand Elasticities: A Comment

STARLOC Report 6: An Economic Growth Model of the Philadelphia Service and Manufacturing Sectors."

1/ The draft Technical Report states on its cover that the final version will be out in March, 1986. No final version has been presented to PECO or the other parties to this proceeding.

(Id., p. 4). The draft Technical Report also references the importance of these forthcoming technical reports; for example: (a) "[g]reater detail on the construction of the Philadelphia data base from which the model was assembled will be given in STARLOC Report 3, forthcoming" (id., §2, p. 7) (emphasis added); and (b) "[e]stimates for other variables of the model are provided elsewhere (see STARLOC Report 4, forthcoming)" (Id., §5, p. 4). In discussing STARLOC Report 4, the draft Technical Report further states:

> "...we undertook the estimation of a residential energy demand model using data from the Residential Energy Consumption Survey (1981), which is reported elsewhere (see STARLOC Report 4, forthcoming). Here [i.e. in the draft Technical Report] we present a succinct summary of the model specifications and estimated parameters."

(Id., §5, p. 2) (emphasis added). Neither a final version of the draft Technical Report, nor any of the other technical reports, has been issued by Dr. Schinnar (Tr. 4665).

Nevertheless, Dr. Schinnar attempted to defend the draft Technical Report by stating that it is a complete "mathematical specification" of the model (Tr. 3296; City St. 1A, p. 13). This simply means that the draft Technical Report contains the mathematical equations that are built into the model. The mathematical specification, however, is only a small part of the documentation of the model. The draft Technical Report does not set forth any of the following essential elements for documenting STARLOC: (a) how

the mathematical equations were developed, (b) how the equations are actually implemented in the model (i.e. the results of the intermediate calculations), (c) the data that are entered into the equations to produce the intermediate and final results, or (d) how the data were developed or updated.

Dr. Schinnar has conceded that STARLOC Report 3, when issued, will contain details on construction of the Philadelphia database (PECO Ex. 22, §2, p. 7; Tr. 3296). The data base contains the actual numbers that have been entered into the equations specified in the draft Technical Report. Dr. Schinnar collected and arranged these data from a wide variety of sources, and was required to update his data to 1981.[2/] The updating process required Dr. Schinnar and his assistants to develop hundreds of equations, calculations and programs separate and apart from the STARLOC model. Dr. Hogan has explained:

> ". . . The model reportedly includes over two hundred equations and one thousand parameters. Naturally, a model of this scope must rest upon an underlying data base of thousands of observations used to estimate the parameters. A review of every one of these equations and estimations, as implemented in the model, would present a formidable task.

2/ Although purporting to project the impact of the PECO rate increase on the Philadelphia MSA for the years 1986 to 1988, STARLOC is constructed only to model the effect PECO's rate increase would have on the Philadelphia economy as it existed in 1981 (Tr. 3366-76, 3372). Since Philadelphia's economy has undergone dramatic changes since 1981, utilizing this early "snap shot" of Philadelphia as the basis for the model merely highlights the speculative nature of its results.

However, this would be an important step in a complete validation of the model and its results."

(PECO St. 37, p. 45) (emphasis added).

The updating procedures utilized by Dr. Schinnar to construct STARLOC's database were not specified or provided within the time frame of this proceeding. Indeed, Dr. Schinnar has stated that "STARLOC Report 3 will contain a complete documentation of the updating procedures employed" (PECO Exhibit 23; Tr. 3300). STARLOC Report 3 has yet to be issued.

2. Documents Produced By The City As A Supplemental Response To Earlier Requests Do Not Allow For The Validation Of STARLOC In The Context Of This Proceeding.

On March 5, 1986, just two days before PECO's sur-surrebuttal testimony was due, the City filed a "supplemental response" to PECO's earlier requests for STARLOC documentation stating:

> "[t]he Staff of the Wharton Policy Modeling Workshop has assembled Supplemental Staff notes used in developing the STARLOC model used in connection with City Statement No. 1. These Supplemental Staff notes are voluminous and, therefore, are being made available for review at the wharton Policy Modeling Workshop, University of Pennsylvania."

(PECO St. 38A, Ex. GRS-4) (emphasis added). PECO had Dr. Schinnar review the documents produced in connection with this supplemental response (PECO St. 38A, pp. 16-17; Tr. 4610-11).

These documents consisted of: (a) workpapers documenting "exactly how the model was being put together" (Tr. 4657); (b) Dr. Schinnar's workpapers instructing his staff on the construction of STARLOC (Tr. 4652); and (c) about 300 pages of computer printouts relating to estimating the energy demand submodel of STARLOC (Tr. 4611).

Dr. Schink testified that it would take until well after the record closed in this proceeding to analyze STARLOC using the workpapers produced pursuant to the supplemental response on March 7th (Tr. 4615). Dr. Schink concluded after reviewing these workpapers that:

> "it confirms my belief that STARLOC cannot be validated in the context of this proceeding."

(Id.).

3. Independent Verification Of The Calculations And Procedures Used To Construct STARLOC Are Essential To Its Validation.

Dr. Schinnar, himself, underscored the importance of an independent verification of the calculations and procedures used in constructing his model. During his cross-examination, Dr. Schinnar stated:

> "Q. Did you think it was important, therefore, for you to check the actual calculations done by your research assistants after you had given them the various conventions and standards that you wanted them to use to do this updating process?
>
> A. I always do.

Q. Why is that? To make sure they are done accurately and correctly?

A. Because I have long experience in model building and because I am also a policy analyst where I am building models to effect or to guide policy decisions; and it is a very important step and I want to make sure that the results are correct."

(Tr. 3371-3372) (emphasis added).

Although Dr. Schinnar may be confident that his procedures and data are correct, he has left the Company and this Commission with no means of independently verifying such procedures and data. Dr. Schinnar has brought a "black box" to this proceeding (PECO St. 38, p. 4). Because its operation cannot be verified, Dr. Schinnar in essence is saying to this Commission and to PECO, "trust me, it works." As discussed below, there is ample reason to doubt that STARLOC functions properly, and no reason to allow its unverified results to be given any weight. Without the necessary documentation, Dr. Schinnar's model cannot withstand public scrutiny and validation and thus is of no valid use in this proceeding.

4. Dr. Schinnar Has Failed Within The Parameters Of This Proceeding To Make Available The Intermediate Calculations Necessary To Validate STARLOC.

The process of validating Dr. Schinnar's model requires "not only a review of the procedures employed in constructing the model and its database, but also an analysis of how the model

actually works. An important element in validating how Dr. Schinnar's model actually works is a review of the intermediate calculations (or parameters) of the model. A review of these intermediate calculations is critical to determining whether the model works in the way that Dr. Schinnar says it does, and also in determining whether the model's results make sense. Unfortunately, the intermediate calculations of STARLOC are not available for review by PECO or this Commission.

Dr. Schinnar has indicated that there are thousands of intermediate calculations performed internally by STARLOC (City St. 1, p. 4; Tr. 3352-53). An intermediate calculation is one that produces results that are passed along internally to comprise an input into further calculations that eventually result in the final output of the computer model (Tr. 3308). The fact that these calculations are computed only internally, and are not printed out, is a function of how the model has been programmed by Dr. Schinnar (Tr. 3311-12; 3350-53).

By way of written interrogatories and oral data requests from PECO's experts, the Company requested that Dr. Schinnar provide all of the intermediate calculations of the STARLOC model (PECO St. 38A, p. 10; PECO St. 37A, p. 4; Tr. 3306). Dr. Schinnar refused the Company's requests and stated that to provide the intermediate calculations would require modification of his computer program, which would constitute an "undue burden" (Tr. 3306; PECO Ex. 24). For example, when PECO sought by way of

interrogatory to examine the changes calculated by STARLOC to the data reflected in Tables 2.2 through 2.6 of the draft Technical Report, Dr. Schinnar responded:

> "these changes are computed internally by the computer program. To generate these tables the computer sub-routines would have to be modified, which would impose undue burden."

(PECO Ex. 24). Moreover, Dr. Schinnar emphasized during his initial cross-examination that he was unable to provide the intermediate calculations:

> "Q. So you are not able at this point to get the computations as would be reflected in the tables because they are inside the computer and you don't have the program at this point to bring them out; is that a fair statement?
>
> A. I am unable at this point to provide it; yes, that is correct.
>
> Q. And this is something that the experts had asked for, was it not?
>
> A. That is something that the experts have asked me, yes, including yesterday."

(Tr. 3306).

In addition to requesting all of the intermediate calculations, the Company and its experts requested to see certain specific intermediate calculations, such as the calculation of the final demand (f*), the calculation of relative wage rates, and the price vector (PECO Ex. 23; Tr. 3339-41; 3436; 4649-50). Dr. Schinnar denied these requests as well.

Although Dr. Schinnar chose not to provide any intermediate calculations to the Company, he has modified his

computer program to allow him to determine the results of certain intermediate calculations that he included in his surrebuttal testimony (Tr. 4644-47). It is apparent that Dr. Schinnar has chosen to modify his program to allow the determination of selective intermediate calculations only when such a modification ostensibly supported his results.

On March 5, 1986, the City served a "supplemental" written response to the Company's earlier request for all intermediate calculations, that stated:

> "[the] Policy Modeling Workshop of the Wharton School estimates that it will take approximately three (3) weeks from the date the Project [to determine and print out the intermediate calculations] is begun to complete the Project."

(PECO St. 38A, Ex. GRS-4) (emphasis added). Since the record closed in this proceeding on March 17, 1986, there was no opportunity for PECO to obtain all of STARLOC's intermediate calculations, let along analyze them in this proceeding.

However, the few intermediate calculations that Dr. Schinnar has provided in his surrebuttal testimony serve to underscore the necessity for a complete review of all such calculations. As discussed fully below, an analysis of the intermediate calculations provided in Table 1 of Dr. Schinnar's surrebuttal testimony (City St. 1A, p. 5) reveals that STARLOC makes at least 3 fundamental errors: (a) it erroneously attributes significant job loss to energy conservation and interfuel substitution, (b) it erroneously double counts certain

other job loss effects, and (c) it erroneously applies labor multiplier effects to its intermediate calculations producing totally unreasonable results. Because the intermediate calculations are sealed internally within STARLOC, its results are effectively hidden from public scrutiny, and this Commission and PECO are thereby precluded from validating STARLOC or its results.

5. Dr. Schinnar Has Failed Sufficiently To Test Or To Document The Limited Testing He Performed On STARLOC.

The process of public validation of a computer model requires that the model's intermediate and final results be tested. The tests performed by Dr. Schinnar were limited to testing the sensitivity of the model to various inputs and outputs (PECO St. 38A, p. 15; see PECO Ex. 29), and to testing the individual components of STARLOC during the model's assembly process. (Tr. 3307-08; 3336). The results of such tests are of little use in the public validation of the model because: (a) Dr. Schinnar did not test STARLOC against historical electric price increases and their impact on economic growth; (b) the tests that Dr. Schinnar purportedly did perform were extremely limited; and (c) the tests that Dr. Schinnar purportedly did perform cannot be replicated and provided to the parties to this proceeding. The need for testing complex economic models, and the process that has been developed for such testing, was described

by PECO witness Dr. Hogan (PECO St. 3, pp. 4-7). Specifically, Dr. Hogan described the model testing approach developed by Stanford University's Energy Modeling Forum ("EMF"), "the principal organization conducting regular comparisons of energy-economy models." (Id., p. 4). Dr. Hogan explained:

> "Due to the complexity of the models, the EMF testing process has been conducted with the assistance of the model developers. The EMF working groups design the alternative scenarios and assumptions, and the model developers conduct the tests. The process usually takes several steps -- design the tests, review the final and intermediate results, and then design a new series of tests to explain the unexpected or unusual results in the first investigation. Typically this process leads to surprises, even for the model developers, and to improvements in the model."

(Id., p. 6) (emphasis added). Dr. Hogan further explained that a review of the inputs and outputs of the model were not enough:

> "Q. Would the tests you describe [as quoted above] be limited to an examination of inputs and outputs?
>
> A. No. The tests should also include an examination of intermediate model outputs in order to evaluate the consistency and validity of the model. In a well-chosen test, the intermediate calculations can isolate the critical parts of the [model's] system."

(Id.).

Dr. Schinnar has conceded that an important procedure for testing the results of a computer model is to compare the results against historical precedents (Tr. 3316-17). Nevertheless, Dr. Schinnar has not undertaken to test his STARLOC model against such precedents. Moreover, Dr. Schinnar has

conceded that he has neither applied his model to any past rate increases in the Philadelphia area to compare the model's projections against actual economic growth experience (Tr. 4638), nor attempted to use STARLOC to predict the impact of electric rate increases in any other metropolitan areas. (Id.).

The only example of historical testing that Dr. Schinnar has provided is reflected in the graphs labeled as Figures 16 and 17 in Dr. Schinnar's direct testimony (City St. 1, p. 37) (also reproduced as Figures 3.1 and 3.2 in the draft Technical Report, PECO Exhibit 22). These graphs, however, relate to the testing of only the growth submodel. Although these graphs illustrate that the growth submodel predicts the changes in overall employment growth rates in the Philadelphia MSA economy fairly accurately, they do not verify the accuracy of the STARLOC model as a whole. Specifically, the growth submodel is not used in the static analysis that produces the loss of new job growth figure of 19,196 jobs. To the extent that the growth submodel accurately predicts the change in employment growth rates for the Philadelphia area, the results reflected in Figures 16 and 17 contradict the magnitude of the economic impact projected by Dr. Schinnar, because the growth submodel is able to make such an accurate prediction without including any variable for electric price changes (see Section IIA2a(2)(F), infra).

Nevertheless, in an effort to portray the testing of his model as extensive, Dr. Schinnar has stated that he provided the

Company's experts with "370 test runs of the model," and that the Company's experts were able to perform "75 sensitivity analysis runs." (City St. 1A, pp. 13-14). However, this reference to the number of sensitivity runs is misleading as to both the quality and adequacy of the tests that the Company was permitted to have performed. By virtue of the manner in which Dr. Schinnar programmed the STARLOC model, Dr. Schinnar and the Company's experts were able to change only a small subset of the inputs, namely electricity price change, inflation rate, number of years and growth rate (PECO St. 38A, p. 15; PECO Ex. 29). They were not able to test the sensitivity of the important intermediate calculations (Tr. 4637). Dr. Schink explained the limited nature of the tests that could be run:

> The "sensitivity runs" which could be performed were severely constrained. We were restricted to changing the same input parameters again and again, and could not test the sensitivity of any intermediate calculations. Dr. Schinnar had determined the content of both the input and output subsets when he programmed the computer.

(PECO St. 38A, pp. 15-16)(emphasis added). As summarized by Dr. Hogan, "[t]his kind of sensitivity testing is elementary, and tells us little about the inner workings of the model." (PECO St. 37, p. 7).

Nevertheless, PECO's experts sought to go beyond this elementary level of testing by suggesting sensitivity runs that changed various internal assumptions and intermediate calculations of the model. However, they were told that such

tests could not be performed. With respect to the assumption in STARLOC that real wage rates remain constant, for example, Dr. Schinnar stated during cross-examination:

> "Q. So at least in that respect, you will agree, will you not, that PECO's experts were not able to test the sensitivity of STARLOC to a scenario which included a change in the real wage rate?
>
> A. The answer is they were not able to test that; right."

(Tr. 4637).

In addition to the sensitivity runs, Dr. Schinnar described his testing of STARLOC on a component-by-component basis (Tr. 3306). STARLOC consists of many complex individual components. Dr. Schinnar has conceded that he tested the calculations of his model only during the process of assembling the components. Dr. Schinnar did not test STARLOC in its entirety after it was assembled to see if all of its component parts function properly when required to interact with other component parts (Tr. 3306-07). Indeed, Dr. Schinnar has conceded that he could not have tested the calculations of his model as a whole, because the memory of his computer is too small to permit him to display the intermediate calculations that are an essential part of such testing (Tr. 3309-13; 3350-53).

Moreover, PECO's experts have been unable to review the component-by-component testing purportedly performed by Dr. Schinnar, because Dr. Schinnar has not made available any written record of such testing, and such testing cannot now be

replicated. Dr. Schinnar has stated that the component-by-component testing may have been performed on the computer terminal screen or may have been printed out, he is not sure (Tr. 3309). Although he has suggested that printouts from such testing may be stored at his workshop (Tr. 3311), Dr. Schinnar has not produced any printouts and has conceded that "much of our time is devoted to observing the output on the screen." (Tr. 3309). Dr. Schinnar also acknowledged that he could have printed out all of the results of his testing at the time STARLOC's components were being constructed (Tr. 3311). However, he chose not to do so. Therefore, neither he nor the Company are able presently to replicate the tests, because the intermediate calculations are now inaccessible (Tr. 3311-12).

Dr. Schinnar also is unable to document or replicate the testing of the STARLOC model's database. As set forth above, Dr. Schinnar assembled the model's database from various sources and updated the data to 1981. Dr. Schinnar has stated that he tested his updated database by comparing "similar data from different sources." (PECO Exhibit 24; Tr. 3302). On cross-examination, however, Dr. Schinnar conceded that this "similar data," including "equivalent historical matrices" (Tr. 3305), cannot presently be retrieved because it is archived on the University of Pennsylvania computers (Tr. 3302-03). Because the comparable historical data cannot be retrieved, the testing of Dr.

Schinnar's database, like the component-by-component testing, cannot be replicated or validated.

6. Dr. Schinnar Modified The Program For His Model Twice During This Proceeding.

The Company's efforts to validate the STARLOC model were further hampered by the fact that Dr. Schinnar modified the programs that run the STARLOC model at least twice after he had filed his direct testimony. One change was made on the eve of Dr. Schinnar's initial cross-examination. The other change was made between the time Dr. Schinnar was cross-examined on his direct testimony and the filing of his surrebuttal testimony. These changes to the model's programs serve to illustrate and underscore the preliminary nature of the model itself: STARLOC is still evolving.

First, on the eve of his initial cross-examination, Dr. Schinnar modified his so-called "static" program when sensitivity tests performed by the Company's consultants yielded results that Dr. Schinnar did not like. (Tr. 3346). Dr. Schinnar's STARLOC model was used to run two analysis, one a static analysis and the other a dynamic analysis (Tr. 3342). The static analysis is the analysis used to produce the 19,196 loss of job growth figure. When Company experts examined this program, they found that the program issued a command on the computer screen to input a growth figure (Tr. 3344). When the Company experts sought to run the program under different growth figures to check the sensitivity

of Dr. Schinnar's results, the results obtained made little sense. Notwithstanding the computer command to input a growth figure, Dr. Schinnar first explained that the only growth input that should be entered into his static program is an input of growth equaling zero (Tr. 3344). Dr. Schinnar then modified his static program overnight so that the results it produced were consistent with the results of the dynamic program (Tr. 3344). The Company experts were not able to observe the changes Dr. Schinnar made to his program; they could observe only the change in results. Thus, when the first series of sensitivity tests performed by Company experts produced unsatisfactory results, Dr. Schinnar responded by modifying his program.

Dr. Schinnar gave the following explanation as to why his static program contained a growth input that was not supposed to be changed:

> "Since this model was built to be used at present by myself and my staff, it was not necessary to do until it is available for general use.
>
> I did not anticipate when I wrote the testimony and even later that I would have Philadelphia Electric experts coming to sit and participate in running the models."

(Tr. 3345). This explanation reveals that Dr. Schinnar himself apparently did not consider his model to be in a form suitable to present for full public scrutiny and validation when he prepared his direct testimony in reliance on the model's results.

Second, Dr. Schinnar modified his program for use in his surrebuttal testimony, in an attempt to respond to the rebuttal

testimony of PECO Witnesses Drs. Hogan and Schink. Dr. Schinnar's second modification allowed him to present certain selected intermediate calculations in Table 1 of his surrebuttal testimony (City St. 1A, p. 5; Tr. 4642). Prior to this modification, Dr. Schinnar had been able to print out only an aggregate loss of job growth figure, and had steadfastly refused to provide any intermediate calculations to the Company.

This second modification revealed for the first time how the model quantified the loss in job growth ostensibly attributable to conservation and interfuel substitution, direct impacts on the cost of doing business, secondary inflation, and the employment multiplier. The loss of job growth quantifications presented for the first time in Table 1, confirmed the analysis of PECO's experts that Dr. Schinnar's model vastly overestimates the loss in job growth due to PECO's electric rate increase proposal.

Had Dr. Schinnar performed this modification of his program before preparing his testimony in this proceeding, he might have been able to observe these errors and correct his program accordingly. Dr. Schinnar does not have the luxury of doing so at this point, so one is left only to wonder how many similar errors and flaws would have been revealed if some or all of the remaining intermediate calculations had been available as requested by PECO.

The errors revealed by Dr. Schinnar's modification of his program to provide even a few selected intermediate calculations confirms that STARLOC presently has not been developed and refined to the point where it can be considered to be reliable for policy-making purposes. As PECO witness Dr. Schink concludes:

> "... I do not believe that there is nearly enough documentation or validation of STARLOC for a decision maker to consider it as anything other than a preliminary draft version of a model."

(PECO St. 38, p. 7).

II. Dr. Schinnar's Model Contains Substantial Conceptual Flaws And Modeling Errors That Cause The Model To Overestimate Significantly The Economic Impact Of PECO's Proposed Rate Increase.

The preliminary nature of the STARLOC model, and Dr. Schinnar's inability to provide the requisite documentation to validate the model, are rendered all the more serious considering that even the minimal information available to PECO's experts enabled them to determine that STARLOC contains significant conceptual and structural flaws and modeling errors.

The implausibly high loss of job growth figure projected by Dr. Schinnar signaled to PECO's experts that serious problems existed with STARLOC in its present form. In a calculation that Dr. Schinnar admits he does not challenge (see Tr. 4650), Dr. Hogan has calculated that the STARLOC model projects a 1% decrease in employment resulting from little more than a 0.2%

increase in the average price of doing goods (PECO St. 37, pp. 7-11). Dr. Schink has performed a similar calculation (PECO St. 38, pp. 8-9). Employing their judgments as trained economists and energy modelers, Dr. Hogan and Dr. Schink observed that these results appeared to be significantly out of line with their experience. As Dr. Schink noted:

> "[t]he aggregate impact of the electricity price rise on job growth [as projected by the STARLOC model] is much higher than one would expect, even assuming the most unfavorable conditions."

(PECO St. 38, p. 8)(Emphasis added). Dr. Hogan agrees that the model's 4 to 1 ratio of employment reduction to increase in average price of goods and services "does not pass the test of common sense" (PECO St. 37, p. 11). In a word, STARLOC produces results that are simply wrong.

When Dr. Hogan and Dr. Schink examined STARLOC's limited documentation in light of the model's implausible results, they were able to determine significant conceptual and structural flaws and modeling errors that drove the model to overestimate employment impacts dramatically. As Dr. Schink explained:

> "the STARLOC model inflates a small decrease in demand into a huge decline in employment. This decline in employment is too large by a factor of five."

(PECO St. 38A, p.9).

The conceptual and structural flaws and modeling errors in STARLOC include: (a) the inclusion in the model of geographic areas that are not within PECO's service territory; (b) the

application of improper "structural assumptions"; (c) the double counting of various employment impacts; (d) the unrealistic projection of job loss allegedly resulting from conservation and inter-fuel substitution; (e) the misapplication of the basic concept of labor multipliers; (f) the contradiction between the results of the growth submodel and the results of the STARLOC model; and (g) the failure to include in the model the positive benefits on the economy of Limerick Unit No. 1.

A. STARLOC Improperly Includes Geographic Areas Not Within PECO's Service Territory

The first error in STARLOC is rather obvious and rather basic. The STARLOC model assumes a constant percentage rate increase across the entire Philadelphia Metropolitan Statistical Area ("MSA"). The Philadelphia MSA, however, includes geographic areas that are not within PECO's service territory, including the entire counties of Burlington, Camden and Gloucester in New Jersey and portions of Bucks, Chester, and Montgomery Counties in Pennsylvania (see City St. 1, p. 3; PECO St. 38, p. 12; PECO Exhibit 28). To the extent that STARLOC assumes that the entire PECO rate increase applies across the entire Philadelphia MSA, the model overestimates the economic impact of PECO's rate proposal.

As Dr. Hogan (PECO St. 37, pp. 16-17) and Dr. Schink (PECO St. 38, pp. 12-13) explain, correcting for the geographical areas that are not within PECO's service territory requires an

80% reduction in the average nominal rate increase to be applied across the entire MSA, from 28.2% to 22.6%. This reduction would reduce the real price increase as applied in Dr. Schinnar's model by almost one-half, from 12.2% to 6.6%, and would reduce the final price increase in the non-electric sector from 0.21% to only 0.11% (PECO St. 37, p. 17). Without regard to the numerous other problems relating to the STARLOC model's final results, this over-inclusion of geographical areas incorrectly assumed to receive the proposed PECO rate increase causes STARLOC to overstate the employment impacts of PECO's rate proposal by at least 25% (PECO St. 38, pp. 12-13).

B. STARLOC Applies Improper "Structural" Assumptions

The second error in STARLOC is not quite as obvious as the first, because it is embedded in the assumptions built into the price submodel, which is another one of the component parts of STARLOC. The price submodel has been designed by Dr. Schinnar in such a way as to assume that an increase in an industry's cost of production will produce a decrease of equal magnitude in the demand for that industry's goods. This assumption has no economic justification.

The price submodel is designed to capture the employment effects of increases in electric prices on industries other than the electric sector. The effect sought to be modeled has been assumed by Dr. Schinnar to be as follows: an increase in

electric prices will cause an increase in costs of production across all industrial sectors, which will cause an increase in the price of final goods. An increase in the cost of final goods will in turn cause a decrease in the demand for such goods. A decrease in demand for goods will in turn cause a decrease in employment in the industry.

In attempting to model this effect, STARLOC, by its structure, assumes that expenditures on net exports and investments (i.e., expenditures on goods and services that are sold outside of the Philadelphia MSA) remain constant in the face of higher prices for those goods and services (PECO St. 37, p. 11). As Dr. Hogan explains, this structural assumption in essence assumes that the consumers outside of Philadelphia will not pay more in total for the goods produced in Philadelphia, but rather that the demand for goods consumed will decrease on a one-for-one basis with the increase in price (Id.). As a matter of economics, it is reasonable to assume that consumers outside of Philadelphia will pay at least some higher prices for Philadelphia goods (and thus will increase their total expenditures), so that demand for goods produced in Philadelphia will not decrease nearly as much as STARLOC is designed to assume (Id. pp. 11-12). The net effect of this assumption in STARLOC is to exaggerate greatly the decrease in demand (and thus the decrease in employment) across industrial sectors as a result of an increase of any cost of production, including electricity.

In his rebuttal testimony, Dr. Schink breaks down this structural assumption into two steps (PECO St. 38, pp. 9-11). First, he describes how equation (4.16) in the draft Technical Report indicates that industries other than the electric sector will pass on electricity costs (or any other cost of production) in the form of a corresponding increase in the price of the various industries' output. That is, a 1% increase in a producer's costs of production due to an electric rate increase will result in a 1% increase in the price of the producer's goods (PECO St. 38, pp. 9-10). Second, Dr. Schink describes how equations (4.18) and (4.19) in the draft Technical Report indicate that STARLOC assumes that a 1% increase in the price of the producers' goods will result in a 1% reduction in demand for those goods (PECO St. 38, pp. 10-11). The net effect of these two steps is that STARLOC has been programmed to assume that a 1% increase in the industries' costs of production will result in a 1% decrease in demand for the goods produced. Not only is such an assumption unsupportable as a matter of economics, but Dr. Schinnar himself has conceded this is not the way the real world functions (Tr. 3361).

Since Dr. Schinnar tried to deny in his surrebuttal testimony that his model contained this serious flaw in the structural assumptions, in his sur-surrebuttal testimony Dr. Schink again explains how it can be demonstrated that this improper assumption is built into STARLOC by outlining a

simplified representation of the way the STARLOC model computes (PECO St. 38a, pp. 6-9). Dr. Schink then concludes that:

> "[t]he STARLOC model is thus inherently and excessively sensitive to any changes in demand induced by price changes whether electric or otherwise. . . ."

(PECO St. 38A, pp. 8-9) (emphasis added).

When asked about this assumption basic to STARLOC structure during meetings with PECO experts and during cross-examination, Dr. Schinnar gave conflicting responses. First he confirmed that his model operates the way that Dr. Hogan and Dr. Schink indicate (see PECO St. 38, pp. 10-11; Tr. 3378-3380), and then he contradicted himself and suggested that his model does not produce this effect (see Tr. 3376-3377; Tr. 3382).

In the Appendix to his surrebuttal testimony, Dr. Schinnar attempts to explain why his model does not produce the improper effect (City St. 1A, p. 27). His explanation, however, fails to focus on this flaw in the structural assumption in the price submodel. Thus, Dr. Schinnar states that:

> "[n]et exports consist of the difference between imports and exports. In STARLOC, the level of imports varies in proportion to the actual output in the economy, which in turn responds to price increases; therefore, net exports vary as well."

(Id.). This explanation simplistically states that the level of net exports will change if the level of imports change. This explanation, however, does not state how net exports are expected to change, nor does it deal with expenditures on net exports. As

Dr. Hogan explained, the model's assumption of constant expenditures on net exports means that a change in the price of exported goods produces a corresponding (and exaggerated) change in the demand for such goods, regardless of the level of imports (PECO St. 37, pp. 11-12).

That Dr. Schinnar can neither recognize nor explain this important structural assumption that significantly exaggerates the results of his model further illustrates the preliminary nature of the model and the need for full understanding, validation, testing and correction of STARLOC before it will be in a sufficient form to allow its results to be considered by policy makers.

C. STARLOC Double Counts Certain Employment Impacts

The third error in STARLOC appears in the intermediate calculations presented for the first time in Table 1 of Dr. Schinnar's surrebuttal testimony (City St. 1A, p. 5). Table 1 presents the breakdown of the STARLOC model's projected employment impacts by cause of impact. This breakdown reveals that Dr. Schinnar has in at least two respects attributed identical or similar impacts to more than one cause. As a result, the STARLOC model double counts these impacts and exaggerates their effect on job growth.

First, Dr. Schink notes that the first two entries in Table 1 reflect a double counting of the adjustment in demand for

electricity resulting from higher electric prices (PECO St. 38A, p. 14). The first entry (conservation and interfuel substitution) projects job losses resulting from adjustments attributable to the increased use of energy conservation measures and the substitution of alternative fuels for electricity. This adjustment is based on the assumption that consumers faced with higher electric prices will demand less electricity and either conserve energy or switch to other fuels. The second entry in Table 1 (direct impact on cost of doing business) projects job loss resulting from reductions in demand for outputs, including PECO's output (electricity), attributable to higher electric prices. The projected reductions in demand for PECO's output would include the use of energy conservation measures and the substitution of alternative fuels. The employment impacts stated in the first entry in Table 1, therefore, are a subset of the impacts set forth in the second entry. Accordingly, these impacts have been double counted by the STARLOC model. (Id.)

Second, Dr. Hogan has observed that the second and third entries in Table 1 represent two different approaches to estimating the maximum plausible impact attributable to PECO's rate proposal (PECO St. 37A, pp. 8-9). The second entry (direct impact on cost of doing business) assumes that the electric price increase is absorbed by businesses as a cost of doing business. Under this assumption, firms will be forced to reduce output and employment. In contrast, the third entry (secondary inflation)

assumes that the electric price increase is not absorbed by businesses, but rather is passed along in the form of higher output prices. Only one of these effects would occur, however, depending on whether businesses choose to absorb or pass along the rate increase. They cannot do both. These entries, therefore, represent alternative means of projecting the same thing, namely the maximum employment impacts from PECO's rate proposal. They are alternative, not additive (PECO St. 37A, p. 9).

As set forth below, the foregoing analysis also explains why the plausible estimates provided by Dr. Hogan and Dr. Schink are independent and should not themselves be added together as asserted by Dr. Schinnar. Under either of the PECO experts' scenarios, the maximum plausible effect from PECO's proposed electric rate increase is the potential loss in job growth ranging from nothing upward to a maximum of approximately 3,000 jobs (PECO St. 37, p. 1; PECO St. 38A, p. 1). This is in sharp contrast to the inflated figure offered by Dr. Schinnar.

D. STARLOC Produces An Unrealistic Projection Of Loss In Job Growth From Conservation And Interfuel Substitution.

The fourth error in STARLOC also appears from the intermediate calculations provided for the first time in Table 1 of Dr. Schinnar's surrebuttal testimony (City St. 1A, p. 5). Table 1 presents, inter alia, the STARLOC model's projection of

the employment impacts attributable to conservation and interfuel substitution. The model projects a loss in growth of 3,142 jobs due to the effect of conservation and interfuel substitution. However, an analysis of this figure in the context of the electricity sector of the economy demonstrates that the projected impact is unrealistically high.

Both Dr. Hogan and Dr. Schink explain that any loss in job growth attributable to conservation and interfuel substitution would be concentrated in the electricity sector, because use of substitutes for electricity would tend to decrease the demand for electricity (PECO St. 37A, p. 7; PECO St. 38, p. 12). Therefore, the 3,142 loss in job growth figure must be analyzed in the context of the electricity sector. Indeed, Dr. Hogan suggests that the 3,142 figure should underestimate the expected loss in job growth in the electricity sector, because one would have to net out the increases in jobs taking place in the sectors that are being substituted for electricity. (PECO St. 37A, pp. 7-8).

However, analyzing the 3,142 loss in job growth figure in the context of the electricity sector produces a result that Dr. Hogan labels as "surprising and remarkable" (PECO St. 37A, p. 8) and Dr. Schink labels as "absurd" (PECO St. 38A, p. 2). When he compared the 3,142 figure with the total employment in the electricity sector as a whole, Dr. Hogan found:

> "This supposed underestimate of the loss in jobs in electric utilities comes in a sector where total employment is only 11,800. In other words, the 12.44% real increase proposed by PECO in the price of electricity produces, according to the STARLOC model, more than a 26% reduction in the number of workers employed in the production of electric service!"

(PECO St. 37A, pp. 7-8)(emphasis in original).

Dr. Schink compared the 3,142 figure to PECO's direct employment, because most of the loss in job growth due to conservation and interfuel substitution should come principally from PECO. Dr. Schink found that the job growth loss of 3,142 "is 38.0 percent of the total PECO electricity related workforce!" (PECO St. 38A, p. 11).

Moreover, Dr. Schink, found that the distribution of job growth changes, as reflected in Dr. Schinnar's printouts from STARLOC, "is extremely peculiar" (PECO St. 38A, p. 13). As Dr. Schink explained:

> "The transportation, communications, and utility sector shows a net gain in job growth while all of the other sectors show job losses. Given that the direct job losses must be concentrated in the electric utility sector, this result is very strange."

(Id.) (emphasis in original).

Finally, Dr. Schink developed an estimate of the potential drop in PECO's employment growth that might result from energy conservation and interfuel substitution utilizing Dr. Schinnar's figures and elasticities (PECO St. 38A, pp. 20-21). Taking this approach, Dr. Schink determined that the potential

drop in PECO's employment growth would be approximately 132 jobs (Id., p. 13). Thus STARLOC overestimated this one component of its overall result alone by over 2000 percent. These incredible and unrealistic projections of STARLOC attributable to conservation and interfuel substitution militate against reliance on STARLOC. As Dr. Hogan explains:

> "[t]hese estimates of losses in new job creation are so large relative to the total electric sector that they cannot be the result of conservation and fuel substitution alone."

(PECO St. 38A, p. 8). Instead, these estimates can only be the result of serious flaws in STARLOC.

E. STARLOC Misapplies The Basic Concept Of Labor Multipliers

The fifth error in STARLOC relates to Dr. Schinnar's use of labor multipliers. Dr. Schinnar simplistically applies a huge labor multiplier to the projected loss in job growth without considering the substantial factors that tend to mitigate the multiplier effect. Because the STARLOC model fails to account for the full range of economic responses to the projected loss in job growth, STARLOC by design significantly exaggerates the employment impact of PECO's rate proposal.

Labor multipliers play a major role in the STARLOC model's projection of loss in employment growth. The exaggerated importance of labor multipliers in producing the large employment impacts projected by STARLOC is quantified in the fourth entry in

Table 1 of Dr. Schinnar's surrebuttal testimony. (City St. 1A, p. 5). Dr. Schinnar's labor multipliers alone account for the loss in job growth of 7,562 jobs, which is nearly 40% of the entire employment impact projected by STARLOC (Id.).

Dr. Hogan explains that STARLOC produces this huge multiplier result because in programming the model, Dr. Schinnar ignored the role of important mitigating factors that lessen the multiplier effect in a real economy (PECO St. 37A, pp. 12-13). These mitigating factors include lowering of wages, the availability of unemployment compensation, welfare and other government "transfer" payments, and the use of savings or borrowings. These factors not only dampen the downward spiral of job loss effects, but actually produce positive multiplier effects of their own. Dr. Hogan explains:

> "Any of these and other countervailing actions will tend to mitigate the proposed rate increase's impact on the local economy, thereby supporting higher employment growth. That higher level of employment growth will also be subjected to multiplier effects, creating more jobs which will create other jobs. Hence, the net effect on total employment growth depends more on full evaluation of all of the responses of the economy to the proposed price increase rather than on a simple application of the multiplier to only one portion of the possible response."

(PECO St. 37A, pp. 12-13). By failing to consider the full range of multiplier effects, the STARLOC model inherently overestimates the employment impact of PECO's rate proposal.

The exaggerated multiplier effect is compounded by a curious structural flaw in the model's design. In his rebuttal testimony, Dr. Hogan explains how a series of steps in STARLOC designed to account for expenditures have the effect of causing entire households and their related expenditures simply to drop out of the economy whenever a job is lost according to the model. (PECO St. 37, pp. 15-16). Because this drop in expenditures produces a further reduction in jobs, more and more households drop out of the economy as structured by STARLOC, producing a downward spiral of reduced employment and reduced expenditures (Id.). As Dr. Hogan points out:

> "Dr. Schinnar has assumed that the local economy will respond to electric price increases by simply unwinding and unraveling, and that allegedly resulting unemployed workers and their families will disappear from the economy. I know of no justification for this extreme assumption."

(PECO St. 37A, p. 13).

The exaggerated multipliers and the job spiral effect magnify the other errors in the STARLOC model (Id., p. 9). As the other errors cause STARLOC to double count or overestimate the employment impacts of PECO's rate proposal, the exaggerated multipliers and the job spiral effect mechanically adjust these unreasonable impacts even further upward into the realm of the absurd.

F. STARLOC's Results Contradict The Results Of Dr. Schinnar's Growth Submodel.

The sixth error in STARLOC relates to Dr. Schinnar's growth submodel. The growth submodel is a component part of STARLOC designed to predict the rate of job growth in the Philadelphia metropolitan area. Although the growth submodel is used in Dr. Schinnar's "dynamic" analysis, it is not used in the "static" analysis which produces the 19,196 figure of loss in new job growth (Tr. 3279).

The equation for the growth submodel appears in Table 3.1 of the draft Technical Report (PECO Exhibit 22). As specified by Dr. Schinnar, the growth submodel suggests that the rate of job growth in the Philadelphia MSA depends on: (a) the job growth in the United States; (b) time; and (c) the ratio of the average wages in Philadelphia to the average wages in the United States (PECO St. 38, p. 5). The growth submodel thus does not contain a variable for electric rate changes.

Without specifying a variable for electric rate changes, the growth submodel is able to predict the rate of job growth in Philadelphia fairly accurately. (City St. 1, p.36). Dr. Schinnar's equation for the growth submodel, for example, explains 90% of the historical variance in job growth in Philadelphia (See PECO Exhibit 22, Table 3.1). Moreover, the historical testing of the growth submodel, which appears in Figures 16 and 17 of Dr. Schinnar's direct testimony (City St. 1,

p. 37) (also reproduced in Figures 3.1 and 3.2 in PECO Exhibit 27), demonstrates the relative historical accuracy of the growth submodel. The fact that the growth submodel can accurately predict the rate of job growth without a variable reflecting real electric price changes suggests that the change in job growth due to electric price changes is minimal. This result contradicts the substantial job growth impact projected by STARLOC.

Moreover, application of the growth submodel to historical electric price increases directly contradicts the job growth impact projected by STARLOC. Thus, during his cross-examination, Dr. Schinnar stated:

> "I have looked at rate increases for Philadelphia over the past 10 to 12 years, and even if we remove for that period -- when we remove for that period, for example, the effect of the OPEC oil price shock, PECO's increases on an average were roughly one percent above inflation.
>
> When I compared that with separate forecasts of the growth model which does not include rate increases, the numbers come out to be identical."

(Tr. 4670). STARLOC is designed to project job growth impacts only for electric rate increases that are above the rate of inflation. If PECO's rate increases averaged roughly one percent above the rate of inflation over the past decade, one would expect STARLOC to project significant loss in job growth throughout the entire period. Nonetheless, the actual rate of job growth was consistent with the predictions of the growth submodel, which does not include electric rate changes. This

suggests that the rate changes in the past did not have a significant impact on job growth, and also suggests that the fundamental precept of STARLOC (that real increases in electric rates cause significant detrimental effects on job growth) is flawed.

G. STARLOC Fails To Account For The Positive Benefits On The Economy Of Limerick Unit No. 1

The seventh error in STARLOC is that the STARLOC model is not designed to include the positive contributions of Limerick Unit No. 1 in its economic assessment of PECO's rate proposal. Dr. Schink explains:

> "Dr. Schinnar stated to me that this version of STARLOC could not assess the positive contribution of Limerick construction on the economy, could not assess the positive impact of property and other taxes paid by PECO for Limerick, could not assess the continuing positive employment contribution due to Limerick operation, and could not assess the positive impacts of purchases from local firms to support construction and operation of Limerick. This version of STARLOC could only assess the potential negative impacts of higher electric rates."

(PECO St. 38, p. 12). This failure to include the benefits of the Limerick plant is further evidence that the STARLOC model is by design inherently biased to capture only the potential negative impacts of PECO's rate proposal.

STARLOC has been shown by PECO to be a model still in its early developmental stages containing significant conceptual and structural flaws and modeling errors. These problems result

in STARLOC seriously overestimating the effect on potential job growth in the Philadelphia SMA of PECO's proposed electric rate increase. Accordingly, STARLOC's results, and the conclusions Dr. Schinnar draws from them, should be given no weight in this proceeding.

H. UUC/UP Witness Feldman's Projection Of The Employment Impacts Of PECO's Proposed Rate Increase Are Based Entirely On Dr. Schinnar's Model, And Thus Should Receive No Weight.

UUC/UP Witness Stephen L. Feldman (UUC/UP Sts. 2 and 2A) bases his conclusions regarding the employment impacts of PECO's proposed rate increase entirely on the results of Dr. Schinnar's STARLOC model (UUC/UP St. 2, p.7; Tr. 3859). Indeed, Dr. Feldman admits that he has not performed an independent study of these impacts (Id.). Because the projections of Dr. Schinnar's STARLOC model are so unverifiable, speculative and grossly overstated as to merit no weight, Dr. Feldman's testimony should be disregarded as well.

In his surrebuttal testimony, Dr. Feldman attempts to bolster the credibility of Dr. Schinnar's results. Dr. Feldman states:

> "I have adopted the calculations of Dr. Arie P. Schinnar, the witness for the City of Philadelphia in this case (City Statement No. 1) as having the most sophisticated, methodologically valid, and accurate model using Philadelphia specific data."

(UUC/UP St. 2A, p.4). When one examines the efforts Dr. Feldman undertook to validate STARLOC, however, there is no support for this sweeping vote of confidence.

Thus, Dr. Feldman appears to concede that he is not a person upon whom to rely in validating the results of Dr. Schinnar's model. During his testimony, Dr. Feldman conceded:

> "I am by no means as sophisticated as Dr. Schinnar, who is the inventor of the model, and therefore I don't know how to break into his computer code."

(Tr. 3876).

As a result, Dr. Feldman's efforts to validate STARLOC appear at best to have been half-hearted. During his cross-examination, Dr. Feldman conceded that he had not read in detail the draft Technical Report (Tr. 3859), yet the draft Technical Report is virtually the only documentation that Dr. Schinnar has made available to use in validating his model. Dr. Feldman also conceded that he had not read any of Dr. Schinnar's workpapers (Tr. 3860), had not read the model code (Id.) and had not examined the intermediate calculations of the model. (Tr. 3861). In addition, Dr. Feldman had no idea how STARLOC's database was constructed or what procedures were employed to update the raw data to 1981:

> "Q. Have you examined the methodology by which Dr. Schinnar's data has been updated?
>
> A. I don't know what update you're talking about. I'm sorry."

(Tr. 3860).

With respect to the testing of STARLOC, Dr. Feldman stated that he had tested STARLOC "[o]nly against the testimony of Dr. Lewis Perl, which was provided by the company in the Lukens Steel case." (Id.). Dr. Perl, however, testifies that the model he employed in the Lukens Steel case (Re Lukens Steel Company 58 Pa. P.U.C. 256 (1984)) was not Philadelphia specific and could not be applied to the Philadelphia MSA. (PECO St. 11A, pp.20-21). Therefore, it is appears that Dr. Feldman was able to make the statement that Dr. Schinnar's model is "the most sophisticated, methodologically valid, and accurate model using Philadelphia specific data" (UUC/UP St. 2, p.4), because Dr. Schinnars' model was the only model using Philadelphia specific data at which Dr. Feldman looked, if only casually.

I. PECO's Experts Project No More Than A Minimal Employment Growth Impact As A Result Of PECO's Rate Proposal.

The testimony of PECO's experts establish that the impact, if any, of PECO's proposed rate increase on the growth of employment in the Philadelphia area will be minimal at worst.

1. Dr. Hogan and Dr. Schink Have Used Dr. Schinnar's Figures To Determine That There Will Be No More Than A Minimal Impact On Job Growth From PECO's Rate Proposal.

As an effort to demonstrate the implausibly overstated nature of Dr. Schinnar's results, both Dr. Hogan (PECO St. 37, pp. 17-18) and Dr. Schink (PECO St. 38A, p. 1) suggest an

approach to determining the upper limit or maximum plausible loss in job growth resulting from PECO's rate proposal using Dr. Schinnar's figures. Although they approach the question from opposite directions, Dr. Hogan and Dr. Schink produce consistent results.

Dr. Schink's approach is based on the concept that when local businesses are faced with higher costs, these local businesses potentially could cut back their level of activity and thus reduce employment growth. Dr. Schink used Dr. Schinnar's figures to calculate the increase in the Philadelphia MSA's cost-of-doing-business due to a 28.2% electric rate increase over three years. These calculations showed that the real cost of doing business only rose by 0.17% due to PECO's proposed electric rate increase. Therefore, employment growth, in turn, should be reduced by at most 0.17% or 3,550 jobs (PECO St. 38, p. 9).

Dr. Hogan, on the other hand, approaches the question by examining the potential impact of higher electric rates on the prices of other goods and services produced within the Philadelphia MSA. Dr. Hogan's approach is based on the concept that if higher electric rates result in higher prices for all other goods and services produced within the region, then sales of locally produced goods and services could fall and employment growth will slow. While Dr. Hogan argues that it is extremely unlikely that the entire electric rate increase will be passed through in the form of higher prices for all other goods and

services, his analysis suggests, even under this most adverse scenario, that the impact on job growth would be between 2,000 and 3,000 jobs (PECO St. 37, pp. 17-18). Dr. Hogan goes on to argue, however, that:

> "In the real economy, something in between no job loss and the upper limit of 2,000 to 3,000 fewer new jobs created would be plausible."

(Id, p. 18) (emphasis added). The figures suggested by Dr. Hogan and Dr. Schink each individually reflect the realistic maximum impact of PECO's rate proposal by assuming alternative behavior. Consequently, their maximum suggested impacts cannot be added together as asserted by Dr. Schinnar (City St. 1, p. 5), but rather are alternative means of demonstrating that the effect on job growth of PECO's rate proposal will be minimal at worst.

2. Dr. Perl Demonstrates That A Model He Used For An Unrelated Proceeding Cannot Be Used In This Proceeding To Resurrect The Flaws In Dr. Schinnar's Model.

Dr. Schinnar (City St. 1A, p. 11; Tr. 3409-3410) and Dr. Feldman (UUC/UP St. 2A, pp. 5-6; Tr. 3876-3877) attempt to bolster their position by comparing STARLOC's results to the results of a model used by Dr. Perl in the Lukens Steel case Docket P-810310. Dr. Perl's model, however, is not directly comparable in that it was developed to model the effect on the entire Commonwealth of Pennsylvania of electric price increases (PECO St. 11A, p. 20). Because of significant differences

between the economy of the Philadelphia MSA and the economy of Pennsylvania as a whole, Dr. Perl's model cannot be extrapolated simplistically to apply to this case (Id., pp. 20-21).

Dr. Perl cites several factors that militate against extrapolating from his Lukens analysis in this proceeding: (a) the base of activity is smaller in the PECO service territory; (b) the elasticities used in the Dr. Perl's analysis were biased upward by a few highly electric intensive industries that are not significant factors in the Philadelphia MSA; and (c) the multipliers used in Dr. Perl's Lukens analysis were biased upward by the fact that consumers in Pennsylvania spend a much larger percentage of their disposable income on goods and services produced in Pennsylvania than the consumers in Philadelphia spend on goods and services produced in Philadelphia (PECO St. 11A, pp. 20-21).

Dr. Schinnar and Dr. Feldman responded by developing projections supposedly based on Dr. Perl's model and comparing the results of these models to the STARLOC result. The methodologies used in making these projections, however, bear little resemblance to Dr. Perl's analysis. These projections are created arbitrarily to provide illustory support for STARLOC's exaggerated projections.

First, Dr. Schinnar and Dr. Feldman employ Dr. Perl's manufacturing elasticity notwithstanding his caution that its use is improper with respect to the Philadelphia area. (PECO St.

11A, p. 21). Dr. Schinnar attempts to adjust Dr. Perl's elasticity on the basis of relative electric intensity, but makes the adjustment based on a comparison of Philadelphia with the entire United States, rather than the Commonwealth of Pennsylvania (PECO St. 11B, p. 8). This tends to underestimate the adjustment, because the United States, on average would be less electric intensive than a Northeastern industrial state such as Pennsylvania.

Second, Dr. Schinnar and Dr. Feldman both employ an arbitrary multiplier for the service sector. No rational basis exists, however, in Dr. Perl's analysis for either the multiplier chosen, or for use of a service sector multiplier at all. Dr. Perl explains:

> "Dr. Schinnar derives this effect by simply assuming an employment elasticity in the service sector of about half the level I derived for the manufacturing sector. But such an employment elasticity is not to be found anywhere in my model and seems entirely implausible to me. In particular, only seven manufacturing industries exhibit an employment effect in response to changes in electricity price and all of these industries have relatively high intensities of electricity use. For these industries, the ratio of electricity consumption to employment is 82 megawatt-hours per employee, whereas the average ratio of electricity consumption to employment in the service sector is 8 megawatt-hours per employee, or one tenth as large. Thus the idea that the service sector would exhibit employment elasticities which are one half as large as those in the manufacturing sector, or that there would be any significant employment effects in these sectors, does not seem at all plausible and certainly cannot be inferred from my model."

(PECO St. 13B, p. 8) (emphasis added).

Dr. Schinnar and Dr. Feldman have tried to fit a square peg in a round hole by claiming that Dr. Perl's analysis in the Lukens case is somehow relevant to this proceeding. The attempt fails, and in any event does nothing to salvage STARLOC from the manifest flaws and errors which have been designed into Dr. Schinnar's model.

3. Dr. Clemente Demonstrates That STARLOC's Results Do Not Comport With Impacts From Historic Electric Rate Increases That Have Been Observed In The Nation's Major Metropolitan Areas.

PECO Witness Dr. Frank Clemente provides testimony that places the magnitude of STARLOC's projected employment impacts into historical perspective (PECO Sts. 36, 36A and 36B). Dr. Clemente summarizes his testimony by stating:

> "My point is not that electric rate changes have no socioeconomic effects, but that in a complex economy rate changes are dwarfed by far more significant variables and thus have had no measurable socioeconomic effects that are relevant for policy-marking purposes."

(PECO St. 36B, p. 9).

Dr. Clemente's studies examine how the economies of a broad range of metropolitan areas, including all of the metropolitan areas in the Northeast, have fared in the face of changes in electric rates. Dr. Clemente found that there was little evidence to support the proposition that increases in electric rates are a significant factor in the employment growth

patterns of metropolitan areas (PECO St. 36, p. 10). Dr. Clemente concluded that:

> "Dr. Schinnar and Dr. Feldman place an inordinate and unjustified amount of faith in the unsubstantiated predictions of computer models and blindly ignore the objective reality of what has actually happened in metropolitan areas that have experienced electric rate changes of various magnitudes." (PECO St. 36B, p. 2).

Dr. Clemente admittedly did not set out to examine every variable that could affect economic growth (Tr. 4418-4419). Rather, by focusing his study broadly on the historical relationship between electric rate changes and economic growth, he was able to demonstrate that electric rates were not the driving force behind the economic growth patterns of metropolitan areas. That he did not control for variables other than electric rates is not an indictment of his methodology, but rather a confirmation that these other variables, in the aggregate, dwarf the effect of a change in electric rates. Dr. Clemente's study thus suggests that the practical effect of electric rate changes as demonstrated by actual, as opposed to hypothetical, data is minimal.

Dr. Clemente's studies underscore the need for public testing and validation of STARLOC's results on which Dr. Schinnar and Dr. Feldman rely totally for their conclusions. As Dr. Clemente observes:

> "[I]t is clear that Dr. Schinnar's assumptions of large multiplicative adverse effects from electric rate increases do not represent real world experience."

(PECO St. 36, p. 10).

III. Conclusion

As demonstrated above, STARLOC is a complex econometric model that is still in the earliest stages of development. It has had virtually no complete documentation presented in the context of this proceeding. STARLOC's intermediate calculations, which are essential to validating the model, are locked inside the model and inaccessible by the parties to this proceeding. STARLOC has not been tested as a completed model and it has not been tested comparing actual electric rate increases with actual job growth in the Philadelphia MSA or elsewhere. The brief glimpse that PECO's experts have been shown of STARLOC and its functioning reveals that there are serious conceptual and structural flaws and modeling errors in STARLOC. These flaws and errors result in STARLOC overstating the impact of PECO's rate increase proposal by at least a factor of five. Accordingly, Dr. Schinnar's testimony, and the testimony of Dr. Feldman based on the results of STARLOC, should be given no weight in this proceeding.

APPENDIX B

PECO WAS PRUDENT IN ITS MANAGEMENT OF LIMERICK UNIT 1 AND COMMON CONSTRUCTION

This Appendix has been prepared to describe the evidence presented on this record to demonstrate the prudence of PECO's conduct in the management of Limerick engineering, construction, start-up and licensing. As the prudence of the Company's actions has, with only minimal exceptions, not been challenged, this description has been provided as an Appendix and not in the body of the Brief.

A. PECO's Initial Decision To Build And Its Decisions to Continue Constructing A Nuclear Generating Station At The Limerick Site Were Prudent And Reasonable.

Extensive testimony on PECO's initial decision to construct a nuclear generating station at the Limerick site was presented by Vincent S. Boyer, PECO Senior Vice-President, Nuclear Power, in the first Limerick Investigation at Docket No. I-80100341. Excerpts from that testimony were introduced into the instant proceeding by Mr. Boyer as Appendix A to PECO Statement No. 1 and were further discussed in his direct testimony.

As explained by Mr. Boyer, for the electric utility industry, the period from the 1960s and early 1970s was characterized by electrical demand exceeding forecasts, brownouts and blackouts, increasing regulatory concern about adequate and reliable electric power systems and power plant siting delays, and inadequate reserve margins. PECO was not exempt from these concerns. Load growth for PECO was increasing so rapidly during

this period that voltage reductions and voluntary customer load curtailments were experienced during 1967, 1968 and 1969, because demand had exceeded available capacity (PECO St. 1, Appendix A, p. 3).

Under these conditions, the Company prudently decided that to mitigate future adverse impacts to its customers, the addition of new base-load capacity was warranted. After extensive and detailed analysis evaluating the costs and benefits of alternative forms of generation, i.e., nuclear, coal, oil, gas, etc., PECO chose the nuclear option. This choice was based on the demonstrated projected economic advantage that would accompany the long-term operation of a nuclear facility compared to other forms of energy production. Corroboration of this decision was supplied by the Atomic Energy Commission, Directorate of Licensing, when it found in its November 1973 Final Environmental Statement that "expansion of the applicant's plant capacity by 1979 appears to be a prudent and necessary action to satisfy the growth requirements of his service area" (p.9-5). In its Order entered August 27, 1982, regarding the Limerick Investigation the Commission agreed with ALJ Klovekorn's Initial Decision that PECO was reasonable in its decision to construct Limerick stating that:

> "...actions in the 1968-1974 period were reasonable and its decision at that time to construct a nuclear unit at Limerick was a valid exercise of managerial discretion" (p. 8).

Once the determination had been made to construct a nuclear generating station, PECO turned its attention to site selection. In its Order entered August 27, 1982, the Commission affirmed the reasonableness of PECO's site selection decision, stating as follows:

> "While we are convinced that PECO appropriately considered relevant options in choosing the plant site, we acknowledge that there may be occasions when the supply of water will be such as to effect the simultaneous operation of Limerick Units I and II at full capacity. However, even with this possible infirmity, we agree with the finding of the Nuclear Regulatory Commission, that the site chosen was the best available..." and that "...we do not foresee any long-term inability to secure water from these projects" (p.16).

The NRC, in its final Environmental Statement for Limerick (NUREG-0974), stated:

> "The NRC staff has determined that the Limerick generating station can be operated with minimal environmental impact. To date, no new information has been obtained that alters the overall favorable balancing of the benefits of the station operation versus the environmental costs that resulted from evaluations made at the construction permit stage" (NUREG-0974, pp. 6-4).

That referenced environmental statement (issued in November 1973) concluded that:

> "The site at Limerick is a reasonable selection from the alternatives available" (Final ES; November 1973; p. 12-12)."

In addition, the independent review of TB&A regarding the selection of the Limerick site, concluded:

"[T]he choice of the Limerick site [was] the product of an effective management process and to be reflective of reasonable management actions" (PECO St. 8, p. 46).

Finally, the Company presented substantial and uncontested evidence that its decisions to continue construction of the Limerick station through the late 1970's and 1980's were prudent and well supported. Company Witness Dr. William H. Hieronymus reviewed PECO's capacity planning studies from the 1975-80 period and concluded that throughout that time PECO's studies demonstrated that Limerick construction was cost-effective and should be continued (PECO St. 15, pp. 78-89). Dr. Hieronymus further concluded that the major assumptions made by the Company as the basis of these studies, including its load growth efforts, were entirely reasonable as compared to the prevailing views of government and economic experts at the time. He also concluded that the Company's analytical methodology, although not that which he would recommend, in fact understated the reasonably to be anticipated costs and benefits of the Limerick Station (PECO St. 15, pp. 86-91).

Company Witness Dr. Lewis J. Perl developed an independent analysis which demonstrated that Limerick 1 was part of the least cost capacity mix for PJM in 1973, 1976, 1978 and 1980, and that Limerick 1 promised greater economic benefits to consumers when compared with a contemporaneous coal plant or continued use of oil and gas.

Dr. Perl compared the cost of coal and oil-fired alternatives to the cost of completing Limerick 1. These comparisons showed that in every year from 1975 through 1980, the incremental cost of completing Limerick 1 - expressed in terms of the cost per kWh of generation over the lifetime of the plant - was never more than 59% of the cost of the cheapest alternative, which was coal in each year (PECO St. 11, Schedule 6, p. 2). The present worth in 1984 of the savings from completing Limerick 1 compared to the coal alternative ranged from $663 million to $3.58 billion depending on the year of analysis (Id., Schedule 5, p. 2).

Dr. Perl concluded that throughout the 1976 to 1980 period, even on a total cost basis and assuming zero load growth for PJM, the Limerick plant was part of the least cost expansion plan for PJM. Dr. Perl also concluded that, due to the considerable economic advantage of Limerick over the alternatives, completion of Limerick would have remained economic even if PECO's booked capital cost projection had been as high as $2,989 per kw, more than twice what PECO was projecting in 1978 (PECO St. 11A, pp. 10-16, 29-44).

Company Witness Louis A. Guth reviewed PECO's load forecasts and forecasting methodology since 1973. Mr. Guth concluded that the methodologies were sound; that the forecasts made use of all relevant information; and that the underlying assumptions and conclusions, though belied in some ways by

subsequent, unforeseeable events, were nevertheless consistent with the assumptions and conclusions of the mainstream forecasters in the electric utility industry, government, and private forecasting services (PECO St. 12, pp. 8-10).

B. PECO And Bechtel Had Effective Organizational Structures And Capabilities

As stated by John S. Kemper, PECO Vice-President of Engineering and Research:

> "The Company's objective has always been to ensure that a safe, reliable and licensable plant is constructed at a reasonable cost. To achieve this objective, the Company has continuously maintained a substantial and active role in all areas of Project management and in cost and schedule control" (PECO St. 2, p. 4).

Day to day management authority for Limerick was vested in Mr. Kemper, whose responsibilities covered all functional aspects, i.e., engineering, construction, quality assurance, licensing, etc., of project management and included extensive interaction with other PECO departments, i.e., Purchasing and General Services, Electric Production, Finance and Accounting and Legal, on Limerick related matters (PECO St. 2, p. 5).

Supplementing Mr. Kemper's involvement on the Limerick project was the assistance provided by Vincent S. Boyer, PECO Senior Vice President, Nuclear Power. Mr. Boyer concentrated his efforts primarily on the interface between PECO and regulatory bodies who had jurisdictional authority over aspects of the project and resolution of concerns and issues that arose over Limerick.

Under Mr. Kemper, a project management organization was implemented to manage the design, construction and planning activities which occurred at Limerick (PECO St. 2, p. 6). The administrative focal point of this organization was the Project Manager who, although reporting organizationally to the Chief Mechanical Engineer, had direct access to Mr. Kemper. The Project Manager was responsible for a myriad of project activities including, but not limited to, the coordination of the development of project schedules, budgets and forecasts, monitoring cost and schedule performance, maintenance of an interface between PECO, GE, Bechtel and other project parties, conducting meetings to resolve project concerns and preparation of reports, memoranda and other documents which served to keep PECO management informed of project status (PECO St. 2, p. 7). Additional principal company managers at Limerick include the Resident Project Manager, located at Bechtel's offices in San Francisco, who provided direct monitoring and control over engineering activities, and the Project Manager-Construction, who was responsible for day-to-day control over construction activities at the Limerick site.

Various PECO divisions assisted the above managers and played an integral role in Project management. For example, the Mechanical Engineering Division was responsible for reviewing the mechanical design work of Bechtel and General Electric and the Electrical Engineering Division was charged with reviewing

instrumentation and control systems and electrical design. Other involved PECO divisions were the System Planning Division, responsible for cost and budget preparation and capacity and economic evaluations; the Engineering and Design Division who were responsible for revisions of drawings and maintenance of records and files; and the Quality Assurance Section who were responsible for ensuring that Limerick's design and construction met or exceeded all the federal quality assurance requirements of 10 CFR 50, Appendix B. A close working relationship also existed with the Electric Production Department, through the Station Superintendent, who was responsible for review of plant equipment, systems design and arrangement of plant facilities for operability and maintainbility. Additionally, the Finance and Accounting Department provided the plant accounting, accounts payable and internal audit functions, while the Purchasing and General Services Department was involved in the review and approval of recommendations by various project groups for the purchase of material and equipment, the award of contracts or the retention of subcontractors. Further, where necessary, PECO retained outside consultants with the requisite technical skills necessary to accomplish specialized tasks or projects (PECO St. 2, pp. 7-10).

The benefits to be gained by PECO's utilization of this form of project management organization were many. As stated by

Mr. Kemper, PECO adopted this form of organizational approach because:

> "First, this organizational approach provided for the creation of centralized, executive responsibility placed upon myself and the Project management team, while at the same time involving in the Project needed expertise from all organizations within the Company. We believe that this approach, used successfully at Peach Bottom, best served Project management needs. Second, this approach maximized the availability of experienced personnel in Company-wide operations. It must be remembered that during Limerick's engineering and construction period, the Company was also completing startup testing, supporting initial operation and, during later periods, making major post-TMI and other NRC-required changes to Peach Bottom. Third, adoption of this structure assured a transfer of knowledge and experience gained from Peach Bottom startup and operations to Limerick. This facilitated the early, low cost correction of potential problems or regulatory backfits at the Limerick plant. Finally, and most importantly, this organizational structure had been successfully used in managing the design and construction of the Peach Bottom units" (PECO St. 2, p. 11).

A site construction management organization, which had been used successfully on prior PECO construction projects, including Peach Bottom Units 2 and 3, was directed by Mr. James J. Clarey. As stated by Mr. Clarey, the purpose of the site team was to:

> "...assure fulfillment of the Project's cost, schedule, quality and procurement requirements and to assure that contractor activities were carried out in an effective and efficient manner" (PECO St. 4, pp. 4-5).

The site construction management team was organized into five functional branches: Technical Analysis, Schedule and Progress Review, Subcontract Monitoring Cost, Analyses and Quality Control. The activities of the Technical Analysis group included review of project drawings and specifications, monitoring construction activities in the various disciplines, i.e., mechanical, electrical, civil, and responding to inquiries by the NRC regarding field activities. Personnel assigned to the Schedule and Progress Review groups were directed to closely monitor field construction activities in specific areas of the plant to assess field management effectiveness and the general fulfillment of project schedule goals.

The Cost Analysis team reviewed the portions of Bechtel Forecasts (cost estimates) associated with field labor and material, evaluated labor performance and reviewed Bechtel's field procurement activities. The Subcontract Monitoring engineers were concerned with reviewing and approving activities, i.e., participation in pre-bid meetings, bid package preparation and selection and approval of bidders, associated with the award of sub-contracts for work not performed by Bechtel. This group also performed continual monitoring of sub-contract performance and change order and claim resolution. Finally, the Quality Control group performed daily inspections of certain construction activities to assure thoroughness of work and high quality workmanship. The Quality Control team operated under a formal

quality assurance program developed by PECO management (PECO St. 4, pp. 5-6).

The thoroughness and completeness of activities performed by PECO's site construction management organization was best described by Mr. Clarey when he stated that:

> "...the site team monitored and controlled all functional areas of Project construction. Principal regular activities performed by the site management organization included monitoring construction activities for compliance with design requirements, reviewing construction drawings, attending construction meetings, witnessing completion of significant construction activities and assessing the effectiveness of field supervision and manpower utilization" (PECO St. 4, p. 6).

A large majority of the construction activities that the PECO site team monitored were being performed by Bechtel. As designer and constructor of the Limerick project, Bechtel was charged with the responsibility (subservient, of course, to PECO's ultimate responsibility) of conducting and managing the daily engineering and construction functions necessary to cost-effectively complete, in a quality manner, the Limerick project. Mr. Charles K. Soppet headed the Bechtel project organization assigned to this task. The Bechtel project organization was divided generally into six functional areas: Engineering, Technical Services (Cost and Scheduling), Quality Assurance ("QA"), Administration, Procurement and Construction (PECO St. 7, p. 4). Bechtel maintained both field and home office (San Francisco) organizations under the overall direction

of Mr. Soppet with the field group supervised by the Project Field Construction Manager.

The Bechtel home office organization comprised all the above mentioned functional areas. The Engineering group was subdivided into six areas, i.e., civil/architectural, plant design, mechanical, quality engineering, electrical/control systems and management, with responsibility for the Limerick design and support of construction. The Technical Services (Cost and Scheduling) group was charged with preparation of Forecasts and trends and was responsible for planning, scheduling and estimating. The QA group, functionally distinct from the Limerick project organization, monitored compliance with the NRC's quality assurance regulations. The Procurement group was responsible for activities related to subcontracting, bidding and purchasing, while the Administration group handled records and correspondence (PECO St. 7, pp. 4-5).

At the Limerick site, the Bechtel construction organization consisted of six functional groups all supervised by the Project Field Construction Manager. These groups included: Field Engineering, whose efforts were directed solely at support of construction activities; Construction Superintendents, who were charged with labor relations and craft labor supervision; Services, whose personnel performed cost and schedule functions as well as managing subcontracts; Finance and Accounting, who performed as a local financial agent; Field Procurement,

responsible for the purchase of field materials and the management of warehouses and stores and; Quality Control, reporting independently to the Bechtel Quality Control organization and who were responsible for inspection of safety related systems (PECO St. 7, pp. 5-6).

Bechtel's Limerick project organizations, including both the field and home office groups, employed a system of matrix management which, as stated by Mr. Soppet,

> "...permitted each of the various project functional groups to receive technical direction and information, based on experience at other Bechtel projects, from the larger functional organizations within Bechtel, while receiving project direction with respect to budget, schedule and project activities from my project operations organization" (PECO St. 7, p. 6).

In summary, the Limerick project organizations were reflective of the inherent complexity of nuclear plant construction, PECO's and Bechtel's extensive previous experience in constructing nuclear units and their close working relationship which had developed during the successful completion of Peach Bottom Units 2 and 3. PECO and Bechtel prudently and appropriately adopted organizational approaches for the Limerick project which incorporated their prior lessons learned and which presented the best opportunity for successful project completion from a cost, schedule and quality viewpoint.

The Company's objective . . ."has always been to ensure that a safe, reliable and licensable plant is constructed at a reasonable cost" (PECO St. 2, p. 4). As Mr. Kemper testified:

> "Although Limerick has cost significantly more and has taken longer than we originally projected, I believe that we have been successful in achieving our objective. In completing the plant and obtaining its license, we have had to overcome a number of unanticipated problems, including NRC-mandated, continuous changes in the design requirements for licensing, lower than anticipated cash resources to devote to construction and labor shortages, all of which were beyond our control. These problems and the inter-related and unanticipated impact which they had on the Project made Project management an extremely challenging and, often, very frustrating process. I believe that we have responded to these problems appropriately and have resolved them in an efficient and effective manner. This can be seen by recognizing that despite these problems, Limerick's cost is no greater than the average plant constructed today. Further, we have avoided the exceedingly high cost levels, or worse yet-the apparent quality failures which will prevent plant completion and operation as have been experienced at several contemporaneous projects. Accordingly, I believe that we have achieved our objective of constructing a safe, reliable and licensable plant at a reasonable cost" (PECO St. 2, pp. 5-6).

C. The Cost And Schedule Control Systems Employed For The Construction Of The Limerick Project Effectively Supported Both The PECO And Bechtel Project Management Organization.

PECO ensured that the critical functional groups within their project organization, i.e., engineering, procurement, construction, startup, licensing and quality assurance, employed

appropriate control tools and management processes that supported overall project cost, schedule and quality objectives. For example, engineering activities have been continually monitored by PECO since design work began in 1969. Prior to the receipt of the construction permit in 1974, ". . .engineering management was primarily achieved through quarterly Project status review meetings and reports which began in 1969" (PECO St. 2, p. 12). These meetings were attended by the Manager or Vice President of the Engineering and Research Department, the Project Manager and Project Manager-Construction, various division heads, PECO QA personnel and responsible Bechtel and GE employees, and were used to review and discuss key events, schedules, costs, contracts and other topical items. PECO also initiated, in 1969, monthly meetings of their Mechanical and Electrical Division personnel to allow for frequent discussion of critical project items (PECO St. 2, p. 13).

Subsequent to 1974, in response to the increasing amount of regulatory imposed design changes, the Company established the position of PECO Resident Project Manager at Bechtel's San Francisco office. The functions of the Resident Project Manager were to monitor Bechtel and GE engineering activities and to provide a direct conduit for information flow between Bechtel, GE and PECO management. During that period, PECO also initiated the Monthly Project Status Review Meeting. This meeting was conducted under the direction of Mr. Kemper and was utilized as a

forum to address and expedite the resolution of then current project issues and concerns (PECO St. 2, p. 14).

PECO control over engineering cost, schedule and quality was further enhanced by the Limerick Project Manager's Bi-weekly Meeting, which addressed design changes and modifications, NRC concerns and other action items and the weekly conference between the PECO, Bechtel and General Electric project managers, where engineering progress and design problems were reviewed. Additionally, in order to enhance the control of engineering design changes, the Notice of Change in Design ("NCD") mechanism was utilized. This tool required that significant increases to budgeted engineering hours be documented and approved by the PECO Chief Electrical or Mechanical Engineer before work commenced. Subsequent to 1982, design changes were further scrutinized by the Jobsite Review Board, comprised of Bechtel and PECO startup and construction forces (PECO St. 8, pp. 14-15).

The technical quality of Limerick's design was assured by similarly extensive control mechanisms. Initial preparation of specifications, drawings, plans, etc. were performed by Bechtel and were to include all applicable regulatory and technical design requirements. These documents were then reviewed by other Bechtel personnel to ensure compliance with specified technical criteria and overall accuracy. Following this, PECO conducted their own independent evaluation of the documents. This three tiered approach was, to the best of Mr.

Kemper's knowledge, "...more extensive than was typical in the industry" (PECO St. 2, p. 16).

Confirmation of Limerick's effective engineering management has been provided by outside third party reviews. For example, in their Independent Design Verification of the Limerick core spray system, performed in November 1984, Torrey Pines Technology concluded that "...an adequate documented design control procedural system existed for the designers of the Limerick Generating Station No. 1, mainly Bechtel and GE" (PECO St. 2, p. 17). Further evidence of PECO's technical competence, concern with safety, and timely response and cost-effective solutions to engineering issues was supplied by the NRC in its Systematic Assessment of Licensee Performance (SALP) reports. The April 18, 1983 SALP report, for instance, stated that:

> "Generic re-evaluations of suppression pool hydrodynamic forces identified deficiencies in the design of downcomer supports. The applicant's active participation in the BWR owners group and significant resource allocations to this problem resulted in satisfactory resolution with modifications being completed without major problems. After this assessment, the applicant completed a full scale test of the Unit 1 suppression pool to verify the theoretical analysis of the hydrodynamic forces. This is indicative of the firm management commitment to satisfactory resolution of technical issues" (PECO St. 2, p. 17).

The January 16, 1984 SALP Report further found that:

> "The applicant's resolution of technical issues has been demonstrated during this period by a clear understanding of the issues, the election of a conservative approach when

the potential for safety significance existed and timely response to issues in most cases. The applicant's approach reflected a sound knowledge of the current industry-wide status of technical issues, usually due to their involvement with the issue on the Peach Bottom operating plant or participation in industry groups seeking a resolution to technical issues (e.g., BWR Owners Group). The applicant's approach reflected a thorough knowledge of the design of the Limerick plant and the safety significance of issues" (PECO St. 2, p. 17).

The PECO construction management organization was similarly well-equipped with control tools to monitor, plan, schedule and track site activities and progress. The principal systems used to manage Limerick's construction were the Limerick Resource Management Systems ("LRMS"), a computerized control system that tracked the installation status of material and equipment, as well as projecting quantity to be installed, and the Forecast and Control Updating System ("FOCUS"), which calculated both actual and projected unit rates for the installation of various commodities (PECO St. 4, p. 7). The LRMS and FOCUS programs were also used in the preparation of project Forecasts. Forecasts were developed by Bechtel utilizing the detailed information on material and labor costs and quantities contained in the LRMS and FOCUS reports, but were throughly reviewed by Company personnel and received final approval from PECO management, thus assuring a complete transfer of relevant project cost and schedule information to all levels of management (PECO St. 4, pp. 8-9).

The construction management organization provided further cost control monitoring through their use of the Trend program. Trend Program results were contained in a monthly report intended to identify significant variations from the project plan i.e., variations with a possible significant impact on project cost and schedule. PECO construction management forces used the Trend Program, along with the other cost control tools, such as their Monthly Cost Report, to continually assess the reasons for, and magnitude of, possible Limerick cost increases (PECO St. 4, p. 10).

The progress and schedule performance of the Limerick project also received a high degree of scrutiny from PECO personnel. As explained by Mr. Clarey, there were " . . . three principal types of schedules used to manage construction activities at Limerick" (PECO St. 4, P. 10). The first type, at the lowest level, was the three to four week rolling schedule, used by foremen and superintendents to plan daily activities for the crafts. The second type, the 12-month schedule, provided mid-range planning to allow for the coordination of engineering, construction and procurement activities. Each revision of this schedule was reviewed by PECO personnel to ensure support of the third type, or long-range, schedule. Limerick's long-term planning and schedule system, until 1979, was the Management Scheduling and Control System ("MSCS"), a computerized, critical path schedule which was used to schedule approximately four

thousand activities on a facility/elevation and systems/commodities basis. Beginning in 1978, PECO also utilized the Intermediate Construction Schedule ("ICS") for long term planning. ICS reflected the project's need for a system that focused on the tracking and planning the installation of bulk mechanical and electrical commodities. Through the use of these three major types of schedules, and other tools described below, PECO was able to obtain the detailed short-term, and also long-term strategic perspectives necessary to manage construction activities at Limerick (PECO St. 4, p. 10).

In addition to the previously mentioned programs, PECO also used other management tools to monitor construction costs and schedule. For example, the Construction Activities Report was issued monthly, prior to the Monthly Project Status Review Meeting, to update PECO home office construction personnel on the site teams current activities and recommendations in the areas of subcontracts, procurement, quality control and other topical fields. Also, PECO Construction Management produced the monthly Philadelphia Electric Schedule Analysis Report (PESA), which provided a detailed analysis of construction progress, and the Monthly Cost Report, which summarized recent cost trends and manpower levels, and compared actual cash flows and unit rates to budgeted figures. Also, construction and engineering forces made use of scale models of various plant areas to facilitate design coordination and to facilitate construction activities by

identifying in advance potential construction interferences. Early recognition of possible design or construction difficulties resulted in both cost and schedule savings.

Control tools similar to those used to monitor engineering and construction tasks were also incorporated into PECO's Procurement, Startup, Licensing and Regulatory Relations, and Quality Assurance and Quality Control management organizations. PECO's proactive posture in the management of these project functions was again the basis for numerous laudatory comments from the NRC. For example, regarding PECO's startup, and licensing and regulatory relations managements, the NRC concluded in its January 14, 1985 SALP report that:

> "Based on an extensive review of tests and test results by the NRC, it appeared that the test program had been adequately managed to assure satisfactory performance of those plant systems covered by it. Much of the success of the test program was due to the quality, scope and depth of the reviews made by the licensee's Test Review Board which reviewed and approved test procedures and test results, including the closure of all test exceptions" (PECO St. 2, p. 22).

and that:

> "The licensee's management participated actively in virtually all licensing activities. This included the attendance of the Senior Vice President for Nuclear Power at several meetings on the probabilistic risk assessment review and at all four ACRS meetings. The Chairman of the Board and at least three Vice Presidents attended the NRC Management Readiness meeting in September 1984. The Vice Presidents for Nuclear Power, Electric Production and Engineering and Research were directly involved in many of the

> decisions supporting resolution of technical issues during the rating period. The Senior VP for Nuclear Power and the VP for Engineering and Research have also been heavily involved in activities at the plant site during the rating period" (PECO St. 2 p. 28).

Further, addressing the Company's management of the Quality Assurance/Quality Control program at Limerick, the NRC, in its January 16, 1984 SALP report found that:

> "Overall, the licensee has demonstrated continued strong management attention, prompt identification and resolution of problems, ability to initiate and effectively implement long term corrective action and strong QA/QC coverage. Documentation of work has been complete and easily retrievable" (PECO St. p. 32).

Significantly, these laudatory comments from the NRC, as well as others already cited, serve to demonstrate and confirm the positive effects that accompanied PECO's commitment to effective project management.

This commitment to effective project management control systems also extended to the Bechtel organization. As explained by Mr. Soppet, the project control system utilized at Limerick ". . .consisted of three parts: 1) a project plan communicated throughout the Bechtel and PECO project organizations, reflecting the planned scope, schedule and cost; 2) a monitoring system that measured progress and performance against an established baseline; and 3) a reporting system that identified deviations from the cost and schedule plan and provided analysis to facilitate decisions by the project team, as well as Bechtel and

PECO management" (PECO St. 7, p. 6). Some of the more important control mechanisms which aided Bechtel in controlling cost and schedule at Limerick were the following:

- Estimate and Milestone Summary Schedule
- Project Forecasts
- Trend Program
- Limerick Resource Management System
- Quantity Tracking
- Engineering Budget and Schedule Control
- Procurement Controls
- Field Cost/Schedule Control System
- Commodity Curves for bulk commodity installation
- Special Topic Logic Schedules
- Weekly Labor Cost Report
- FOCUS System
- MSCS/ICS

Although the actual functions of only a few of the above control tools have been described earlier, the pervasive nature and comprehensiveness of these cost and schedule programs is clearly evident.

In summary, PECO and Bechtel both established comprehensive and effective control systems and management organizations to ensure that Limerick Unit 1 and Common would reflect the requisite quality demanded of nuclear power plants, and further, would be completed as timely and as cost-effectively

as circumstances would allow. The Company has shown that the control systems employed for engineering, construction, start-up and licensing activities were pervasive, comprehensive and, as demonstrated by the frequent laudatory comments received from the NRC in various SALP reports, extremely effective. In light of the extensive evidence presented herein and in the absence of any substantive challenge to the contrary, the Commission must clearly conclude that PECO's management of the construction of Limerick Unit 1 and Common was prudent and reasonable.

D. Theodore Barry And Associates, A Management Consultant Previously Retained By The Commission And The OCA, Conducted An Independent Review Of Company Management Of Limerick Construction And Found It To Have Been Prudent.

In 1984, Theodore Barry and Associates ("TB&A") was retained to perform an independent assessment of the prudence and reasonableness of PECO's management of the Limerick project. As described by TB&A, this assessment, or retrospective review, is an

> "investigation of how effectively the project obtains and employs an organization, managerial and system options and resources to minimize -- through project management -- project costs and schedule, while producing a product of the requisite quality. The emphasis is on the processes in place, and the assessment focuses on how well those controllable aspects of the project that most significantly impact cost, schedule and quality are managed." (PECO St. 8, p. 13).

TB&A has stressed their need to maintain an independent stance in the conduct of their review of PECO's management of Limerick. Indeed, TB&A had never worked for PECO in any capacity prior to their independent review of Limerick. They had, on the other hand, worked for the Pennsylvania Office of Consumer Advocate in a similar proceeding on the Salem 1 project, reviewing the prudence of PECO's owner oversight role in the Salem project. TB&A was also retained by the Pennsylvania Commission to perform a broad operations and management audit of Bell Atlantic, as well as to review the management and operations of General Public Utilities Company following the TMI-2 incident.

TB&A, by virtue of its 67 Project Management Reviews and extensive experience in the conduct of retrospective reviews of nuclear generating station construction projects, is preeminent in this practice area of management consulting. They have been retained by both advocates, attorney generals and other attorneys, utilities and commissions and have supplied expert testimony in rate proceedings evaluating the prudency of owner actions and decisions at the Shoreham (i.e. upon behalf of the New York Public Service Commission Staff), Diablo Canyon, South Texas and Clinton nuclear construction projects (PECO St. 8, p. 10). In total, TB&A has conducted 12 retrospectives of major nuclear construction projects and has testified in 16 separate proceedings (including those involving fossil units) on their assessment of the reasonableness of owner project management. By

virtue of their several hundred man-years of experience analyzing and evaluating the prudency of management practices, TB&A was unquestionably qualified to perform the retrospective assessment of Limerick Unit 1 and Common. Table 1 shows TB&A's major project management testimony experience over the past 8 years.

The TB&A team that performed the retrospective audit of the Limerick project was well qualified to do so. The engagement director, James O. Love has testified in eight other major project prudency proceedings and the project manager, Basil P. Kononetz had fourteen years of nuclear power plant project experience. The experience of the entire TB&A team included "...more than 60 man-years in the power industry and over 40 man-years specifically involved in nuclear projects. . ." (PECO St. 8, p. 16). Their Limerick Project review encompassed over 2000 consultant-days of effort and resulted in detailed findings and conclusions in the project's major functional areas of Pre-Project Planning, Project Structure, Engineering and Procurement Management, Construction and Startup Management, and Project Deferral Announcements and Continued Justification Analysis. Additionally, TB&A administered the preparation of the cost reconciliation study, jointly sponsored by PECO Witnesses Clarey, Kemper, Helwig and Sproat, which identified project cost increases and attributed them to major cost driver categories, and developed an as-built construction schedule for Limerick Unit 1 and Common.

For their review of Limerick, as for their reviews of other nuclear projects, TB&A acquired a broad understanding of the project environment and its issues and concerns by conducting a series of "top down" and 'bottom up" interviews of PECO and contractor employees. These interviews served to supplement TB&A's detailed and comprehensive studies and analyses, which were based on their review of many thousands of records, memoranda, letters and reports contained in project documentation. TB&A utilized these data sources, in conjunction with their own experience to independently assess and evaluate on a contemporaneous basis, i.e., without the benefit of hindsight, the reasonableness and prudency of PECO management's actions and decisions on the construction of Limerick Unit 1 and Common (PECO St. 8, p. 15).

TB&A's approach in their review of Limerick Unit 1 and Common was systematic and thorough. Based on their extensive experience in conducting other retrospective audits, they concentrated their initial analysis efforts on the aspects of the project that have the greatest impact on project cost, schedule and quality. These areas include engineering and construction management organizations; contractual relationships with the major project participants; cost and schedule controls; senior management involvement; major external events impacting on the project; and quality and safety control mechanisms. Subsequently, they performed individual detailed reviews of areas

that warranted further investigation. For example, TB&A performed a comprehensive analysis of PECO's method of addressing issues related to the Mark II containment problem that was identified in 1975. They also conducted numerous schedule related analyses which,

> "collectively presented a comprehensive picture of critical schedule activities and related events and encompass the following categories:
>
> - Licensing schedules
> - Engineering schedules
> - Procurement schedules
> - Site construction schedules
> - Startup and preoperational testing schedules
> - Financial plans and schedules"
>
> (PECO St. 8A, p. 35).

The purpose of this form of analysis was to enable the TB&A team to address major project concerns and also allow for a more detailed examination of particular areas identified as critical to Limerick's cost, schedule or quality. To ensure the factual veracity of their findings, TB&A conducted several verification sessions involving PECO and Bechtel project management personnel.

The standard of reasonableness and prudency that TB&A utilized when performing their retrospective review of Limerick is the same standard that they have universally applied in all of their recent retrospective assessments. That standard is:

> "Whether PECO, in managing the Limerick project, made the decisions and took the actions, including implementation of management and control systems, that a

reasonable, experienced and competent manager would want and need in order to assure that a project of this size and complexity had a good chance of being completed in a cost-effective manner. And, where it appeared that such actions were possibly not being taken, and systems not implemented, we looked to see whether PECO top management took reasonable and timely steps to correct the situation." (PECO St. 8, p. 10).

TB&A further notes that:

> "an assessment of management performance must focus on the reasonableness and appropriateness of decisions and actions related to the controllable aspects of a project in the context of information and courses of action contemporaneously available . . ." and that ". . . evaluation must be made without falling into the trap of hindsight" (PECO St. 8, p. 11).

An examination of the above standard indicates that it is generally analogous to the standard of prudence employed by the Pennsylvania Commission and other regulatory bodies. For example, at Docket P-830453, et. al., Energy Cost Rate Statement No. 8, the Commission stated that the ALJ had correctly defined the standard of prudence when he stated as follows:

> "Prudence is that standard of care which a reasonable person would be expected to exercise under the same circumstances encountered by utility management at the time decisions had to be made. In determining whether a judgment was prudently made, only those facts available at the time judgment was exercised can be considered. Hindsight review is impermissible.
>
> Imprudence cannot be sustained by substituting one's judgment for that of another. The prudence standard recognizes that reasonable persons can have honest differences of opinion

without one or the other necessarily being "imprudent"

Cost disallowance based on imprudence is not permitted unless the alleged imprudence was the real and proximate cause of some injury" (R.D., pp. 6-7).

The following sections of this brief contain many of the findings and conclusions that TB&A arrived at following their independent assessment of the various functional areas comprising the Limerick project. In the aggregate, TB&A concluded that:

> "throughout the 20-year history of the Limerick Project, PECO made reasonable and appropriate decisions and employed reasonable management practices. In sum, we have found, based upon our extensive investigation, that PECO's decisions and actions throughout the project satisfy our standard of reasonable and prudent management conduct..." (PECO St. 8, p. 17).

Significantly, TB&A's conclusions, in the main, have been uncontested. Clearly, the Commission should respect and accept the results of what is demonstrably a thorough and exhaustive review of PECO management practices and activities related to the construction of Limerick Unit 1 and Common. The evidence that TB&A has presented in their testimony very clearly demonstrates that the management practices and decisions employed by PECO during the various phases of the project were reasonable and prudent.

1. TB&A Concluded That The Project Structure And Management Control Systems At Limerick Were Reasonable And Appropriate.

Important to the successful engineering and construction management of a nuclear power plant is the establishment of an effective project structure. As defined by TB&A, evaluation of project structure,

> "...includes an evaluation of the organizational strategy selected by the owner/utility, the owner's selection of technical and other consultant organizations to assist in project completion, and the establishment and administration of contractual relationships with such organizations. This area of evaluation also includes a review of the understanding and implementation of project relationships, responsibilities and communication between organizations, and of the role of the owner/utility in facilitating project organization, cost, schedule and quality controls and ultimate completion. Also included in this latter area is a review of the project controls, procedures and systems utilized by the owner and its major contractors to exercise project management control, including an examination of their effectiveness" (PECO St. 8, p. 47).

TB&A carefully assessed PECO's relevant nuclear experience, historical organizational strategies and the specific management structure implemented for Limerick. They concluded that,

> "PECO's organizational approach, supplemented by its exceptionally high level of involvement and relevant nuclear experience, allowed PECO to fulfill its owner oversight responsibilities...in a reasonable and appropriate manner. PECO's organization strategy and the organizational relationships

it established provided a good prospect of successful project completion from a cost, schedule and quality vantage point and facilitated PECO and its major contractors in the execution of their responsibilities." (PECO St. 8, p. 59).

TB&A further examined the process used by PECO for the selection of Bechtel as the architect/engineer and constructor and General Electric as the nuclear steam supply system vendor (NSSS). Their examination included a review in three areas - 1) PECO's selection process and evaluation criteria, 2) type of contract awarded, and 3) the terms and conditions of the contracts, i.e., whether PECO's interests were adequately addressed. In the selection of Bechtel, TB&A concluded that "...the reasoning presented by PECO for the choice of Bechtel is compelling. Thus, Bechtel's selection reflects reasonable and appropriate management action" (PECO St. 8, p. 65). TB&A based this conclusion on PECO's then-extensive nuclear experience, its ongoing relationship with Bechtel at Peach Bottom, Bechtel's extensive nuclear experience and PECO's original intent to duplicate the Peach Bottom design at Limerick. TB&A found that the contract between PECO and Bechtel adequately addressed, from a contemporaneous standpoint, the key issues including liabilities, performance, fee and responsibilities pertaining to the project.

The selection process that PECO employed in their choice of the NSSS supplier was also found to be detailed and comprehensive. TB&A concluded, after a thorough analysis of

PECO's bid evaluation process, that the selection of General Electric was appropriate and was reflective of reasonable management actions. Further, TB&A found that the contract between PECO and General Electric gave sufficient consideration to PECO interests and was reasonable in addressing major issues germane to the successful fulfillment of a contract to supply an NSSS for Limerick (PECO St. 8, p. 69).

A key element to the successful completion of a nuclear power project is the implementation of strong project control systems. The main objective of project controls is to provide the information required to identify problems and initiate corrective action on a systematic and timely basis in order to meet project cost and schedule goals. At Limerick, the project controls program implemented by PECO and Bechtel consisted of comprehensive cost and schedule control programs. For example, over the course of the project PECO utilized approximately 30 different programs to plan, schedule, report and monitor work on the project (PECO St. 8, Schedule 11, p. 80A). These programs were based upon proven systems that Bechtel had used on other nuclear projects, and experienced further evolution over the course of construction at Limerick. TB&A's review of the project controls which were employed at Limerick found that:

> "PECO demonstrated sound project control management practices by establishing, at the outset of the project, cost and schedule goals and programs to appropriately monitor and control the project toward the attainment of those goals" (PECO St. 8, p. 82).

and further that,

> "PECO instituted and employed throughout the project an appropriate project controls program to properly achieve the functions of project planning, reporting and monitoring" (PECO St. 8, Page 82).

A major role for PECO at Limerick consisted of monitoring Bechtel and other major contractors' project performance and their compliance with contract provisions. PECO also provided direction on the project with regard to overall cost and schedule goals and, when required, recognized the need for and took appropriate actions to overcome project difficulties. PECO was responsible for providing reasonable assurance that the project could be completed satisfactorily from a cost, schedule, quality and safety standpoint. TB&A's process for determining whether PECO properly fulfilled its owner oversight roles and responsibilities included: 1) a review of information flow to management to ensure that they received timely, detailed and sufficient data to allow for reasonable, informed decision-making; and 2) an analysis to determine whether the information received was utilized in a manner that permitted reasonable control of project activities.

TB&A found strong evidence of PECO's proactive oversight involvement, on the Limerick project. Citing just a few examples, TB&A stated that:

> "The Monthly Project Status Review Meetings, which were chaired by a PECO Vice President. These meetings served to identify project

issues and concerns and also served as a forum for implementing and monitoring action items that were utilized to resolve those concerns.

The Company President's frequent presence at the monthly review meetings, which ensured that executive management remained aware of critical project activities, and impressed all project personnel with top management's commitment to cost, schedule, quality and safety goals.

PECO top management's early and continued commitment to the highest licensing and quality standards. This commitment resulted in frequent laudatory comments from the NRC in their Systematic Assessment of Licensee Performance (SALP) Reports concerning PECO licensing, quality assurance and management involvement at Limerick" (PECO St. 8, p. 85).

Based on their detailed review of PECO's management oversight role at Limerick, TB&A concluded that PECO management was informed and involved in project activities to a degree that allowed for "...a reasonable prospect of successful project completion from a cost, schedule and quality perspective" (PECO St. 8, p. 88).

2. TB&A Concluded That Engineering And Procurement Management Was Reasonable And Prudent At Limerick.

Engineering and procurement management consists of owner and A/E engineering and procurement organization, staffing and communications; engineering and procurement schedule and cost control; and engineering and procurement quality management. Each of these functions was subject to an in-depth analysis by TB&A in performance of their evaluation of engineering and

procurement management at Limerick. Their review examined both the role and responsibilities of PECO, the plant owner, and Bechtel, the plant engineer.

TB&A concluded that PECO's functional organization, i.e., task oriented, afforded PECO the "...ability to maximize the transference of Peach Bottom experience both early and throughout the project, and to maintain the functional skills required by the Company for projects other than Limerick" (PECO St. 8, p. 96). The use of a functional organization also maximized the potential for applying "lessons learned" between Peach Bottom and Limerick, since many of the same individuals and organizations were involved on both projects. Bechtel's use of a dedicated Limerick project organization, which was reflective of the standard Bechtel nuclear project organization allowed for timely response to client concerns and individual project issues.

As plant owner, PECO's responsibilities included monitoring the management and technical activities of Bechtel to ensure that reasonable engineering management and technical performance was achieved. To meet these responsibilities, PECO took a strong position by clearly defining Bechtel's roles and responsibilities through the issuance of the project procedures manual, which covered all administrative aspects of the project. In addition, PECO maintained responsibility for regulatory compliance, including the review and submittal of the Preliminary Safety Analysis Report (PSAR) and Final Safety

Analysis Report (FSAR), and was appropriately involved in the Quality Assurance aspects of Bechtel's work at Limerick by performing regular QA audits.

An important aspect of the organization of the Limerick project was PECO's establishment of a Resident Project Manager and two Resident Project Engineers within Bechtel's San Francisco Home Office. These individuals established and maintained the PECO "presence" in Bechtel's home office and were the focal point of PECO's oversight of Bechtel's engineering and procurement activities. PECO also established early in the project, monthly project meetings at which the Monthly Project Status Report, which presented extensive detail on project activities, was issued and discussed. In addition, regular meetings (bi-weekly until early 1982 and monthly thereafter) were held involving the Limerick Project Manager and Section Heads, which addressed all relevant Limerick engineering-related activities such as schedule status, labor status, Peach Bottom modifications that could affect Limerick, licensing items and other significant items.

Regarding PECO and their involvement in the engineering at Limerick, TB&A concluded that:

> "PECO's management of both their own and Bechtel's organization and resources was reasonable and appropriate. PECO's use of their experienced engineering personnel from the Peach Bottom project and the transference of that experience to the Limerick Project through their functional organization was sound.

PECO's implementation and effective use of their Resident Project Manager and Resident Project Engineers were likewise appropriate. Their detailed involvement in the daily Bechtel engineering activities, together with the detailed nature of the engineering related meetings, specifically the monthly progress meeting, is indicative of the high level of attention and involvement consistently displayed by PECO in the project" (PECO St. 8, p.105).

The effectiveness of the PECO and Bechtel engineering organizations manifested itself in the cost and schedule control, quality control and procurement functions of the project. For example, TB&A found that the engineering cost and schedule controls used at Limerick contained the important elements of an effective program, which include: 1) forecasts of total manhour requirements; 2) monitoring of both expended and earned manhours against the forecast; 3) identification and control of scope increases; and 4) the implementation of corrective action as required. TB&A assessed this element of project management and concluded that:

"The engineering planning, scheduling, monitoring and control methods and tools used on Limerick were effective" (PECO St. 8, p. 115).

PECO's use of effective engineering cost and schedule controls also contributed to the fact that engineering was supportive of construction needs, i.e., construction forces were able to proceed without restraint from engineering throughout the project. TB&A found that the management processes that PECO and Bechtel utilized imparted a "high degree of probability that

engineering would support construction activities" (PECO St. 8, p. 159). Significantly, TB&A also found that during periods of overall project extension, the pace of engineering activities was never reduced.

Another aspect of engineering controls that TB&A found that PECO had effectively managed was the area of engineering quality assurance. Specifically, they stated that:

> "PECO was significantly and appropriately involved in both the formal QA and technical engineering quality control activities at Limerick" (PECO St. 8, p. 122).

This finding is supported by both Torrey Pines Technology, based on their 1984 Independent Design Verification of the Core Spray System, and the NRC, in their 1984 SALP report, wherein they concurred that the overall engineering and design effort was of high quality.

Additionally, due to the importance of the procurement of engineered items at Limerick, TB&A performed an in-depth review of the management processes utilized by PECO and Bechtel in this important area to assess the reasonableness of their actions. Through this review, TB&A determined that PECO had established and outlined their role with Bechtel early in the project. It was PECO's responsibility to: 1) review and approve specifications prior to issue; 2) review and approve the bidders list; 3) review and approve bid evaluations prior to award; and 4) review purchase orders and change orders. TB&A's assessment of PECO's management of the procurement function was based on

analyses of a number of representative purchase orders and subcontracts. From these studies TB&A found that:

> "PECO was intensely involved in engineering equipment procurement activities. Their review of specifications was thorough as evidenced by the detailed technical nature of their comments, their concern for ensuring that the appropriate decisions resulted from studies as evidenced by PECO's requests to Bechtel to consider further assumptions and alternatives, and their concern about the suitability of potential vendors as evidenced by their requirements that the necessary prerequisites to award and fabrication (financial, quality assurance and procedural requirements) be thoroughly reviewed beforehand" (PECO St. 8, p. 168).

A major impact to the engineering of the Limerick plant was the increasing regulatory requirements that occurred over the course of the project. For all such new regulatory guidelines or technical criteria, PECO directed Bechtel to review the various requirements as they were issued to assess the impact that each would or might have upon the Limerick design and to determine, if applicable, the most cost effective method of incorporating the new requirements. For example, in the area of fire protection, to respond to the issuance by the NRC of numerous new requirements, PECO directed Bechtel to perform a major re-analysis of the safe shutdown capability of Limerick in the event of a serious fire. This re-analysis resulted in a significant reduction in the need for raceway fire barriers over that which would have been required from a more cursory review, and, because

of the avoidance of this additional work, aided in the project's ability to meet its targeted fuel load schedule.

TB&A examined PECO management actions during the licensing process, from preparation and submittal of the Construction Permit application through the Operation License Review. TB&A found that from the earliest stages of the project, licensing impacted the project. For example, the evidentiary hearings for Limerick spanned a period of 23 months (from January 1972 until December 1973) due to the concerted efforts by outside intervenors. This lengthy process for obtaining a construction permit, delayed the start of construction until June 1974. TB&A found that PECO prudently developed and implemented a status summary tracking program for various regulatory activities. Another PECO action indicative of management's concern in minimizing potential delays in obtaining an Operating License, was their submittal of the Limerick FSAR 43 months prior to the then-anticipated fuel load date of October 1984. Generally, the NRC expected an FSAR submittal to occur only 30 months prior to the anticipated fuel load date. These and other PECO actions in the licensing process at Limerick demonstrate conclusively the involved and prudent nature of PECO management.

Additionally, from both a regulatory and technical perspective, one of the most important problems that PECO had to resolve during the course of the Limerick project was the incorporation of the newly-discovered hydrodynamic loads

associated with the Mark II containment design. TB&A reviewed in detail the process, decisions and actions PECO undertook to resolve this issue. Their review consisted of a detailed examination of the project documentation for the Mark II containment problem, interviews with the various individuals responsible for the decision-making process in this area, and an analysis of documentation regarding the effect of Mark II within the industry. In May 1975, all owners of Mark II plants formed the Boiling Water Reactor Owners Group ("BWROG") in order to effect a resolution to the problem. PECO was actively involved in the BWROG, participating in the regularly scheduled meetings and with PECO managers filling key leadership positions within the group.

TB&A found that PECO's solution of the Mark II problem reflected their recognition of Limerick's construction status, served to minimize construction rework and was in concert with the overall Limerick schedule requirements. Specifically, TB&A stated:

> "PECO's actions were reasonable and appropriate. PECO's decisions consistently reflected a concern for ensuring that the least conservative design criteria, consistent with supporting the project schedule requirements, would be utilized. Indeed, the fact that four other Mark II plants were projecting fuel load dates as much as 42 months ahead of Limerick caused PECO to appropriately expect that significant benefits could be derived from the 'lessons learned' from the lead plants" (PECO St. 8, p. 155).

In summary, TB&A's assessment of the Company's resolution and implementation of regulatory and technical changes led to their conclusion that:

> "PECO maintained a proactive involvement in the resolution and implementation of regulatory changes throughout the course of the Limerick Project. Both PECO and Bechtel implemented the necessary procedures to ensure that new or revised regulatory requirements were addressed in an orderly and timely manner.
>
> PECO and Bechtel worked effectively to ensure that the project was responsive to the changing needs that were being imposed not only on the Limerick Project but on the nuclear industry in general. PECO consistently demonstrated a concern for minimizing cost and schedule impact while ensuring at the same time that the proposed solutions fully complied with the criteria or the intent of the criteria" (PECO St. 8, pp. 134-135).

In the area of PECO's involvement in the Licensing activities for Limerick, TB&A concluded:

> "PECO maintained an appropriate level of staffing and management involvement . . ." (PECO St. 8, p. 138).

and that

> ". . . PECO exhibited a continuously high level of aggressive involvement in the regulatory relations and licensing activities. PECO's involvement and coordination of the overall Limerick licensing activities resulted in the timely development of their operating license application and response to the many outstanding issues and contentions raised by both the NRC and external intervenors" (PECO St. 8, p. 141).

3. TB&A Concluded That Construction Management At Limerick Was Prudent And Reasonable.

TB&A performed a comprehensive review of PECO's and Bechtel's construction management actions. Their review consisted of examining each of the major areas that comprise construction management: 1) PECO and Bechtel's construction organization, staffing and communications; 2) subcontract management organization; 3) construction quality management; 4) construction schedule and cost monitoring and control; 5) construction manpower planning and management; and 6) construction materials and equipment management. Additionally, TB&A examined major construction events and activities, including the effects of regulatory change, cash constraints, labor unavailability, and unit rates on construction activities.

In the area of organization and staffing, TB&A examined both PECO and Bechtel's organizations, their interface, the experience of their project personnel, and the methods used by both organizations for reporting and communicating. From this review TB&A found that the construction organization structure of both PECO and Bechtel were appropriate and reasonable, with both organizations being established early in the project prior to the start of construction. TB&A also found that both organizations were staffed with individuals with an acceptable level of construction and construction management expertise. The reports, meetings and other channels of communication between the

organizations were reasonable in providing the appropriate information to management in a timely manner. Specifically in the area of meetings, TB&A found, via both review of minutes and through direct observation by attendance at several meetings, that the monthly review meetings "provided an effective forum for problem resolution and for project review and planning" (PECO St. 8, p. 180).

Subcontract administration is another important area that TB&A reviewed in detail during its examination of the construction management processes at Limerick. Subcontract administration includes "the coordination, monitoring and implementation of the requirements of the subcontract following selection of a successful bidder" (PECO St. 8, p. 180). On the basis of their in-depth review, TB&A concluded that:

> "the organization structures that were utilized by both PECO and Bechtel were appropriate for administration of subcontracts at Limerick" (PECO St. 8, p. 185).
>
> "Effective control mechanisms were established from the outset of the construction project for handling major areas of subcontract management, including backcharges, amendments, defaults and terminations of a subcontract" (PECO St. 8, p. 185).

The third major area of construction management that TB&A reviewed was construction quality assurance management. A formal construction quality assurance program is required in order for a nuclear plant to obtain an operating license. The establishment of a formal quality assurance program is a

requirement of the NRC regulations, 10 CFR 50. TB&A examined and assessed the Limerick construction quality assurance program against the following four specific key quality program elements:

> "1) a well organized, structured and staffed quality organization which is independent of the organizations being audited and which has adequate authority to effectively monitor compliance with technical requirements; 2) owner commitment to a high level of quality and communication of that commitment to site personnel; 3) work product acceptance, i.e. inspections and other steps taken to assure that work is being performed in compliance with applicable requirements; and 4) timely corrective action to remedy nonconforming conditions and a defect prevention process to eliminate root causes of recurring problems" (PECO St. 8, p. 186).

When examined against these four elements, TB&A concluded that not only did PECO and Bechtel meet all four criteria, they went well beyond the minimum requirements in the area of quality. TB&A found that:

> "PECO's commitment to a high level of quality was established early in the Limerick Project and was communicated throughout the duration of the project" (PECO St. 8, p. 194).

Further evidence of the effectiveness of the quality programs at Limerick is the fact that the project schedule was not impacted by a breakdown of the quality program as has occurred at many nuclear projects.

An aspect of construction management fundamental to the success of a project the size and magnitude of Limerick is the implementation of effective cost and schedule controls. Cost and schedule control consists of 1) the development of a reasonable

cost and schedule target for construction activities; 2) continuously comparing and monitoring actual progress against the established performance targets; 3) effective monitoring to identify problems so that management may take the necessary corrective actions; and 4) periodic updating of the performance targets to reflect past progress and the project conditions.

In analyzing the reasonableness of the Limerick cost and schedule efforts, TB&A scrutinized the schedule tools used at Limerick against the above criteria. TB&A examined in detail the Limerick cost controls to ensure that the systems were well developed; were provided early in the project; changed over time as needed; presented a reasonable performance standard against which to measure performance; identified causes for deviations from the performance standard; and that the cost control system was integrated with the schedule control system.

Based upon their comprehensive and detailed analysis of schedule control at Limerick, TB&A concluded that:

> "throughout the project, PECO and Bechtel supplied appropriate schedule control systems and management expertise to effectively control the project. These systems and their features and usage appropriately evolved or were updated over time. Using these tools, PECO and Bechtel management recognized schedule slippages and their causes and sought to take corrective action" (PECO St. 8, pp. 204 - 205).

With regards to cost control, TB&A concluded that:

> "PECO and Bechtel used sound cost control techniques that provided key information to those who needed it and allowed both PECO and

Bechtel to maintain an accurate awareness of the status of the project at all times" (PECO St. 8, p. 210).

"PECO and Bechtel utilized state-of-the-art . . . cost control and estimating tools for the . . . Limerick Project" (PECO St. 8, p. 210).

"PECO and Bechtel were reasonable in their efforts to control costs for the Limerick Project" (PECO St. 8, p. 211).

Manpower planning and labor management is an important facet of construction management, and is an area that TB&A analyzed in detail. Manpower planning involves the identification and deployment in a timely fashion of those manpower resources required to maintain the project's target cost and schedule. Labor management relates to the effective and efficient utilization of labor resources available to the project, and encompasses minimization of labor delays, determination of level of craft supervision, use of overtime and shift work, manpower training, labor relations, work rules, personnel safety and site security. Through their detailed, in-depth review and analysis of the manpower planning and labor management at Limerick, TB&A found overwhelming evidence of reasonable and prudent actions on the part of both PECO and Bechtel construction management. In their conclusions, TB&A stated that:

"PECO and Bechtel employed appropriate tools to effectively manage the extensive labor resources at the Limerick site. From the beginning of the project, management recognized the importance of careful manpower planning and the need for implementing

effective systems to measure, control and improve the overall productivity and costs associated with manpower resources" (PECO St. 8, p. 221).

"...construction management for the Limerick Project properly maintained control over manpower at the jobsite. Appropriate numbers of supervisory personnel were utilized in the construction process by PECO and Bechtel management, who also effectively maintained control over the percentage of non-manual labor used during the project. TB&A found that PECO management most appropriately realized the limited, but costly effects of using high levels of overtime, and properly kept cumulative overtime on the project to approximately 5.5% through fuel load" (PECO St. 8, p. 221).

. . . .

"...PECO and Bechtel management were aware of the importance of measuring and monitoring craft productivity in controlling overall labor costs at Limerick" (PECO St. 8, p. 221).

"...management took appropriate steps relative to manpower training and employee safety at the site. The safety record at Limerick during the construction phase is indeed impressive. In addition, TB&A concluded that site security programs and procedures were comprehensive and diligently enforced at the site" (PECO St. 8, p. 222).

TB&A also reviewed several key events or activities; identified their impact on construction; and examined PECO's and Bechtel's actions taken in response. These areas included 1) the effects of regulatory changes on construction; 2) the effects of cash constraints to the construction budget; 3) labor unavailability; 4) unit rates and labor productivity; and 5) the HVAC subcontract.

TB&A also investigated the effect that regulatory changes had on the construction cost and schedule. The effect of these new regulatory requirements caused increases in the quantity of materials required for constructing Limerick; resulted in more stringent code requirements for both construction procedures and quality assurance/quality control practices; caused increased crowding and congestion; and led to removal and replacement of previously installed materials due to changing requirements. These effects were not unique to Limerick but were common throughout the nuclear industry.

Some examples of regulations that had a major impact on construction included:

- Modifications resulting from the incident at Three Mile Island
- Mark II containment resolution requirements.
- Fire protection requirements.

TB&A demonstrated that PECO and Bechtel did initiate a number of efforts to minimize these impacts, including:

> "Aggressive pursuit by PECO of solutions to problems being addressed by regulatory change in a manner conducive to the project, through use of the BWR Owners' Group and negotiation with the NRC" (PECO St. 8, p. 229).
>
> "Frequent revisions of schedule logic to take into account changes in work scope and revisions" (PECO St. 8, p. 229).
>
> "Development of scale models to visually determine the effects of the required design changes" (PECO St. 8, p. 229).

Their analysis of the effects of regulatory changes upon construction at Limerick led TB&A to conclude:

> "PECO's and Bechtel's actions were reasonable and that they aggressively attempted to minimize cost and schedule impacts due to regulatory changes. The management systems in place had the flexibility to implement these changes in the most effective manner, and PECO closely monitored construction activities to minimize interferences and additional work that resulted from these impacts" (PECO St. 8, p. 229).

The construction budgets at Limerick were constrained by PECO management during the 1974 to 1980 time period. TB&A performed an in-depth review of how PECO site management responded to the effect of these budgetary constraints and found that PECO site management took action to minimize their effect. TB&A concluded that PECO prudently continued engineering design work even during the construction cutbacks; actual cashflow was closely monitored and compared to budget expenditures to maximize cash allocation; PECO prudently focused resources on critical and near critical path activities in order to maintain overall schedule progress; and PECO maintained more aggressive construction target schedules than those publicly announced through August 1980.

As a result of these types of actions on the part of PECO site management, TB&A concluded:

> "PECO and Bechtel handled construction-related cash constraints in an appropriate and reasonable manner" (PECO St. 8, p. 231).

The Limerick project experienced shortages of pipe welders and sheetmetal welders during the 1978-1980 period, which impacted the progress in the critical areas of piping and HVAC duct installation. TB&A found that PECO took appropriate action in response to these shortages which included the institution of an on-site welders' training program, and arranging with PSE&G to train prospective welders at Hope Creek for assignment at Limerick. Because of actions such as these on the part of PECO site management, TB&A concluded that:

> "PECO effectively analyzed the best available options for recruiting manpower, calculated the associated costs and benefits of each option and acted aggressively in implementing the chosen solution" (PECO St. 8, p. 234).

As part of their review of the site management at Limerick, TB&A also analyzed the unit rates experienced at Limerick. Their review analyzed the unit rates over the duration of the project, to determine both the causes for the changes and the actions taken by PECO site management to improve productivity. Based upon this detailed analysis of productivity at Limerick, TB&A concluded that:

> "the unit rates achieved at the Limerick Project were reasonable given the significant changes that took place on the project specifically and throughout the nuclear industry generally during this time frame" (PECO St. 8, p. 241).

> "the efforts by PECO and Bechtel to improve unit rates were reasonable" (PECO St. 8, p. 241).

"active involvement allowed PECO management to take action which precluded increases greater than those that eventually occurred" (PECO St. 8, p. 241).

TB&A performed a detailed examination of the HVAC subcontract which focused on:

1. design and scope changes,
2. manpower availability,
3. potential subcontractor bankruptcy,
4. subcontract renegotiation, and
5. the increase in the final cost of the subcontract.

TB&A's review found that PECO appropriately became very involved with the management of this Bechtel subcontract, thus avoiding any potential impact on the overall project schedule. Specifically, rather than having the subcontractor enter into bankruptcy, which would have potentially delayed the project, PECO appropriately directed Bechtel to renegotiate the subcontract.

TB&A concluded that:

> "Both PECO and Bechtel made major efforts and were extensively involved in resolving difficulties encountered with the HVAC subcontract. PECO initiated a number of studies in 1978-1979 to determine a solution to the HVAC subcontract problem in a manner that was in the best interests of the project. PECO renegotiated the subcontract in January 1980, which permitted work on the HVAC system to continue and avoided the major delays that most certainly would have occurred had a new subcontractor been retained" (PECO St. 8, p. 246).

In response to sheetmetal welders shortages, TB&A found that:

". . . the Company and Bechtel made every effort to resolve this problem and that sufficient staffing levels were ultimately achieved" (PECO Statement 8, p. 244).

In summary, with regard to the HVAC subcontract, TB&A concluded that:

"PECO closely monitored HVAC subcontract performance, taking actions that were reasonable in light of the possible detrimental impact to the project in terms of schedule delay and its associated cost. As the result of such PECO and Bechtel actions, significant schedule delays were avoided" (PECO St. 8, p. 246).

4. TB&A Concluded That Startup Testing Management Was Prudently Performed And PECO Management Involvement Was Extensive And Commendable.

Another important phase of a nuclear power project is the startup testing phase, which is the period in which plant systems are tested following their construction completion. Once a system is completed, the construction organization "turns over" the system to the startup organization for initial operation and testing.

Based upon their detailed, in-depth analysis of the startup organization and staffing, scheduling and monitoring of startup activities at Limerick, TB&A found that this aspect of the project was appropriately managed by PECO. TB&A also noted that other organizations also reached similar conclusions. For example, the NRC in the 1985 SALP Report stated:

"the involvement of senior PECO corporate and site management continued to be evident. In fact, the involvement of corporate management

increased during the latter part of the period with the full-time presence of the Vice President of Engineering and Research at the site to lead a project completion team composed of himself, the Superintendent of Nuclear Generation, and the Bechtel Project Manager. This team, along with PECO Project Construction and Field Quality Assurance organizations, greatly enhanced the performance of the licensee especially regarding completion of licensee punch-list items and preoperational test activities" (PECO St. 8, p. 256).

In their conclusions, TB&A stated that:

"PECO management maintained extensive and commendable involvement in the startup effort. PECO's concern for meeting the October 1984 fuel load target is exemplified by the assignment of senior management to the jobsite on a full-time basis" (PECO St. 8, p. 256).

"Because of the effective startup organizational structure, careful PECO management and monitoring of startup activities, and the extensive involvement of senior management personnel, PECO Startup management was successful in attaining the scheduled fuel load date" (PECO St. 8, p. 258).

5. TB&A Concluded That PECO'S Financial Planning And Continued Justification Analyses For Limerick Were Reasonable.

TB&A performed an in-depth, comprehensive examination into PECO's financial planning process; collected, analyzed and compared PECO's key financial statistics to the utility industry in general; and reviewed PECO's generation planning process and their continued justification analyses of the Limerick Project.

TB&A, in their review of PECO's financial planning process, examined the total flow of information for the financial decision-making process and the transfer of that information between the key departmental groups involved in the process. TB&A found that the mechanics of PECO's financial planning process were similar to those utilized contemporaneously by other utilities, and that the process permitted "...flexibility when unusual circumstances dictated" (PECO St. 8, p. 261).

TB&A concluded from their analysis of the PECO financial planning process that:

> "PECO's financial planning process during the 1970's was representative of sound management procedures, addressed the relevant aspects of financial planning and practices, and allowed for reasoned and informed decision-making" (PECO St. 8, p. 262).

In addition, TB&A performed a detailed analysis of PECO's financial condition during the 1970s, a period that TB&A characterized as "...very turbulent for electric utilities in general and for those with nuclear construction programs in particular" (PECO St. 8, p. 263). Factors that TB&A cited as the cause of this turbulence included: 1) the oil embargo and its impact on energy costs, 2) declining sales and load growth, 3) rapid escalation in construction costs, 4) restrictive Public Utility Commissions, and 5) reevaluation by the financial community of the risks associated with utility investments.

TB&A found that during the 1970s, PECO did indeed experience poor financial performance, which they attributed to:

"...1) limited cashflow, which resulted from lower than anticipated sales revenue; 2) poor quality of earnings, which reflected the high component of non-cash earnings due to AFUDC; 3) a high dividend payout ratio, which resulted in reduced levels of retained earnings; and 4) returns on equity which fell well below the allowed returns and those of the industry in general" (PECO St. 8, p. 264).

Further, TB&A compiled a group of relevant PECO financial statistics (Yield, Return On Equity, Allowance For Funds During Construction as a Percentage of Earnings, Market to Book Ratio, Interest Coverage Ratio, and Bond Ratings), as achieved during the 1970's, and compared them to that of the electric utility industry in general and in particular, seven utilities who were also constructing nuclear power plants and experiencing financial difficulties. Based upon their detailed analysis of PECO's financial condition, TB&A conclusively found that:

"PECO's financial condition: 1) was worse than the utility industry in general; 2) was worse than many utilities who also deferred construction on nuclear power projects during the 1970s; 3) significantly hindered their ability to utilize external sources of financing; and 4) resulted from circumstances that were not controllable by Company management" (PECO St. 8 p. 271).

TB&A also evaluated the analyses that PECO performed for the continued justification of Limerick. An important function of PECO management was to review on a timely basis various key aspects of a major generation project, both in terms of cost and need for the power produced by the planned facility. TB&A's

review focused on two distinct areas: 1) PECO's load forecasting and 2) PECO's studies on the cost effectiveness of Limerick versus other generation alternatives.

As a result of their in-depth and comprehensive review of PECO's analytical process for justifying the continuance of Limerick, TB&A concluded that:

> "PECO's contemporaneous position that generating capacity would be required in the near future to meet anticipated energy demand was the result of sound analytic techniques and procedures. Furthermore, TB&A finds that the management process, utilized by PECO in determining that Limerick was the optimal choice to meet this demand was sound and reflected a reasonable consideration of alternatives" (PECO St. 8, p. 278).

In summary, the financial and generation planning processes utilized by PECO during the Limerick Project were reasonable and appropriate, and allowed PECO to prudently plan their financial requirements for new or planned generation facilities, and to adjust those plans in response to changing conditions in a timely manner. Further, the continuing justification analyses performed by PECO were prepared throughout the project and provided the Company with a sound basis for determining the ability of continuing the Limerick project.

TABLE 1: TB&A TESTIMONY EXPERIENCE

Date	Project	Client(s)	Thrust
1977	North Anna 1, 2, 3 & 4	Virginia Electric Power Company	Comprehensive Prospective Review of Project Management Practices
1978	Sequoyah 1 &2 Watts Bar 1 &2 Hartsville 1,2,3&4 Phipps Bend 1 &2 Yellow Creek 1 &2	Tennessee Valley Authority	Comprehensive Prospective Review of Project Management Practices
1978	Several Projects	Boston Edison	Construction Work Force Management Practices
1978	Salem Unit 1	• Public Advocate of New Jersey • Office of Consumer Advocate of Pennsylvania • Delaware Commission	Retrospective Prudency Audit of PSE&G's Project Management Practices Prudency of Joint Venture Owners' Oversight
1978	Holcomb	Kansas Corp. Commission/ Semflower Elect.	Comprehensive Review of Technical & Economic Feasibility

Date	Project	Client(s)	Thrust
1979	Clinton Unit 1	Illinois Power Company	Project Management Practices Contracting Engineering Management
1980	Clinton Unit 1	Illinois Power Company	Use of Incentives and Work Force Management Improvement Program
1981	Pleasant Prairie	Wisconsin Public Service Commission	Comprehensive Prudency Audit of Project Management Decisions and Actions
1981/1982	Trans-Alaska Pipeline System	State of Alaska Attorney General	FERC Prudency Audit of: Project Management Regulatory Relations Materials & Equipment Management Quality Program Management
1984	Shoreham	New York State Department of Public Service	Comprehensive Prudency Audit of Project Management Actions and Decisions
1984	Diablo Canyon	PG&E	Comprehensive Prudency Audit of Project Management Actions and Decisions

Date	Project	Client(s)	Thrust
1984	South Texas	HL&P	Comprehensive Prudency Audit of Project Management Actions and Decisions
1985	North Valmy Unit 2	Sierra Pacific Power Company	Comprehensive Prudency Audit of Project Management Actions and Decisions
1985	Limerick	Philadelphia Electric	Comprehensive Prudency Audit of Project Management Actions and Decisions
1985	Clinton	Illinois Power Co.	Prudency Audit of Project Management Decisions & Actions
1986	Hope Creek	PSE&G	Prospective Management Analysis

APPENDIX C

EXCERPT FROM PECO EXHIBIT 2

RE: EXPLANATION OF REASONS FOR COST GROWTH

II. EXPLANATION OF REASONS FOR COST GROWTH

A. Introduction

This explanation is presented by dividing cost growth into the following categories:

- Cost Impact of Regulatory and Other Externally-Imposed Conditions
- Cost Impact of Design Changes to Facilitate Plant Operability and Reliability
- Cost Increases Due to Estimate Refinements and Other Causes
- Cost Impact of Unanticipated Escalation

A summary of the costs determined to be associated with each category is presented in Schedule 1.

B. Cost Impact of Regulatory and Other Externally- Imposed Changes

1. TMI-2 ANALYSES AND DESIGN CHANGES $57.5 Million

The Three Mile Island, Unit 2 (TMI-2) incident had a significant impact on light water reactor (LWR) construction and operations cost. Following TMI-2, various panels within the NRC, such as the Lessons Learned Task Force

Schedule 1

LIMERICK UNIT 1 & COMMON
COST GROWTH RECONCILIATION

($ in Millions)

Original PECO Capital Authorization Unit 1 and Common, Direct Costs		$344.1
Regulatory and other Externally - Imposed Conditions		
- TMI-2 Analyses and Design Changes	57.5	
- Plant Staffing, Startup and Training	181.6	
- Seismicity	119.6	
- Impact of Mark II	136.1	
- Fire Protection & Electrical Separation	65.8	
- Equipment Qualification	38.6	
- Anticipated Transients Without Scram	20.9	
- ALARA & OSHA	39.6	
- ASME Code Requirements	20.9	
- Security Requirements	43.5	
- Intergranular Stress Corrosion Cracking	10.2	
- Licensing Costs	62.9	
- Miscellaneous Other NRC Regulations	116.3	
- Non-NRC Requirements	63.8	
- Cost Impact of Schedule Delays Due to Licensing Delays and Other Factors	385.1	
		1362.4
Design Changes To Facilitate Operability and Reliability		111.9
Estimate Refinements and Other Causes		208.6
Unanticipated Escalation		322.1
DIRECT COST RECONCILIATION TOTAL		$2349.1

and Emergency Preparedness Task Force, reviewed the incident and issued findings and recommendations in the form of NUREG reports. These requirements were for the most part detailed in NUREGs -0578, -0654, -0660, -0696, -0700, -0737, revisions to Regulatory Guide 1.97, amendment of 10CFR50 Appendix E, and Supplement 1 to NUREG -0737 which were issued during the period July 1979 to May 1983.

Examples of Limerick design changes as a result of these requirements are as follows:

- Post-Accident Sampling System (PASS) added in accordance with NUREG-0737, Item II.B.3;
- Accident monitoring equipment upgraded and new equipment added per NUREG-0737, Item II.F.1 and Regulatory Guide 1.97, Rev. 2;
- Automatic closing of drywell purge isolation valves on a high radiation signal added in response to NUREG-0737, Item II.E.4.2(7);
- A control room design review (CRDR) was performed and resultant changes implemented as per NUREG-0737, Item I.D.1, as further clarified by Supplement 1 to NUREG-0737;
- Technical Support Center (TSC) added in accordance with NUREG-0737, Item III.A.1.2;
- Computer and software for offsite dose assessment added in compliance with NUREG-0737, Item III.A.2.2, clarified by NUREG-0737, Supplement 1;
- Added emergency microwave telecommunications system between PECO main office, plant, and Emergency Operations Facility (EOF) in accordance with NUREG-0654, Item E.1;
- Relocation of vent radiation monitoring equipment to provide post-accident access per NUREG-0737, Items II.F.1 and II.B.1;

- System leakage study performed and modifications implemented as per NUREG-0737, Item III.D.1.1;

- Emergency Response Facility Data System (ERFDS) added in compliance with NUREG-0737, Item I.D.2 to provide safety parameter display system (SPDS), clarified by Supplement 1 to NUREG-0737;

- Modifications to the high pressure coolant injection system and reactor core isolation cooling system (HPCI/RCIC) in accordance with NUREG-0737, Items II.K.3.15 and II.K.3.22;

- Emergency public notification system added per 10CFR50, Appendix E;

- Modifications to the Automatic Depressurization System (ADS) logic per NUREG-0737, Item II.K.3.18;

- Added Seismic Class I air supply system to the ADS valves per NUREG-0737, Item II.K.3.28;

- Purchase and installation of a Safety Relief Valve Position Indication System per NUREG-0737, Item II.D.3;

- Isolation signal reset interlocks added to safety feature systems per NUREG-0737, Item II.E.4.2;

- Operations Support Center added per NUREG-0737, Item III.A.1.2;

- Development and implementation of emergency procedures per NUREG-0737, Item I.C.1, as further clarified by Supplement 1 to NUREG-0737.

The effects of the TMI-2 incident upon project cost and schedule exceed actual hardware and engineering analyses accounted for in this subsection. Substantial cost additions set forth in Subsection 2 of this testimony, reflecting increases in plant staffing, startup and training, are also attributable to new requirements or revised interpretations of existing

requirements adopted because of TMI-2. Further, one of the most significant indirect impacts of TMI-2 was a heightened level of regulatory awareness and scrutiny, which significantly impacted project cost.

2. PLANT STAFFING, STARTUP, AND TRAINING $181.6 Million

Project costs increased substantially relative to the original December 1970 estimate due to increased requirements in the areas of staffing, startup, and training. For instance, startup test procedure preparation and review process requirements are far more extensive than those in effect at the time of the original cost estimate. Hence, manpower requirements were considerably greater than originally estimated. Additionally, requirements for operations personnel, operating procedures, and operator training have greatly expanded since the TMI-2 incident.

The following are examples of changes in staffing, startup, and training due to increased requirements:

- Expanded startup and power ascension testing programs required in accordance with Regulatory Guide 1.68, Revision 2, Revision of Standard Review Plan Section 14 and Regulatory Guide 1.108;
- Independent Safety Engineering Group required per NUREG-0737, Item I.B.1.2;
- Fire Protection assistant added to the plant operations staff in response to SRP Section 9.5.1 and BTP CMEB 9.5-1;
- Shift Technical Advisors added per NUREG-0737, Item I.A.1.1;

- Reactor operator training and qualifications upgraded per NUREG-0737, Item I.A.2.1;
- Shift staffing, overtime, and turnover practices revised per NUREG-0737, Items I.A.1.3. and I.C.2;
- Operations Experience Assessment Committee established in response to NUREG-0737, Item I.C.5;
- Increased training for the mitigation of core damage events provided per NUREG-0737, Item II.B.4;
- Staffing increases needed to handle expanded NRC requirements for documentation and reporting;
- Increased size of administration complex based on additional staffing requirements;
- Increased number of procedures required due to NRC expansion of the scope of plant Technical Specifications.

3. SEISMICITY $119.6 Million

Major requirements for seismic design classification impacting Limerick are detailed in Regulatory Guide 1.29. This guide, adopted in June 1972 and revised as late as 1978, describes an acceptable method of identifying and classifying those features which should be designed to allow the plant to be safely shutdown in the event of an earthquake. Compliance with Regulatory Guide 1.29 was extremely costly in that numerous supports for piping, electrical equipment, and HVAC were impacted in terms of requirements for additional engineering analysis, and labor manhours required for the installation and modification of supports and hangers.

The AEC/NRC dictated several significant changes to the Limerick seismic design basis after the Preliminary Safety Analysis Report (PSAR) was docketed in February of 1970. Many of these changes were due to NRC and ACRS concerns about the ability of nuclear power plants to withstand seismic events, concurrent with keeping safety-related systems and components functional. These changes, all of which defined more conservative seismic loads to be used for the design of Limerick, included:

- Vertical direction seismic analysis for all safety-related structures;
- Twenty-five (25) percent increase in maximum ground acceleration for the design basis earthquake;
- Three earthquake component combinations for design of piping systems per requirements of Regulatory Guide 1.92.

These criteria changes resulted in structural design changes, while the increase in seismic response had a major impact in terms of costs on plant systems, components and equipment which necessitated increases in strength, number and size of components and supports.

Examples of design analyses and field changes made at Limerick in response to the seismic design requirement changes include:

- Upgrading of HVAC ductwork (relative to Peach Bottom) to Seismic Class I in the reactor enclosure and control structure per PSAR commitment and Regulatory Guide 1.29;
- Increases in structural steel in the reactor enclosure to satisfy seismic criteria;

- Increased metal conduit and cable tray installation cost to allow for Seismic Class I supports due to increased seismic response spectra and ground acceleration value;

- Increased installation manhours for all conduit, instrument tray, piping and tubing supports due to increased congestion and complexity;

- Control room ceilings upgraded from Seismic Class II to Special Class IIA in compliance with Regulatory Guide 1.29;

- Hanger and snubber quantity increases resulting from decreased hanger spacing due to revised seismic loads;

- Changes in unit cost and fabrication of large pipe and hanger material due to reassessment of dynamic loads.

These new or revised seismic design requirements were imposed during the period June 1972 to September 1978.

4. IMPACT OF MARK II $136.1 Million

A new category of load phenomena associated with BWR Mark II containments was identified in 1975. This was comprised of the hydrodynamic loading conditions during a safety relief valve (SRV) discharge or loss-of-coolant accident (LOCA). These hydrodynamic SRV and LOCA loads have come to be known simply as Mark II loads.

Various requirements have been issued by the NRC concerning acceptable means of addressing these loads by owners of BWR Mark IIs. These include NUREGs -0487, -0763, -0783, -0802, and -0808. As a result of these requirements, a number of

analyses and design changes were made at Limerick. Examples of these include:

- Engineering to evaluate the suppression pool swell phenomenon, perform containment analysis, provide technical support to the BWR Mark II Owner's Group, and conduct plant unique analysis and support design. These analyses included:
  - fatigue evaluation of downcomer and SRV lines;
  - analysis of wetwell and drywell vacuum breakers;
  - analysis of shroud support legs;
  - asymmetric SRV acceleration time histories and response spectra analysis.
- Modifications to seismic structures adjacent to the containment to account for hydrodynamic loadings;
- Field modifications and installation costs associated with the re-evaluation of design loading requirements for pipe supports and piping systems, including the addition of hangers and other materials such as snubbers and struts.

These Mark II-related NRC requirements were issued during the period 1978 to 1982.

5. FIRE PROTECTION AND ELECTRICAL SEPARATION $65.8 Million

Following the Browns Ferry Nuclear Power Plant fire in 1975, the NRC made a comprehensive evaluation of the design criteria for fire protection at nuclear power plants. The major regulatory requirement that resulted from this review was 10CFR50.48. Appendix R to 10CFR50, although not directly applicable to Limerick by regulation, was the basis for Standard Review Plan Section 9.5.1 and Branch Technical Position (BTP)

CMEB 9.5-1, against which the Limerick design was reviewed. The requirements contained in this document are intended to ensure that, in the event of a fire, personnel and plant equipment would be adequate to safely shutdown the reactor, and to maintain the plant in a safe shutdown condition.

Electrical separation requirements in the form of Regulatory Guide 1.75 also impacted the Limerick design by requiring the redesign and rework of raceway and control systems to achieve physical independence of safety-related circuits and electrical equipment.

The following are examples of the regulatory impacts stemming from BTP CMEB 9.5-1 (fire protection), and Regulatory Guide 1.75 (electrical separation):

BTP CMEB 9.5-1

- Fire protection changes and modifications pertaining to the separation of safe shutdown circuits, namely: fireproofing of cable tray, added cable tray supports, additional sprinkler systems, modifications to existing fire protection systems, increased structural steel fireproofing, penetration sealing and fire protection of wall gaps, and relocation of equipment from hazardous areas;

- Addition of automatically initiated, permanently installed Halon 1301 fire suppression system on the PGCC.

Regulatory Guide 1.75

- Raceway separation tests were conducted, and other electrical separation design changes incorporated;
- PGCC, NSSS, and balance of plant panel modifications due to separation requirements;
- Q-listed equipment inspection and NRC reviews to verify conformance with Class 1E equipment internal separation requirements.

These increased fire protection and electrical separation requirements were adopted during the period 1975 to 1981 with major modifications spanning from 1982 to 1984.

6. ENVIRONMENTAL AND DYNAMIC EQUIPMENT QUALIFICATION — $38.6 Million

Limerick safety-related equipment, located inside as well as outside primary containment, is required to be capable of maintaining its functional operability for its installed life under all service conditions postulated to occur during normal operation and as a result of design basis events. Equipment qualification is the documented demonstration of this capability.

Major regulatory requirements affecting environmental and dynamic equipment qualification costs at Limerick include NUREG-0588, Regulatory Guide 1.100 and 10CFR50.49. The latter regulation specified the requirements to be met to demonstrate the environmental qualification of electrical equipment important to safety located in a potentially harsh environment, and

expanded the scope of qualification and documentation required for safety-related equipment.

Costs due to environmental and dynamic equipment qualification on Limerick include:

- Qualification and/or modification, replacement, or relocation of equipment to meet environmental conditions in compliance with NUREG-0588 and 10CFR50.49;
- Plant design changes associated with replacement or relocation of equipment due to qualification;
- Evaluations to determine reactor building environmental conditions under various conditions;
- Qualification and/or modification, replacement or relocation of equipment to meet dynamic conditions in compliance with Regulatory Guide 1.100 including analyses of equipment for Mark II dynamic loads and seismic qualification (SQRT) reviews.

These requirements were imposed, during the period 1980 to 1983.

7. ANTICIPATED TRANSIENTS WITHOUT SCRAM — $20.9 Million

An Anticipated Transient Without Scram (ATWS) occurs when the control rods fail to insert as a result of an undefined common mode failure when a reactor scram signal is initiated.

In December 1978, Volume 3 of NUREG-0460, "Anticipated Transients Without Scram for Light-Water Reactors" was issued describing the proposed plant modifications the NRC staff considered necessary to reduce the risk from ATWS to an acceptable level. In response to the NRC's concern with the ATWS

issue, the following features were included in the Limerick design:

- Lower main steam line isolation valve isolation setpoint;
- High pressure coolant injection system flow split;
- Redundant reactivity control system for:
  - (1) Alternate rod insertion
  - (2) Recirculation pump trip
  - (3) Automatic initiation of standby liquid control with improved injection flow path;
- (4) Additional uninterruptible power supply.

8. AS LOW AS REASONABLY ACHIEVABLE (ALARA) AND OSHA — $39.6 Million

The NRC requires that all nuclear power plants be designed so that radiation protection measures are taken to ensure that internal and external dosages to plant personnel and contractors as a result of plant conditions, will be within the limits established by 10CFR20. This regulation addresses and details the requirements for:

- Determination of accumulated doses;
- Individual exposures to concentrations of radioactive materials in the air in restricted areas;
- Radioactivity in effluents to unrestricted areas;
- Surveys of radiation hazards;
- Personnel monitoring;
- Caution signs, labels, signals, and controls;
- Waste disposal;

- Records, reports, and notification;
- Enforcement.

Regulatory Guide 8.8 provides more detailed guidance relevant to attaining goals and objectives for planning, designing, constructing, operating, and decommissioning a light-water reactor nuclear power plant. The goals of both Regulatory Guide 8.8 and 10CFR20 are to keep the annual integrated (collective) dose to station personnel as low as is reasonably achievable (ALARA).

Modifications to the Limerick Station design as a result of these requirements include:

- Reviews, identification, purchase, and installation of radiation shielding associated with potential radiological exposure areas;
- Modifications to the breathing air system to prevent radioactive contamination;
- Special coatings in radiation areas to facilitate decontamination and cleanup;
- Relocation of instruments to low radiation areas.

Compliance with OSHA requirements for worker safety also impacted station costs. Examples of required compliance measures include:

- Eye protection for craftsmen;
- Increased lighting fixture quantities;

- Added room signs, identification signs, directional and elevation signs;
- Additional personnel access platforms.

9. ASME CODE REQUIREMENTS $20.9 Million

ASME Code requirements increased substantially during the design, procurement, and construction of the Limerick project. At the time of initial project design and cost estimates, the ASME Code Sections pertaining to Nuclear Power Plant Components were in the developmental stage and thus, their full impact could not be accurately anticipated. Examples of areas where the evolution of applicable ASME code requirements to increased project costs are as follows:

- Preparation of nuclear piping design specifications;
- Additional weld preparation for non-destructive examination;
- Additional non-destructive examination;
- Additional stress analyses of piping and hangers;
- Preservice inspection.

In addition to these costs, ASME code changes caused substantial increases in the cost of equipment, field fabrication and documentation which could not be specifically accounted for in the project cost records. These costs are absorbed in other entries included in the subsections on Estimate Refinements and Other Cost Increases.

10. SECURITY REQUIREMENTS $43.5 Million

The original scope of Limerick security provisions consisted of standard industrial property fence and general site access control. With the promulgation of 10CFR73.55 in February 1977, however, significant changes in physical protection were required at all nuclear facilities. The current Limerick security system consists of an integrated computer-based system interfacing with extensive access control and alarming hardware, perimeter monitoring and alarming, TV surveillance, and personnel processing facilities.

The required extensive security system increased the costs of engineering, construction, startup and testing, and carries a constant maintenance requirement. Further, associated security personnel required to support the system prior to commercial operation have increased substantially over original project estimates.

11. INTER-GRANULAR STRESS CORROSION CRACKING $10.2 Million

In response to BWR operating experience with inter-granular stress corrosion cracking (IGSCC), susceptible materials in the Limerick primary coolant and ECCS piping systems were replaced with IGSCC resistant materials during the construction phase as opposed to a more costly replacement of the materials when the plant is operational. Subsequent regulatory

requirements for dealing with this problem contained in NUREG-0313 and NUREG-1061, were satisfied by this action.

12. LICENSING COSTS $62.9 Million

Changes and additional evaluations which were required during the Limerick licensing process contributed towards additional project cost increases. Examples of these necessitated changes are:

- Use of a new format and context requirement for preparation of the FSAR;
- Additional geological investigations;
- Completion of a control systems interaction study in response to questions regarding USI A-49;
- Preparation and defense of a Probabilistic Risk Analysis (PRA);
- Completion of an Independent Design Verification Program (IDVP);
- Hardening of the reactor enclosure to withstand aircraft impact;
- Missile protection of the refueling floor;
- Increased cost of snubber exercising per I&E Bulletin 81-01.

13. MISCELLANEOUS OTHER NRC REQUIREMENTS $116.3 Million

A large number of plant design changes were required due to changes in NRC requirements which do not have a central theme or purpose, such as those itemized in

separate sections above. Examples of such changes are indicated below:

- Increased monitoring of effluents per 10CFR50, Appendix I;
- Modifications to facilitate containment leak testing per 10CFR50, Appendix J;
- Addition of an ultimate heat sink complying with Regulatory Guide 1.27;
- Expanded interpretation of quality assurance program requirements per 10CFR50, Appendix B;
- Concrete anchor bolt test program per I&E Bulletin 79-02;
- Additional diesel generators provided per Regulatory Guide 1.81;
- Addition of an MSIV leakage collection system per Regulatory Guide 1.96;
- Inclusion of an augmented offgas system per 10CFR50.34a;
- Improvement of leakage detection capability per Regulatory Guide 1.45;
- Use of high density spent fuel storage racks (because reprocessing is unavailable);
- Masonry wall modifications per I&E Bulletin 80-11;
- Addition of a loose parts monitoring system in compliance with Regulatory Guide 1.133;
- Analysis of high and moderate energy line breaks and subsequent plant changes per BTP ASB 3-1, and BTP MEB 3-1;
- Design changes for control room habitability per Regulatory Guide 1.78;
- Addition of radwaste solidification equipment per 10CFR61.

14. NON-NRC REQUIREMENTS $63.8 Million

Requirements imposed by entities other than the NRC caused increases in project costs. Revised or new requirements from the EPA, PaDER, and ANI in areas such as effluent limitations, erosion control, flood plain management, and worker safety all contributed to project cost increases. In addition, various unanticipated increases in taxes and other items were imposed upon the project.

15. COST IMPACT OF SCHEDULE EXTENSIONS DUE TO LICENSING DELAYS AND OTHER FACTORS $385.1 Million

Delays in the construction and operating schedules resulted in time related direct cost increases due to the prolonged period of equipment maintenance and project staffing. Schedule extensions were experienced as a result of:

- Delays in receipt of a Construction Permit from the NRC;
- Cash flow and financing constraints;
- Limited availability of craft manpower;
- Delays in receipt of the low power operating license from the NRC;
- The cumulative effects of regulatory change on project engineering and construction;
- Delays in receipt of the full power operating license from the NRC.

C. Cost Impact Of Design Changes To Facilitate Operability And Reliability $111.9 Million

The three basic sources of non-regulatory-imposed design and work scope changes on the Limerick Project were those initiated by the architect/engineer/constructor, vendors, and PECO. Many changes in this cost causation category were identified as being the result of operating experiences derived from PECO's Peach Bottom BWR Units in addition to general industry operating experience. The objective in making these changes was to enhance plant safety, reliability, and operability. Examples of such design and work scope changes are:

- Change from hydraulic to mechanical snubbers;
- Design modifications to small pipe vents and drains;
- Revised turbine drain design to prevent water induction into the turbine based on a GE recommendation as a result of industry operating experience;
- Addition of protective coating for the entire suppression pool;
- Rerouting of plant heating pipe, addition of steam traps and condensate return units;
- Modifications to reactor feed pump seals, main condenser internals, loop seals, vents and drains, HVAC systems and turbine drains;
- Addition of an equipment vibration monitoring system;
- Utilization of three additional safety relief valves in lieu of safety valves.

D. Cost Increases Due To Estimate Refinement And Other Causes $208.5 Million

Costs included in this section represent estimate adjustments and re-evaluations, pricing changes, and other subcontract changes not wholly attributable to specific causation factors. Certain of these cost changes resulted, albeit indirectly, from changing regulatory requirements and other uncontrollable factors described elsewhere.

Examples of cost changes associated with this category are:

- Addition of stainless steel liner for reactor well due to estimate omission;
- Re-evaluation of the concrete batch plant support operations, including additional requirements for concrete trucks;
- Reduced weather protection costs based on fewer winter placements;
- Credit for pre-commercial power generation;
- Estimate adjustments based on actual contract awards.

E. Cost Impact Of Unanticipated Escalation $322.1 Million

Costs included within this category are changes in the determination of escalation due to unanticipated inflation made throughout the project, unanticipated escalation associated with schedule extensions, and unanticipated changes in labor rates.

APPENDIX D

EXAMINATION OF THE KEY AREAS OF DIFFERENCE IN THE LIFE CYCLE BENEFIT FORECASTS PRESENTED DEMONSTRATES THAT LIMERICK 1 WILL PRODUCE SUBSTANTIAL ECONOMIC BENEFITS OVER ITS OPERATING LIFETIME

APPENDIX D

I. EXAMINATION OF THE KEY AREAS OF DIFFERENCE IN THE LIFE CYCLE BENEFIT FORECASTS PRESENTED DEMONSTRATES THAT LIMERICK 1 WILL PRODUCE SUBSTANTIAL ECONOMIC BENEFITS OVER ITS LIFETIME.

The various intervenor parties who have presented life cylce cost benefit analyses in this proceeding each focus their attention on various components of Dr. Hieronymus' Limerick 1's life cycle analysis. This Appendix will summarize and address the Company's response to various criticisms levelled at each component. Perhaps the most important point to bear in mind in considering the reasonableness of the forecasts that underlie the various life cycle analyses is that all of the intervenor witnesses have acknowledged that a forecaster must apply judgment in reaching his conclusions (See OCA St. No. 6, p. 25; Tr. 2909; Tr. 3469).

Thus, where the wide range of "plausible" regressions presented in this proceeding suggest conflicting results, not only between the Company and the intervening parties but among the intervening parties themselves, the judgment applied by the forecaster in reaching a particular conclusion must be carefully scrutinized. Moreover, the fact that the results of the analyses are dependent on forecaster judgment underscores the speculative nature of any projections of future events.

A. Operation And Maintenance Expense Forecasts

Comparison of the various O&M expense projections by opposing party witnesses reveals that, while they are derived by different means, all of these O&M expense projections, except Mr. Chernick's, support the general reasonableness of PECO's projection. OCA witness Komanoff's projection of O&M expenses is 12.5% higher than the Company's in present value, within the range of reasonable difference of opinion in forecasts of this type (PECO St. 15A, pp. 28-29). PAIEUG witness Falkenberg's forecast, despite a fundamental internal inconsistency discussed below, even more closely supports PECO's projection, together with his capital additions forecast amounting to a net present value difference of only $55 million (PECO St. 15A, p. 29; Tr. 3458). UUC/UP witness Chernick's projection, however, is completely out of line with all of the other O&M forecasts and is nearly five to seven times PECO's forecast (PECO St. 15A, p. 30). His forecast would be even greater had he actually used the model he developed, which projects expenditures of from $54 billion to $132 billion per year by the end of Limerick 1's life (Id.). Mr. Chernick, rather than rely on the results of his model, arbitrarily chooses instead to apply the linear growth rate suggested by his model for 1986-87, resulting in a forecast "only" five to seven times greater than the Company's O&M forecast (PECO St. 15A, pp. 29-30). Thus, in comparison to all

of the other witnesses presenting life cycle analyses in this proceeding, Mr. Chernick's judgment on potential O&M expenses is open to considerable skepticism.

1. Mr. Komanoff's O&M Projections Are Lower In Present Value Than PECO's Until 2008 And Generally Support The Reasonableness Of PECO's O&M Projection.

Mr. Komanoff's O&M projection is reached by averaging a linear and an exponential equation (Tr. 2876). The linear equation, which has superior R^2 and f statistics, and is therefore statistically more significant (Tr. 2879-81), actually produces a forecast which is lower than PECO's (PECO St. 15A, p. 29). By averaging the linear equation with the exponential equation, which extrapolates the compounded historic growth rate for 40 years, Mr. Komanoff's projection results in a forecast of O&M expense only 12.5% above PECO's (PECO St. 15A, p. 29). Mr. Komanoff conceded during cross-examination that "in the early years, the first roughly ten years -- that's not precise -- the Company actually estimates higher Limerick O&M than I do" (Tr. 2877). Further, his forecast is below PECO's in present value until 2008, or for more than half of the plant's life (PECO St. 15A, p. 29). Thus, as Mr. Komanoff has conceded, his differences with PECO essentially occur more than 20 years in the future (Tr. 2877-78). Given that his difference with the Company, however small, is speculatively based on cost escalation not occurring for more than 20 years, Mr. Komanoff's forecast should be relied

upon in this proceeding for no other purpose than to substantiate the reasonableness of the Company's forecast.

2. Mr. Falkenberg's Forecast Is Actually Lower Than PECO's If His Own Model Is Used.

Mr. Falkenberg's O&M forecast, which together with his capital additions forecast (Tr. 3458) is only $55 million more than PECO's in present value, is achieved through a two step process. First, Mr. Falkenberg adopts the Company's 1986 forecast as his starting point. Then he takes the growth rate trend developed from his own O&M forecasting equation which is based on the Peach Bottom history (PECO St. 15A, p. 29). In his rebuttal testimony, Dr. Hieronymus describes this as a "highly questionable procedure," inasmuch as Mr. Falkenberg's own equation would have derived an O&M forecast "well below PECO's" had he relied on it to forecast the base year for 1986 expenditures (PECO St. 15, p. 29). Significantly, Mr. Falkenberg did not defend his O&M forecast in his surrebuttal testimony.

3. Mr. Chernick's O&M Forecast Fails To Control For Factors Affecting Historic Trends And Fails To Exercise Reasonable Judgment Regarding Future Trends.

Mr. Chernick's O&M model derives a compound growth rate from a geometric regression based on 17 years of historical O&M experience (UUC/UPI St. 1, p. 66). After deriving a starting point figure of $73-85 million for 1986, he applies the compound

growth rate suggested by his geometric regression to extrapolate to huge future values. In his rebuttal testimony, Dr. Hieronymus questions the basis for Mr. Chernick's having "arbitrarily used the 1986-87 growth rate from his exponential model and assumed a linear growth at the 1986-87 rate for the life of the plant" (PECO St. 15A, p. 30). Mr. Chernick's unusual methodology results in a forecast that is entirely inconsistent with those of all other parties in this case. In Exhibit WHH-36 of his rebuttal testimony, Dr. Hieronymus shows, for example, that for the year 2022, the O&M cost forecasts of Falkenberg, PECO, and Komanoff fall in the range of $0.7-$1.0 billion, while Chernick's forecast is $3.75 billion. Indeed, this Exhibit, attached as Schedule D-1, clearly demonstrates, Mr. Chernick's forecast consistently and dramatically exceeds the forecasts of all other parties in this proceeding after the first few years of Limerick 1's life.

The apparent basis for Mr. Chernick's projection is his assumption that nuclear O&M costs will increase for the next 40 years at a linear rate which he arbitrarily selects from his model's forecast for a chosen point (PECO St. 15A, p. 30; PECO St. 15B, p. 14). Mr. Chernick's response to criticism concerning the gross unreasonableness of the forecast produced by his model was that he didn't actually use it (UUC/UP St. 1A, p. 4). But if Mr. Chernick's forecast is not based on the forecast derived by his model, then his forecast is without any basis whatsoever. By

using his model to forecast the 1986-87 escalation rate, on which his O&M forecast is based, Mr. Chernick gives the illusion of empirical support for a forecast based purely on his own judgement. Further, if the only basis for his judgment is the model which his ultimate forecast disavows, it is clear that his judgment cannot be trusted. Dr. Hieronymus describes Mr. Chernick's methodology in this way:

> "...his model is extraordinarily sensitive to minor changes in specification, and hence very suspect as a basis for forecasting. This is true irrespective of whether the forecast used is literally that produced by the model or one derived in some subjective fashion from the model. Since Mr. Chernick did not directly rely on his own model's forecast, he could have picked the 1983-1984 growth rate it produces, the 1989-1990 rate, or the 2009-2010 growth rate. This ad hoc procedure permitted his model to "predict" whatever result he desired with very broad latitude. Thus, the only real basis for Mr. Chernick's O&M forecast is his judgment as to what is reasonable. My discussion of his geometric forecast was an exploration of his model, not his judgment for which he provides no basis and upon which he has no practical background."

(PECO St. No. 15B, p. 14).

Despite the fact that Mr. Chernick's forecast assumes unrelenting increases in future O&M costs, he has recognized that past trends cannot be blindly assumed to continue indefinitely:

> "Q. You are not saying, are you, that based on the history of the nuclear industry that any particular future trend is inevitable?
> A. That is certainly correct.

Q. And just because you may have had a pattern develop over the last 15 years in the nuclear industry, that does not mean that it will necessarily continue for the life of this plant; is that also true?

A. That's true."

(Tr. 2913). Nevertheless, his forecast does assume continuation of the extreme pattern derived from (though grossly inconsistent with) his exponential model, without offering any justification.

Mr. Chernick's reliance on extrapolating trends without any serious investigation of underlying causes or implications is manifest in his statement that even his unrestrained geometric forecast is more likely to occur than the Company's forecast (Tr. 2909-10). This means that, in Mr. Chernick's judgment, the trend implied by his model that results in a forecast of $132.7 billion in O&M expenses in 2024, based on an unceasing compound growth rate of 18.5 to 20% real escalation for 40 years, is "at least" as likely as the Company's forecast of $801 million (Tr. 2908-10). Further, this means that in Mr. Chernick's judgment, it is at least as likely, or "not terribly implausible", that O&M costs in the year 1999 will be $1.1 billion as compared to the $187 million forecast by PECO (Tr. 2911).

Despite his insistence that his forecast represents the most plausible trend, Mr. Chernick made three statements in his direct testimony which acknowledge that the Company's forecast, though five to seven times smaller than Mr. Chernick's, could in

fact be more reasonable (PECO St. 15B, p. 30; UUC/UP St. 1, p. 65). First, Mr. Chernick concedes that "[b]ased on the historical [sic], PECO's projections for Limerick 1 O&M are fairly reasonable for the first few years"; second, he notes that PECO's assumption that real escalation will slow to 3% through 1990 "is not totally implausible"; and third, that "projecting continued real escalation past the year 2000 (another 16 years into the future) is rather speculative" (UUC/UP St. 1, pp. 65-66).

A finding that future O&M forecasts of $800 million and $132 million are "equally plausible" shows how little faith Mr. Chernick has in his forecasting method (Tr. 2908-10). Thus, to the extent that Mr. Chernick has also recognized the reasonableness of the Company's forecast in the near term, and has not offered any justification for what he has conceded are speculative projections of real escalation beyond the year 2000, Mr. Chernick's forecast must be rejected.

a. Adding A Basic Explanatory Variable To Mr. Chernick's O&M Regression Equation To Account For Decreases In Post-TMI Regulation Dramatically Reduces His Forecast And Demonstrates The Implications Of His Failure To Apply Reasonable Informed Judgment To His Analysis.

One obvious adjustment that Mr. Chernick failed to make, and that Mr. Komanoff does make in his regression equation, is to

account for an easing of regulatory pressures on the growth in non-fuel O&M costs as the TMI-inspired changes reach a plateau. Even Mr. Komanoff adjusts his forecast for this factor in order to account for "the possible diminution of the extra TMI costs." (OCA St. 6, p. 21). Mr. Komanoff testified that reducing the "post-TMI" effect on costs was "appropriate in view of its reduced statistical significance in the updated data base with 1984 costs" (OCA St. 6, pp. 21-22).

Mr. Chernick himself acknowledges that one important reason to expect that historic rates of O&M cost escalation will precede is due to the learning that has now been accumulated within the nuclear industry:

> "Q. In the past there have been some severe events, I take it, that have had some impact on the increase in the non-fuel O&M figures; isn't that true?
>
> Three Mile Island, as an example, did that have an impact?
>
> A. That certainly had some effect, yes.
>
> Q. And you're not saying that there is going to be an event of that nature which you are predicting will happen in the future?
>
> A. Well, I wouldn't expect an identical event to occur, and if it did occur it probably wouldn't have the same kind of effect that the original event did since some of the lessons about dealing with that particular kind of problems have already been incorporated into O&M costs."

(Tr. 2913). Nevertheless, Mr. Chernick completely ignores the

stabilization of regulatory pressures assumed by all other forecasters in this proceeding in his forecast of non-fuel O&M costs.

Dr. Hieronymus exposes the fragility of Mr. Chernick's regression analysis, upon which his entire growth rate projection is based, by adding the post-TMI variable utilized by Mr. Komanoff, which reduces the O&M forecast derived from Mr. Chernick's regression equation by 70% (PECO St. 15A, p. 30). This result shows that Mr. Chernick's regression -- his only empirical basis for support of his O&M forecast -- is exceptionally unstable. The mere acknowledgment that some portion of past O&M growth was due to TMI reduces the resulting forecast of future O&M costs by 70%. Thus, no confidence can be placed in the regression, nor any forecast that the regression purportedly supports.

B. Capital Additions Cost Forecasts

OCA witness Komanoff and UUC/UP witness Chernick dispute PECO's capital additions cost projections, and each offers alternative projections. These differences are quite substantial. Mr. Chernick's forecast is more than two-and-a-half times PECO's, while Mr. Komanoff's is nearly seven times larger. Generally, the difference between the Company and these two witnesses arises from disagreement over how the past is used to predict the future.

The Company's forecast is based on its determination that the large capital additions made at BWRs in the past will not be required for Limerick 1 (PECO St. 5A, pp. 34-41). Implicitly, the Company's forecast also assumes that Limerick 1 will benefit from the extensive operating history compiled in the nuclear industry and that the degree of regulatory turbulence associated with an intensive period of sophisticated regulatory intervention will stabilize. Mr. Chernick assumes that the average level of capital additions required at BWRs in the post-TMI period will be required at Limerick 1. Mr. Komanoff makes the still more pessimistic assumption that problems requiring major repairs will not only continue to evolve but will also accelerate (PECO St. 15A, pp. 34-37).

1. The Capital Additions Cost Forecasts Of Mr. Komanoff And Mr. Chernick Fail To Attribute Any Benefit To Limerick 1's State-of-the-Art Design Features.

The Company has presented evidence that a proper forecast of future capital additions costs must make some attempt to account for Limerick 1's unit-specific characteristics. Company witness Helwig devotes considerable discussion to the specific state-of-the-art improvements that have been incorporated in Limerick 1's design (PECO St. 5A, pp. 35-41). He concludes that it is unrealistic to expect, as does the forecast of Mr. Komanoff, that "capital additions costs will climb at unabated historic rates experienced by less sophisticated plants

in the past" (PECO St. 5A, p. 40). Rather than achieving some plateau effect, Mr. Komanoff's, and to a lesser extent Mr. Chernick's, projections assume unrelenting increases in average yearly capital additions costs, with the result that as plants reaches the age of 20, they will require a major repair every other year (PECO St. 15A, pp. 36-37). Dr. Hieronymus provides an illustration demonstrating that by cumulative overforecasting, Mr. Komanoff's regression equation predicts that Limerick 1 would experience capital additions costs equivalent to the cost of a major rebuild "on continuous two-year cycles" (PECO St. 15A, p. 26). He concludes that Mr. Komanoff's forecast implicitly requires the assumption:

> "not only that Limerick 1 will experience the problems of problem plants historically, and not only that these problems will then recur cyclically, but also that as they recur the 'fixes' will either become more expensive (in constant dollars) or last less and less long. Quite simply, this forecast is not justified by the data."

(PECO St. 15A, p. 37). In stark contradiction to the ever increasing capital additions cost assumed by Mr. Komanoff's forecast, Mr. Chernick notes that the data for large units, such as Limerick 1, shows that there has been "no real sign of an upward trend since 1980 (other than a jump in 1984)" (UUC/UP St. 1, p. 69). This recent evidence of a lack of trend, at least with respect to large nuclear units, suggests that the Company's expectation that capital additions costs are leveling off is, in fact, proving to

be correct even for existing plants. Obviously, a plant which has been designed to reflect all the lessons learned in the industry to date, and which has incorporated known or reasonably anticipated regulatory requirements, can be expected to outperform even recent experience at plants which are considerably older and have already undergone repairs which Limerick 1 will not need (PECO St. 5A, pp. 35-41; PECO St. 15B, pp. 11-12). In fact, as described by Company witness Helwig in PECO St. 5C, pages 5-7, substantial post-commercial capital additions expenditure has been avoided by the resolution of identified issues during construction.

a. Mr. Komanoff's Regression Fits The Data Poorly And Fails To Capture Important Differences Between Plants Requiring, Or Not Requiring, Repairs.

Mr. Komanoff's projections of capital additions costs are seven times greater than PECO's, and account for $1.8 billion of the life cycle benefit difference between PECO and the OCA (PECO St. 15A, p. 34). Mr. Komanoff's forecast, based on a time trend drawn through historic data, predicts that Limerick will experience capital additions costs averaging $75/kw per year (PECO St. 15A, pp. 34-35). The weakness of Mr. Komanoff's forecasting method, even before its extrapolation into the future, is demonstrated by the fact that his model explains only 21.6% of the historic variation in capital additions and has a confidence interval of plus-or-minus $61/kw per year, more than

twice the average expenditure in his database (PECO St. 15A, p. 34). Mr. Komanoff's forecast is excessive on its face in light of the fact that the $75/kw average predicted by his model exceeds the capital additions cost experienced for 92% of all years of reactor experience (PECO St. 15A, p. 35).

The very poor "fit" of his model to even the historic data exposes his model's inability to discriminate between reactors whose design has required major back fits and those which have not (PECO St. 15B, pp. 11-12). Dr. Hieronymus criticized the reliability of Mr. Komanoff's regression, as follows:

> "Other than a wage variable, which is not statistically significant, his model contains no variables which are causally related to capital additions costs. While some capital additions are due to new regulations, the largest ones are due to design problems which impact plant output, maintainability and safety. Neither age nor vintage -- his principal explanatory variables -- are good predictors of the effects of such problems though they may have been correlated in the historical data."

(PECO St. 15A, pp. 34-35). Thus, it is clear that Mr. Komanoff's regression equation, which poorly fits the data for older reactors, should not be relied upon when it predicts that a state-of-the-art nuclear reactor will repeatedly experience major repairs.

In view of the poor fit of Mr. Komanoff's regression, it is significant to note Mr. Chernick's skepticism as to the possibility of developing reasonable regression results for

capital additions:

> "Basically I've always been very pessimistic about the feasibility of doing a regression analysis which would be able to sort out the difference between variation due to causal factors such as those that I list on page 68 and just the fact that, unlike O&M where every year you put in more or less the same number of manhours of operations and certain kinds of standard maintenance, and if you refuel the plant you have some kind of standard requirements for services to do that job, for capital additions you may have year in which you add essentially nothing, and other years in which you have a major outage and you put a lot of new equipment in."

(Tr. 2917).

Mr. Komanoff's willingness to rely on a regression which considerably overstates even the historic averages to predict capital additions for Limerick 1 results in a forecast far larger than that supported by any other witness in this proceeding. The extent of this exaggeration, when compared to the other forecasts, is shown in Dr. Hieronymus' Exhibit WHH-37. This Exhibit, attached as Schedule D-2, demonstrates that by the year 2024, Mr. Komanoff's capital additions cost forecast is more than twice that of Mr. Chernick, and more than ten times greater than the Company's.

b. Mr. Komanoff's Forecast Exaggerates Historic Experience, Inaccurately Assumes That Limerick Will Require Repairs Equal In Magnitude To The Worst Performing Plants In His Data Base, And Erroneously Assumes That Limerick 1's Capital Additions Cost Trend With Age Will Surpass Historical Averages.

Comparison of Mr. Komanoff's forecast for Limerick 1 capital additions costs, on a year by year basis, with the cost for other reactors of corresponding age also shows the exaggeration in his forecast. This analysis, summarized in Dr. Hieronymus' Exhibit WHH-41, reveals that Mr. Komanoff expects Limerick 1's annual capital additions costs to far exceed the historic average of plants in his data base in each and every year (PECO St. 15A, Ex. WHH-41).

Mr. Komanoff responded to this demonstration by claiming that the average to which Dr. Hieronymus has compared OCA's projections is low because it includes plants that have cheaper expected costs than Limerick 1 due to their earlier vintage, cheaper wage, or single unit advantages (OCA St. 6A, pp. 7-8). Further, Mr. Komanoff claims that historical averages of more recent plants that share Limerick's later vintage show that his capital additions cost forecast is not inconsistent with the historical average cost (OCA St. 6A, pp. 8-9). Mr. Komanoff makes this latter point by dividing his data base into three groups of plants, and compares Limerick 1 to plants with commercial operation dates beginning in roughly 1976 and

thereafter (OCA St. 6A, pp. 9-10).

Although Mr. Komanoff attempts to shore up his capital additions cost regression by comparing it to historical data, his attempt to break down the historical data by group further exposes the weakness of his method. This method places Limerick 1 at the peak of costs for historic plants and then applies a trend for an aging effect which does not exist in the very group to which comparison of Limerick 1 Mr. Komanoff deems most appropriate. These serious flaws are summarized by Dr. Hieronymus:

> "The primary difference between his Groups 1 and 2 (the older reactors) and his Group 3 has far less to do with when the reactors were placed in service, per se, than it has to do with the year in which reactors reached a given age. It is uncontested that capital additions costs were far lower in the 1970's than in the 1980's. What is contested is whether the experience of the 1980's -- which is dominated by TMI retrofits, IGSCC repairs and steam generator retubing -- is more reflective of what can be expected for Limerick 1. Moreover, my primary dispute with Mr. Komanoff is not whether data for the 1980s should be the basis for the Limerick 1 forecast, it is whether one can validly draw a trend between the 1970s and 1980s and extrapolate growth in costs into the future.
>
> However, even were I to accept the notion that his Group 3 reactors are the appropriate comparable group, his forecast appears high. Exhibit WHH-54 shows Mr. Komanoff's Group 3 forecast and his Limerick 1 forecast. His forecast is still nearly 60 percent higher than the history for plants completed since 1976. Even more striking is the absence of his age trend in the Group 3 data, a trend which is his sole basis for forecasting future growth in Limerick capital additions. This

points up that perhaps the major factor responsible for the extreme results produced by his regression model is that it derives a high starting value based on plant vintage and then applies a high aging effect based on past trends for plants of older vintages which do not seem to be appropriate for more recent plants. (Emphasis added).

(PECO St. 15A, pp. 10-11). Therefore, it is clear not only that Mr. Komanoff's regression does not adequately explain the historical data, but also that it is contradicted by the same data on more recent plants which Mr. Komanoff contends support his Limerick 1 forecast.

Since the age trend is not apparent for plants of relatively recent vintage, his forecast's assumption of increasing cost trends is completely unjustified. For these reasons, Mr. Komanoff's forecast must be rejected. Furthermore, his Group 3 data includes a number of plants which are not comparable to Limerick 1 because of their much earlier design dates and the fact that they are PWRs (PECO St. 5C, pp. 1-2).

2. Mr. Chernick's Capital Additions Cost Forecast Also Suffers From Blind Reliance On Historical Data.

Mr. Chernick also presents a capital additions cost forecast in this case, although it is considerably lower than the regression-based forecast sponsored by Mr. Komanoff. However, Mr. Chernick's forecast nevertheless suffers from some of the same problems discussed with respect to Mr. Komanoff's forecast. Mr. Chernick bases his forecast on the average capital

additions experience for large units in recent years, 1980-84. He derives a base year average of $28/kW (1983 dollars) and then escalates this figure at the 1.4% annual escalation rate of the regional nuclear Handy-Whitman index over the 1970 to 1983 period. While this attempt to base his forecast on recent experience is more appropriate than Mr. Komanoff's extrapolation, it nevertheless suffers from two important errors.

Mr. Chernick Ignores The Fact That The Historic Averages In The 1980-84 Period Relied Upon Are Distorted By A Small Number of Expensive Repairs.

First, like the forecast of Mr. Komanoff, Mr. Chernick's capital additions cost forecast ignores the fact that the "average experience" of nuclear units in the 1980-84 period is skewed by a small number of substantial repairs. Dr. Hieronymus illustrates the impact of these particular repairs on Mr. Chernick's forecast, and shows that Mr. Chernick's forecast results in a large discrepancy between the historical median in each year for typical expenditures and Mr. Chernick's average annual expenditure for stations with units greater than 800 MW (PECO St. 5A, pp. 32-33).

Dr. Hieronymus summarizes this criticism of Mr. Chernick in the following two passages:

> "The fact that these 55 datapoints contain 11 major repair years means that implicit in the use of the recent historic average is the presumption that Limerick 1 will require significant and relatively frequent retrofits

to correct design problems. I am not aware of any basis for that presumption and none is given by Mr. Chernick." (Emphasis added).

(PECO St. No. 15A, p. 33).

"Mr. Chernick's use of recent average expenditures implies either that Limerick will have the same problems as older plants or that, despite the extensive operating history of nuclear plants, as yet unforeseen design problems will develop. His real cost escalation forecasts are clearly without a valid foundation. If PECO's expectation concerning the quality of Limerick's design is correct, Mr. Chernick's capital additions forecast is likely to be overstated by a factor of 2 to 3." (Emphasis added).

(PECO St. No. 15A, p. 34).

b. Mr. Chernick Applies An Erroneous Escalation Rate To Project Limerick 1's Capital Additions Costs.

Dr. Hieronymus' second criticism of Mr. Chernick's forecast is that it contains a simple, but important methodological error. Dr. Hieronymus asserts that Mr. Chernick's use of the 1970-83 real escalation rate of 1.4%, based on the Handy-Whitman index, to forecast the future escalation rate was not appropriate (PECO St. 15A, p. 33). This is because the 1.4% real escalation derived from 1970-83 is determined almost soley by large increases in the early 1970s when the nuclear industry was expanding rapidly, resulting in an escalation rate reported in the Handy Whitman index of 3.6% annually in real terms. However, the escalation rate since 1976, after which the pace of nuclear plant construction fell off sharply, has been only 0.3%

per year in real terms (Id.). In view of the poor prospects for repeating the growth in the nuclear construction industry experienced in the early 1970s, it is clearly more appropriate to expect that the more recent 1976-85 escalation rate will apply to future capital additions. Mr. Chernick apparently does not dispute this point, since he does not discuss it in his surrebuttal testimony (PAIEUG St. 1A).

In view of his use of an erroneous escalation rate, and in view of the larger problem presented by Mr. Chernick's failure to temper his forecast to account both for Limerick 1's specific design and the low likelihood of Limerick 1's needing repairs to the extent experienced by the plants in his database, Mr. Chernick's forecast should be rejected.

C. Limerick 1's Capacity Factor Forecasts.

Messrs. Komanoff and Chernick claim that the Company's capacity factor projection of 65% is overly optimistic (OCA St. 6, p. 23; UUC/UP St. 1, p. 55). It is important to note at the outset, however, that each witness has placed 65% capacity factor performance within a reasonable band of their own projections for Limerick 1 (Tr. 2875-76; UUC/UP St. No. 1, p. 57).

Though it is not in dispute that the Company's projected average capacity factor exceeds the historical average, the issue is whether the Limerick 1 capacity factor will exceed the historical average. Whether this can be achieved depends on

whether, and to what extent, the regulatory environment stabilizes and whether Limerick 1 will be less vulnerable to prolonged repair outages than the historical average (PECO St. 15A, pp. 37-38). The witnesses in this proceeding have stated various views as to the probability that these events will, in fact, occur. GEC witness Wilson has stated the following in this regard:

> "The 65 percent capacity factor that I have suggested as a minimum operating standard is reasonable. While it is true that in recent years the national average has been slightly below that level, these averages understate the level of performance that should reasonably be expected in the future. That is so because the recent averages contain major post-TMI outages that were required to modify plants to meet new safety standards. Those outages should not be expected to continue in the future and they should not be required for new plants, like Limerick, that have been built to modern specifications. Even PECO witness Hieronymus acknowledged that, except for the TVA units which were all taken off line in 1985 due to internal TVA management problems, the 1985 average capacity factor for all nuclear plants was 65 percent -- and that includes plants that were inoperative for extended periods because of major repair and retrofit requirements." (Emphasis added).

(GEC St. 1D, p. 4).

Mr. Komanoff has expressed a similar belief that improvements in Limerick 1's design and a more stable regulatory environment will combine to some extent to allow the unit to improve upon the historically-based capacity factors by 6-10% percentage points (see OCA St. 6, p. 23). Mr. Komanoff explains

the basis for his judgment as follows:

> "Statistical analysis should be open to informed judgment as to differences to be expected between future and past performance. Based on my reading of factors affecting nuclear plant performance, I noted two phenomena which, though not yet statistically observable, I considered reasonably likely to emerge in the future....
>
> First I believe that much of the almost 10 percentage point drop in BWR capacity factors since TMI reflects containment backfitting and pipe repairs which will not recur to the same extent. Second, I concluded that it was reasonable, if slightly optimistic, to expect that newer units such as Limerick 2 will show some capacity factor gain from the investments committed to newer reactors to improve their performance." (Emphasis added).

(OCA St. 6, pp. 25-26).

Mr. Chernick relies on historical data alone to project Limerick 1's future capacity factor. Thus, while he states that achieving PECO's projected capacity factor is not "completely inconceivable", he generally parts company with the judgment of the rest of the witnesses in this proceeding that Limerick 1's prospects for an improved capacity factor are, to a greater or lesser degree, within reasonable reach (UUC/UP St. I, p. 55).

1. 1985 Data Shows That Mr. Komanoff's Forecast Inaccurately Relies On An Age Variable And Thereby Understates Limerick 1's Likely Capacity Factor By At Least 5%

Mr. Komanoff assumed an average 60% capacity factor in his analysis based on data through 1984 and then adjusting those

data upwards approximately 6-10% for design improvements and for the leveling of post-TMI regulatory involvement (OCA St. 6, pp. 23-24). Mr. Komanoff's "over 12" variable suggests that, based on "very limited data, BWR capacity factors dropped sharply--by almost 30-percentage points" (OCA St. 6A, p. 3). Dr. Hieronymus criticized Mr. Komanoff's "over-12" variable, which implied that after reaching age 12 the capacity factor of nuclear plants would generally begin a steady decline (PECO St. 15A, pp. 39-40). Mr. Komanoff himself has noted that the 1985 data showed that the performance of his "over 12" group had experienced a single year improvement of approximately 37 percentage points, an improvement of over 100% (OCA St. 6, p. 29; PECO Ex. 20). When Dr. Hieronymus added the 1985 data to Mr. Komanoff's model, the "over-12" variable loses significance and, despite the relatively poor 1985 performance of BWR's generally, causes a 5% increase in Mr. Komanoff's 20 year capacity factor forecast (PECO St. 15A, p. 39). Dr. Hieronymus concludes that the additional 5% capacity factor suggested by the 1985 data should be added to Mr. Komanoff's forecast, resulting in the same 65% forecast presented by the Company (PECO St. No. 15A, pp. 39-40).

Mr. Komanoff criticizes Dr. Hieronymus' upward adjustment of his 60% capacity factor for two reasons. First, Mr. Komanoff claims that Dr. Hieronymus has calculated his capacity factor as an arithmetic rather than as a levelized, present worth, average (OCA St. 6A, p. 3). Mr. Komanoff's second

criticism is that Dr. Hieronymus, after identifying that the "over-12" variable was no longer statistically significant, should have deleted it from Mr. Komanoff's model (OCA St. 6A, p. 5). Though Mr. Komanoff was unable, due to time constraints, to himself run his regression without the "over-12" variable, he ventured that if such a regression were run, "the trajectory of projected capacity factors would be flat with respect to age, rather than increasing as in Dr. Hieronymus' projections" (OCA St. No. 6A, p. 5).

Dr. Hieronymus easily disposes of each of Mr. Komanoff's criticisms. First, Dr. Hieronymus explains that capacity factors in themselves should not be levelized, but only the savings which are associated with whatever capacity factor level is achieved (PECO St. 15B, pp. 9-10). If savings per kWh are rising at the same rate as the discount rate, a percentage point of capacity factor should have the same effect on present value regardless of the year in which it occurs. However, if the capacity factors are levelized, this would not be the case. Therefore, it is incorrect to levelize capacity factors (Id.).

Dr. Hieronymus' response to Mr. Komanoff's second criticism is even more basic. Dr. Hieronymus runs Mr. Komanoff's regression without the "over-12" variable, as suggested by Mr. Komanoff (PECO St. 15B, p. 9). The results of the regression, including the 1985 data but excluding the "over-12" variable, are summarized in Exhibit WHH-54. The regression, run as Mr.

Komanoff himself recommends, raises Mr. Komanoff's forecast for the 20 year average capacity factor by 5% and the 39 year average capacity factor by approximately 7.5%. Thus, together with Mr. Komanoff's judgment that capacity factors should be upwardly adjusted in anticipation of improved nuclear performance and an easing of regulatory pressures, Mr. Komanoff's forecast appears to be in substantial agreement with the Company's 65% capacity factor projection.

2. Mr. Chernick's Forecast Of Limerick 1's Expected Capacity Factor Is Based On A Narrow View Of Historical Trends And His Regression Fits The Data Poorly.

Mr. Chernick forecasts capacity factors for Limerick 1 in its first five years of "49%, 41%, 45%, 60% and 52% (averaging 49%), and an average of 57% thereafter" (UUC/UP St. No. 1, pp. 59-60).

However, Mr. Chernick fails to take into account, as have other witnesses in this proceeding, reasonably expected improvements in historical capacity factors caused by a changing regulatory environment and Limerick 1's design improvements (PECO St. 15A, p. 37). Further, Mr. Chernick's capacity factor regression is characterized by both a broad confidence internal and poor explanatory power (PECO St. 15A, p. 38). Dr. Hieronymus reveals in his Exhibit WHH-43, attached as Schedule D-3, that Mr. Chernick's point forecast for the 1987 capacity factor was of 40.8%, and had a confidence interval of 10.0%-71.6%. The meaning

of this confidence interval is that while 40.8% is the model's best guess of the expected capacity factor, the uncertainty is so great that the model can only predict with 95% confidence that the capacity factor will turn out to be between 10% and 71.6%. Such a broad confidence interval means that the point estimate itself should not be accorded much weight. The weaknesses in Mr. Chernick's forecast, summarized in Exhibit WHH-43, demonstrate that Mr. Chernick's regression provides an unreliable basis for projection.

3. Mr. Chernick's Forecast Is Not Consistent With Recent Data For Capacity Factor Performance.

Mr. Chernick's projection of Limerick 1's capacity factor in the first five years of operation, based on data through 1984, is not consistent with the recent data on the actual historical performance of large new reactors (PECO St. 15A, pp. 38-39). Exhibit WHH-56 compares the capacity factors for plants in the post-TMI period with Mr. Chernick's forecasts for Limerick 1. The Exhibit, attached as Schedule D-4, shows, for example, that the average capacity factor in year 2 for the 12 recent plants examined was 58.2% compared to Mr. Chernick's Limerick 1 forecast of 41.1%. This Exhibit suggests that Mr. Chernick's projections are considerably understated. Because the regression relied upon in Mr. Chernick's capacity factor forecast is unreliable, because it is inconsistent with recent data, and because he fails to include

any reasonable allowance for improvement in future capacity factor performance attributable to Limerick 1's specific design features and a stabilized regulatory environment, his capacity factor forecast should be rejected.

D. Fossil Fuels Prices

The Company has calculated in its life cycle analysis the value of fossil fuels displaced by Limerick 1. For its oil price projection, the Company has taken its 1985 base price and assumed a real escalation rate of 3% (OCA St. 6, p. 30). The Company's coal price forecast is based on 1985 prices, and assumes a real escalation rate of 2% (PECO St. 32, Ex. PXE-2). The Company's assumptions are consistent with a realistic view of the cyclical nature of oil markets and a comprehensive review of the historical trends in relevant coal markets (PECO St. 37, p. 27; PECO St. 32, pp. 3-4).

Messrs. Komanoff and Chernick dispute the fossil fuel price escalation rates presented by the Company. In addition, Mr. Komanoff sponsors an alternative forecast for both coal and oil (PECO St. 6, pp. 30, 37). Mr. Komanoff's alternative projections, based on a short-sighted view of the forces at work in world oil markets, and an inappropriate use of historical data to forecast PECO's delivered coal prices, must be rejected.

Mr. Chernick offers only conjectural statements as to why coal prices are unimportant, and as to why the oil prices of

PECO's oil price consultant, Data Resources Inc. (DRI), should be considered to represent the forecasting consensus in the industry (UUC/UP St. 1, pp. 35, 38). Without any analysis, Mr. Chernick adopts OCA's fuels price forecast as his own, so his analysis stands or falls with the demonstrably precarious fuels prices described in the testimony of Mr. Komanoff. Because Mr. Chernick has no experience in fossil fuel price forecasting, or in the fossil fuel market (Tr. 2904-2905), and because his comments lack any basis in fact, his criticisms should be flatly rejected.

1. The Criticisms of PECO's Oil Price Forecasts Are Unrealistic And Are Not Based on Proper Market Analysis.

Mr. Komanoff suggests that, beginning with PECO's 1985 base oil prices, the real escalation rate for oil will be negative 1% through 1990, positive 1% through 2000, and 3% thereafter (OCA St. 6, p. 30). Mr. Komanoff criticizes the Company's expected oil price escalation rates, noting that they exceed those forecast by DRI (Id., pp. 30-31). Consistent with his low oil price forecast, Mr. Komanoff asserts that while oil prices will fluctuate, they "will not undergo concerted escalation until at least until the turn of the century, due to abundant worldwide supplies" (Id., p. 32). Mr. Komanoff further recognizes that "[a]lthough actual [oil] prices will be more volatile than the particular neat pattern [he assumes in his oil price forecast], the specific timing and

magnitude of price savings aren't vital to calculating the benefits of Limerick 1" (Id., p. 37). Mr. Komanoff justifies his oil price projections on the basis that the "psychology of world oil markets has undergone profound changes in the past several years" (Id., p. 38).

To further justify his oil price projection, Mr. Komanoff notes that the forecast of DRI, a consultant hired by PECO, is more consistent with his own forecast than with PECO's and that DRI anticipates "significantly lower" future oil prices than PECO (Id. p. 40). His implicit assumption in including this discussion appears to be either that DRI's forecast is more reasonable than PECO's, or that for PECO to forecast higher oil prices than that foreseen by its consultant is in itself unjustified. Mr. Chernick makes the same argument, and explicitly states that "we must assume that the DRI forecast represents the consensus in the industry, at least before the current downturn in prices" (UUC/UP St. No. 1 p. 23).

a. Mr. Komanoff's Forecast Depends On An Unrealistic Expectation That Demonstrated Historical Cycles Affecting Oil Markets Will Not Be Repeated in the Future.

Company witness Hogan disagrees with Mr. Komanoff's assessment of the forces at work in the world oil market. Dr. Hogan, who has considerable background in oil price forecasting with the Department of the Interior, the Federal Energy Administration, and as one of the principle authors of the widely

respected "Harvard Oil Market Simulation" (HOMS) model, concludes that the oil price forecasts presented by the Company in this proceeding are more realistic than those presented by Mr. Komanoff (PECO St. 37, p. 20). Dr. Hogan generally described the considerations that bear on oil prices follows:

> "The first point is that the oil market is volatile, so that prices at any point in time are highly unpredictable. The second point is that the forces which link supply, demand, and price in the oil market are delayed in their operation, so that today's market conditions are a function of conditions months and even years earlier. Similarly, the effects of conditions today will be felt months and years into the future. The third point is that it is easy to concentrate on current market weakness and assume that it will continue indefinitely, whereas in fact pressures are now accumulating that will tighten the market sooner than most people realize. Lower prices will depress production, stimulate demand, and lead to a new cycle of rising prices. My best estimate is that in 1986-87 we are moving through the bottom of the current cycle. The deeper the bottom, the faster the rebound on the other side. This will of course be followed by another cycle of falling demand and falling prices. Given the concentration and instability of the sources of oil supply, I see no reason for these cyclical patterns, which we have observed in the oil market since 1973, not to continue indefinitely."

(PECO St. 37, p. 27).

Dr. Hogan concludes that Mr. Komanoff fails to adequately account for these factors, and summarizes his criticism of Mr. Komanoff as follows:

> "I believe that Mr. Komanoff fails to appreciate the

strength of the forces which declining oil prices have set in motion. He therefore underestimates the speed with which the declining trend will be reversed. The reversal he sees "before the end of the century" will, in my view, more likely begin before the end of this decade (OCA St. 6 at 39)."

(PECO St. No. 37, p. 20).

Dr. Hogan goes on to explain that the same forces which have caused oil price declines will, in turn, trigger sharp upward pressures on oil prices. First, he notes that the non-OPEC sources of oil production, including those that Mr. Komanoff identifies as having been developed in response to higher prices, have begun a steady decline (PECO St. No. 37, p. 20). Dr. Hogan describes how this trend of declining production will accelerate in response to the recent price drop. Further, falling prices will increase demand for oil, especially outside the U.S. where, until recently, prices continued to rise due to depreciation of local currencies against the dollar (PECO St. No. 37, p. 21). This will exert upward pressure on oil prices, resulting in higher prices in the near future.

Finally, Dr. Hogan describes how rising oil demand and a decrease in non-OPEC supply will increase OPEC's capacity utilization, and how increasing utilization has empirically been related to rising prices (PECO St. No. 37, p. 22). The importance of OPEC's capacity utilization as a predictor of the oil price trend has been confirmed by the U. S. Energy Information Administration (EIA), which uses this relationship in

its Oil Market Simulation Model, a precursor of the model which Dr. Hogan has employed in this proceeding. Both the EIA and the Hogan model (HOMS) correlate the level of OPEC capacity utilization with price increases (Id., pp. 22-23). The HOMS model, recognizing the uncertainty inherent in oil forecasting, generates probability distributions of oil price forecasts rather than point estimates because this provides an explicit means of accounting for the imponderables in the oil market (Id., p. 20, 23).

Dr. Hogan concludes that the HOMS model ascribes a considerably lower probability to the forecast of Mr. Komanoff than to the forecast of Mr. English (PECO St. 37, p. 27). For 1987, for example, there is a 78% probability that Mr. Komanoff's forecast is too low, while only a 35% chance that Mr. English's forecast is too high (Id.). For 1990, the HOMS model demonstrates a 98% probability that Mr. Komanoff's forecast is too low, and only a 10% probability that PECO's forecast is too high. Thus, it is clear that Mr. Komanoff's forecast is very precarious.

The Company's forecast and Mr. Komanoff's forecast are compared with the forecast calculated in the HOMS model in Dr. Hogan's Exhibit WWH-4. As this Exhibit clearly demonstrates, the probability that Mr. English's forecast for PECO is accurate is considerably higher than the probability that Mr. Komanoff's forecast is accurate. Thus, the Company's clearly reasonable

forecast should be accepted. To rely on Mr. Komanoff's and Mr. Chernick's forecasts would be falling prey to the common mistake of adopting the myopic projections of "so-called" energy analysts who simply extrapolate future market developments from recent price movements (PECO St. 37A, Ex. WWH-6).

b. Mr. Komanoff's Ineffectual Response To PECO's Criticisms Demonstrates The Legitimacy Of Dr. Hogan's And Mr. English's Testimonies.

In his surrebuttal testimony, Mr. Komanoff accepts Dr. Hogan's proposition that "lower oil prices may set the stage for higher prices in the future," but raises two arguments in defense of his own forecast (OCA St. 6A, p. 17). First, Mr. Komanoff argues that, because prices have fallen recently, the offset in fuel savings to PECO from future higher prices is "likely to be only partial, due to the time value of money" (Id.). Second, Mr. Komanoff suggests that Dr. Hogan's HOMS model is equally sensitive to decreases and increases in oil prices. Mr. Komanoff asserts that long-term capital investments made in response to earlier high oil prices result in diminished sensitivity to lower oil prices (Id., pp. 18-19).

Dr. Hogan responds to Mr. Komanoff's first point by noting that, in light of OPEC's recent behavior and recent falling prices, the HOMS model anticipates that prices are likely to rebound strongly in the near future:

> "Given the record of the past where [OPEC has] been able to constrain production remarkably, far better than anyone ever predicted early on, I think that the most likely case is that they will reassert control over that market and raise prices. I don't think that they will raise them to $30 a barrel in 1986, but they could certainly go back up into the $20 range.
>
> In any event, the lower prices are going to stimulate a response, higher demand, lower production elsewhere -- and we see it all around us -- and that creates the seeds for future increases that I think are the essence of the story in this model."

(Tr. 4399). Consistent with this analysis, Dr. Hogan states that any further decline in price "would stimulate a faster recovery in demand and a sharper response in the price cycle" (PECO St. 37, p. 26).

Further, Dr. Hogan notes that the range of oil prices predicted by the HOMS model is consistent with two recently issued reports, the first sponsored by the Synthetic Fuels Corporation, and the second sponsored by the International Energy Workshop of Standford University (PECO St. 37 A, pp. 17-18). Confirmation of Dr. Hogan's HOMS model by these two authoritative reports supports his forecast that future oil prices will rebound and that Mr. Komanoff's forecast substantially underpredicts likely future oil prices.

In addition, Mr. English testified that, in his experience, the oil market will rebound quickly and that PECO's forecasts will be substantially accurate as early as 1987:

> "If this thing follows the normal procedure we will see an upkick that will be significant as the world market, perhaps with OPEC emphasizing the fact they have made their point and they have driven the price down and are flooding it, and they will have more control over the marketplace. So what I think we will see happen is more control will come back into the world market which will bring us back to about where we were by the late '80s. It could be '87; it would certainly be '88, I would think, the '88-'89 period."

(Tr. 4361). Thus, for several reasons, no long term significance can attach to the fact that oil prices are currently below those assumed by the Company for 1986. First, the cyclical upturn in response to the recent drop expected by both Dr. Hogan and Mr. English could bring oil prices back in line with PECO's oil price forecasts as early as 1987. Second, to the extent that the recovery in oil prices mirrors the recent drop, the expected oil price increase could far outstrip in present value the "under forecast" for 1986. Indeed, the low probability of Mr. Komanoff's projection of persistently low oil prices for the next ten years suggests that the present dollar value of the likely turnaround in oil prices could more than offset the temporary short-run situation of low oil prices. Indeed, by arguing the significance of the present value consequences of near-term prices, Mr. Komanoff blatantly contradicts his earlier-stated position that "the specific timing and magnitude of price savings aren't vital to calculating the benefits of Limerick 1" (OCA St. 6, p. 38).

Dr. Hogan responds to Mr. Komanoff's second "criticism", which was based on Dr. Hogan's own paper, by noting that Mr. Komanoff misinterpreted the HOMS model (PECO St. 37A, pp. 18-19). The HOMS model differentiates between the demand for oil consumption generated by existing capital stock and the demand generated by future investment in oil-consuming capital stock. Because the HOMS model is designed to measure the responsivity of new capital investment to price elasticities, and the slow adjustment of the inventory of oil-consuming capital stock to market conditions, the HOMS model does, in fact, account for Mr. Komanoff's concern (Id.). Thus, the HOMS model predicts a range of likely oil prices considerably above that predicted by Mr. Komanoff even after taking into account the slow adjustment of demand to price changes that drives future oil market trends.

Because this is the only substantive criticism that Mr. Komanoff offers to the results of the HOMS model, and Mr. Hogan has conclusively responded, it is clear that no credence should be given to Mr. Komanoff's overly optimistic oil price forecast. The HOMS model clearly validates the reasonableness of PECO's forecast, and PECO's forecast should be adopted in this proceeding.

c. Mr. Komanoff's Alternative Coal Price Forecast Relies On Misleading Historical Trends and Supply Sources Not Relevant To Forecasting Price Trends In PECO's Actual Supply Area.

The Company projects that, beginning with PECO's 1985 base coal price of $45.50, coal prices will escalate at an annual rate of 2% (PECO St. No. 32, Exhibit PXE-2). Mr. Komanoff claims that the Company has not provided adequate justification for the coal price escalation rate assumed in its life cycle analysis and advances his own coal price escalation rate of zero escalation through 1990, 0.5% annual escalation through 2000, and 1% annual escalation thereafter (OCA St. 6, p. 30). Mr. Komanoff claims that his forecast rests on two premises: first, that "coal prices will be determined primarily by costs, rather than by market power or price manipulation," and second, that technological improvements will "roughly offset" increased environmental, health and safety regulations, and real increases in coal mining wages. (OCA St. 6, pp. 32-33).

Mr. Komanoff supports his view by referencing the national average of delivered coal from 1950 to 1984, noting an average real increase of 0.7% annually. Further, he notes that during the 1975-84 period, the average delivered price of coal declined in the Commonwealth of Pennsylvania by a real average of 0.7% annually. He attributes Pennsylvania's declining coal prices to increased productivity. Mr. Komanoff notes, finally, that over the 1986-2005 period, DRI's coal price forecast exceeds

Mr. Komanoff's by an average of 6% (OCA St. 6, pp. 35-36).

Both Mr. English and Dr. Hieronymus refute the assumptions upon which Mr. Komanoff's alternative forecast is based. In addition, Dr. Hieronymus demonstrates that Mr. Komanoff's selective use of data and inappropriate assumptions as to PECO-specific considerations result in a misleading picture of the trends likely to affect PECO's coal costs (PECO St. 15A, pp. 41-45).

Mr. English explains that PECO's forecast is based on first-hand contact with vendors in the narrow coal supply area from which PECO procures its coal. He then identifies the factors that affect the rate of delivered coal prices to PECO:

(a) the supply-demand balance;

(b) the depletion of reserves;

(c) mining industry productivity gains or declines;

(d) the timing and mix of contract and spot purchases; and

(e) railroad freight rates.

(PECO St. 32, p. 4).

As to the first factor, Mr. English focuses attention on PECO's particular supply area, rather than on the general national data utilized by Mr. Komanoff. Mr. English explains that although the supply-demand balance in PECO's supply area, Northern Appalachia, has resulted in a depressed market in 1984 and 1985, past experience and current conditions indicate an

upswing in price:

> "Based on my long experience working with the coal industry, however, the depressed coal market will not continue. Without price increases, large numbers of coal producers will be forced to curtail production or shut down. As a result, the market in the areas which produce coal to PECO (i.e. northern West Virginia and western Pennsylvania) should proceed towards equilibrium through the later 1980's. This trend toward market equilibrium will result in a real escalation of mine-mouth prices between 1985 and 1990 well in excess of the zero percent real escalation assumed by Mr. Komanoff."

(Id., p. 5). Mr. English also noted, in this regard, that PECO's expected escalation rate was supported by GEC witness Stauffer in the Limerick Unit No. 2 Investigation. Mr. Stauffer testified in that proceeding that the real escalation rate for coal prices from Northern Appalachia would be at least 3.7% per year between 1985 and 1990 (PECO St. 32, Ex. PXE-3).

Mr. English further refuted Mr. Komanoff's suggestion that the "coal resource base will deplete so gradually as to exert only a very small pull on prices" (OCA St. No. 6, pp. 32-33). Mr. English again focuses on the PECO-specific supply area in explaining why Mr. Komanoff's arguments are not applicable. Mr. English explained that the increased productivity trend will not continue to the extent assumed by Mr. Komanoff in his forecast (PECO St. 32, pp. 6-7).

Mr. English further explains that the absence of rail transportation competition in PECO's coal plant area, together with the failure of federal legislation to protect captive

shippers and the uncertainty surrounding Conrail's status, all threaten to drive PECO's transportation costs still further (PECO St. 32, pp. 8-9). Historically, transportation cost increases have paralleled the 2% average real annual increase that PECO projects in its life cycle analysis for its coal transportation cost (PECO St. 15A, Ex. 51).

Dr. Hieronymus criticizes Mr. Komanoff for his misreading of, or selective attention to, historic data in forecasting an exaggeratedly low coal price escalation rate. Specifically, Dr. Hieronymus emphasizes that the national data relied upon by Mr. Komanoff "cannot be used to predict future prices to PECO's coal plants" (PECO St. 15A, p. 41). By using national data to support his forecast, Mr. Komanoff neglects two important factors impacting the price of coal to PECO:

1) The fact that the Btu content of coal used by electric utilities has decreased by 18% over the past 30 years, and the average national delivered price per million Btu of coal of this kind has increased at 1.5% annually in real terms.

2) Regional distribution of coal production has changed dramatically since 1950, including a decline in production originating in Appalachia where PECO buys its coal, from 74% to 49% of the national total.

(See PECO St. 15A, pp. 41-42). Therefore, the use of national data over this period for projecting future coal prices from a particular region to a particular utility is inappropriate.

Dr. Hieronymus explains that the FOB mine-mouth prices from PECO's supply districts are the more appropriate historical

data to determine PECO's future coal costs. Such price data for all the years for which data is available, namely 1953 to 1984, show that prices in the districts that supply coal to PECO have increased at a real annual rate of between 1.5% and 1.9% over this period (PECO St. 15A, p. 42, Ex. WHH-46). The use of this data is justified not only because it more specifically reflects conditions in PECO's supply area, but also because the 1953-1984 time frame, which is conservative since it both begins and ends with glutted markets, provides a more appropriate measure by which to project future coal price trends (PECO St. 15A, p. 43).

Dr. Hieronymus also demonstrates that Mr. Komanoff's selection of the 1975-1984 coal prices for Pennsylvania utilities, the 1976-1983 data for coal delivered to PECO's plants, and the 1977-1984 data for coal productivity presents a distorted picture of actual trends (PECO St. 15A, p. 43). For example, had Mr. Komanoff measured the growth rate of coal prices over the 1972 to 1984 period, as shown in Dr. Hieronymus' Exhibits WHH-47, WHH-48 and WHH-49, his results would have shown an escalation rate far in excess of the 2% real increase rate PECO is projecting. While Dr. Hieronymus does not advocate use of the escalation rates shown in these Exhibits, it is clear that Mr. Komanoff has seriously biased his forecast by choosing a cycle beginning with a peak market period and ending with a glutted market period to measure the applicable historic escalation rate (PECO St. 15A, p. 44).

Mr. Komanoff's Response Focuses On Considerations Not Relevant To PECO's Actual Coal Costs And Fails To Respond To The Company's Criticisms Concerning His Inappropriate Use Of National Data.

Mr. Komanoff responds to only three of the above criticisms. First, he argues that in criticizing him for failing to account for the dramatic change in Btu content, Dr. Hieronymus should have adjusted for changes in sulfur content over the same period (OCA St. 6A, p. 15). It should be noted that Mr. Komanoff's response acknowledges the legitimacy of Dr. Hieronymus' basic criticism, and thus the likelihood that Mr. Komanoff has understated the historic escalation of coal rates.

Mr. Komanoff's counter-argument, however, is without force. Dr. Hieronymus observes that whatever validity Mr. Komanoff's concern might have on an analysis based on national data is essentially reduced by the fact that the coal price data summarized in Exhibit WHH-46, upon which Dr. Hieronymus' more PECO-specific historic coal price trend is based, is prepared on a district by district basis. Since coal sulfur contents are more homogenous within districts than among districts, Dr. Hieronymus' price trends adequately reflect differences related to sulfur contents (PECO St. 15B, pp. 12-13).

Mr. Komanoff's second point is that recent trends toward increased competition due to deregulation in the trucking and air travel industries "will inevitably reach railroads as well" (OCA St. 6A, pp. 15-16). Dr. Hieronymus refutes this criticism by

noting that as a result of recent mergers in the rail industry, the primary means of transporting coal, the actual trend is toward less competition (PECO St. 15B, p. 13). Thus, the increase in competition in the air and trucking industries will not affect the costs of coal delivery. Moreover, in view of Mr. English's description of the captive status of a number of PECO's plants, it is highly unlikely that PECO will receive the benefits of increased competition (PECO St. 32, p.8). Also, as discussed earlier, historical data over last three decades supports PECO's use of 2% real annual escalation in transportation costs.

Finally, Mr. Komanoff claims that "the spectre of 'great' or 'sizeable' increases in mining costs conveyed to Mr. English by producers" is overstated since from 1983 to 1984 "the demonstrated coal reserve base declined by only 0.5% in both Pennsylvania and West Virginia" (OCA St. 6A, p. 16). It is clear, however, that Mr. English's discussion of sizeable increases in mining costs was directed at the causal relationship between deep mine costs and strip mine costs. Mr. Komanoff's aggregate data on the coal reserve base does not address the factors affecting strip mining costs. Since the prices of deep mined coal can be expected to follow increased prices in the strip mining industry, where reserves have been depleted, coal costs generally will rise (PECO St. 32, p. 6).

2. Mr. Komanoff's And Mr. Chernick's Reliance On The Role of DRI In PECO's Forecasting And Its Importance In This Proceeding Are Of No Significance.

Finally, Mr. Komanoff's and Mr. Chernick's discussion of the role of DRI in PECO's fossil fuel price forecasting is addressed by Mr. English. Mr. English clearly describes that DRI is only one of many sources that PECO uses in formulating its oil and coal price forecasts (PECO St. 32, pp. 10-11). Indeed, DRI's forecasts have not been analyzed nor are they relevant for these proceedings. Mr. English testifies that because the oil and coal markets are constantly shifting, PECO relies most heavily on its first-hand contacts with suppliers (PECO St. 32, pp. 3-4, 10). PECO's primary reliance on these contacts is realistic because this enables PECO to account for the conditions most likely to affect their actual costs (PECO St. 32, pp. 3-4). Also, as shown with respect to Mr. Komanoff's coal forecast, studies of national data are generally inappropriate in PECO's determination of the future prices it can expect in the localized areas from which it purchases coal.

Moreover, the suggestion that any significance should attach to the fact that DRI has predicted lower oil prices than PECO is rather anomalous since Mr. Chernick himself has noted that DRI's oil price projections have not proven accurate over time (Tr. 2905). Furthermore, as noted by Company witness English, DRI recently discontinued its quarterly forecasts due to

oil market disarray (Tr. 4359). Therefore, because DRI's forecasts have been shown to be highly uncertain, and because PECO does not place primary reliance on DRI in developing its fossil fuel price forecasts, DRI's forecasts should be disregarded for purposes of this proceeding.

E. Capacity Availability From Outside of PJM

Dr. Hieronymus included a range of estimates of Limerick 1's benefit in his base case life cycle analysis from $2.0 to $2.8 billion (PECO St. 15, pp. 56-57). He stated that the level of Limerick 1's net benefits that will actually occur will depend, in part, on whether three important contingencies are realized: 1) the imposition of acid rain legislation in response to growing environmental concern; 2) the cancellation of ECAR units currently under construction which are otherwise projected to be available, or 3) the growth in ECAR loads at levels above those which are currently expected (Id.). If any of these three contingencies occur, the likely capacity availability from ECAR will dissipate and the actual net benefit of Limerick 1 would more likely fall at the high end of the $2.0 to $2.8 billion predicted range (PECO St. 15, p. 56).

Mr. Komanoff claims that PECO did not support its assumption that two-party purchases would be eliminated after 1993 (OCA St. 6, pp. 9-10). The basis of his criticism is his cursory review of a 1985 NERC report showing a 37% 1984 summer

reserve margin for ECAR. As summarized by Mr. Komanoff:

> "...The 1985 appraisal of future supply and demand by NERC (North American Electric Reliability Council) foresees adequate supplies for ECAR through 1994 (the last year to which NERC forecasts extend). If peak demands in ECAR appear likely to be met with little difficulty at least through 1994, then economy energy should also be available, particularly in view of the relatively high percentage of baseload capacity (primarily coal-fired) in ECAR capacity mix."

(OCA St. 6, p. 10).

Mr. Komanoff then proceeds to quantify what he expects would be the impact on the results of his life cycle analysis if PECO continues indefinitely at its current level of two-party purchases. This calculation accounts for $1.2 billion of the $3.2 billion net cost predicted in Mr. Komanoff's "high case" for Limerick 1 over its 39 year life (OCA St. No. 6, pp. 10-11). Dr. Hieronymus answers Mr. Komanoff's concern by detailing the reasoning for his assumed reduction in two-party purchases. His analysis was based on an ECAR/MAAC Coordinating Group study prepared in June 1985 for the U. S. Department of Energy. Dr. Hieronymus details the specifics of his calculation in the following testimony:

> "A. ...In our life cycle analysis, it was assumed that 2,300 MW of ECAR capacity was available to PJM, all of which was low variable cost baseload capacity. The availability rate for this capacity was assumed to be 75 percent. However, since no forced outages were assumed, this was equivalent to 1725 MW at 100 percent availability. That is, it was assumed to be available year round at prices designed to

assure it would be dispatched. My understanding is that this estimate of availability is consistent with recent experience? the referenced report states that MAAC imports from Western systems ranged from 1,300 to 3,900 MW in 1984; 70 percent of the time imports were between 1,650 and 2,950 MW.

Between 1986 and 1994, ECAR loads are forecasted to grow significantly faster than capacity. Appendix B of the referenced report indicates that ECAR currently has surplus of economic capacity (coal, nuclear, and hydro) of 8,131 MW at the time of summer peak, 7,409 MW at winter peak, and 8,338 MW at the average spring and fall peaks. By 1994, this surplus is anticipated to decline to 2,650 MW, 696 MW, and 3,372 MW, respectively. Thus, depending on the season, between 60 and 93 percent of the current surplus will be eliminated.

Q. Do these figures indicate the amount of power available to PJM?

A. No. They represent the total ECAR surplus. PJM would have to complete with other systems, several of which are projected to be shorter in baseload capacity than PJM.

Q. Based on these numbers, how did you decide that a decrease of availability of of economic capacity from ECAR of 50 to 100 percent was reasonable?

A. Obviously, inview of the 60 to 93 percent decrease in on-peak availability of economic power from current levels, a significant decrease was called for. In reality, this decrease would be gradual, with on-peak availability reduced beginning around 1990 and off-peak availability declining somewhat later. A 50 percent decline in 1994 (with continuing availability of the remaining amount through the life of Limerick 1) is a quite conservative estimate of the effect.

The 100 percent reduction case was motivated by the warning in the referenced report that any one of several circumstances would completely eliminate the surplus by

1994. An increase in ECAR load growth of but 0.5 percent per year above 1985 forecasts would wipe out the surplus of on-peak economic interchange power during all seasons. A decline in the availability rate of baseload capacity from the 75 percent used in the study to the 70 percent level experienced in the late 1970s would also eliminate all of the surplus. Acid rain legislation would so reduce the capacity in ECAR as to turn it into a net importer. Finally, the report assumes that all capacity projected for completion by 1994 will in fact be completed. Any cancellations would further reduce export capacity." (Emphasis added).

(PECO Stmt. 15A, pp. 26-28).

Dr. Hieronymus' carefully documented analysis in support of his assumptions fully answers to Mr. Komanoff's concern. Mr. Komanoff, by contrast, has acknowledged on cross-examination that the extent of his analysis was the above-quoted language that ECAR would itself have "adequate supply" in 1994:

"Q. Have you done any independent analysis as to the availability of power from the ECAR system in the next 10 to 15 year time period?

A. The analysis that I've done on that is essentially what I have described on pages nine and ten and my response to, I believe, the one interrogatory that was proffered to me on this question.

Q. In other words, you're basically relying on the NERC appraisal that there will be, quote, an adequate supply, unquote, from ECAR through 1994?

A. I am relying on that, and that appraisal doesn't come as a surprise to me. I'm not intimately familiar with every capacity and load variable for each member of ECAR but I have a general familiarity with capacity availability and load growth in the upper Midwest and it certainly didn't surprise [me]

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that ECAR concluded that there should be adequate supplies -- I'm sorry -- that NERC concluded that ECAR should have adequate supplies at least through 1994, which is the end of NERC's forecasting horizon.

Q. Right. But you haven't conducted any independent analysis as to that availability?

A. You're correct.

Q. Did you consult any other sources other than the NERC to support your conclusion as to power availability beyond the year 1994?

A. No.

(Tr. 2838-39).

Mr. Komanoff's obivously limited analysis of the reasonably-anticipated conditions affecting the availability of capacity outside of PJM should be dismissed as without proper foundation. Dr. Hieronymus' analysis is carefully documented and Mr. Komanoff's casual claim that capacity outside of PJM will be available should be dismissed as without proper foundation. Further, Dr. Hieronymus' justification for his assumption is well reasoned, and Mr. Komanoff offered no response to that discussion in his surrebuttal testimony. Therefore, Dr. Hieronymus' assumptions as to a decrease in available capacity outside of PJM beginning in 1994, and the corresponding benefit resulting to PECO from Limerick 1's operation resulting to PECO, should be accepted.

F. Avoided Capacity Payments

Dr. Hieronymus determined as part of his life cycle analysis that if Limerick 1 had not been built, replacing its energy generation would require that PECO pursue prolonged and substantial purchases of power from the PJM Interconnection. Because under the express terms of the PJM Interconnection Agreement PJM members are presumed to be self-reliant, except for intermittent purchases and shortages, Dr. Hieronymus assumed that PJM would exact an additional charge from companies which deliberately violated the intent of the Agreement (PECO St. 15A, pp. 23-24). This assumption is plainly reasonable because any organization must insist that its members abide by its rules and regulations or suffer sanctions for non-cooperation. Thus Dr. Hieronymus' life cycle analysis includes two alternative scenarios which were intended to illustrate the dollar impact of likely higher capacity charges, one in which the PJM capacity charge was increased by 50 percent and another in which the charge was increased by 100 percent. These alternative cases raised the $2.0 to $2.8 billion base case net present value benefit of Limerick 1 by $0.6 to $1.2 billion (PECO St. 15, p. 57).

Witnesses Komanoff, Chernick and Lanzalotta all contest the validity of assuming higher capacity charges (OCA St. 6, pp. 41-45; UUC/UP St. 1, p. 12; Staff St. 5, p. 23). These witnesses share three basic criticisms. First, they contend that

Dr. Hieronymus' presumption of capacity charges in excess of PJM's current formula is speculative. Second, they assume that if PJM changed its current price for capacity charges to a level above the cost of a peaker, then PECO or any other PJM member could avoid the charge by purchasing CT's (UUC/UP St. 1, pp. 14-15). Third, they assume that in the absence of Limerick 1, PECO would not have retired various steam units and CT's. Mr. Chernick goes farthest in this regard, assuming 15 year life extensions of seven different steam units and the "unretiring" of 458 MW of leased CT's to the end of their original leases in order to meet the PJM capacity reserve requirement (UUC/UP St. 1, pp. 12-13). Mr. Komanoff and Mr. Lanzalotta likewise recommend that 458 MW of otherwise retired CT's be included in the life cycle analysis (OCA St. 6, p. 42).

1. Dr. Hieronymus' Assumption Of Increased Capacity Payment Charges Is Well Founded And Realistic.

Dr. Hieronymus' response to these criticisms falls into two general categories. First, he argues that PJM would not permit the artifice of purchasing CTs to evade the intent of Article 6.2 of the PJM Interconnection Agreement. The second general category concerns the question of how Limerick 1's value should be measured for purposes of a life cycle analysis.

Dr. Hieronymus readily admits that the specific nature of the capacity charge PJM would impose is uncertain, both

because Limerick 1 was in fact built, and because it is impossible to know for certain how PJM members would respond to PECO's deliberate violation of the terms of the PJM Agreement (PECO St. 15B, p. 17). Nevertheless, he contends that PJM would respond in some fashion to the opportunistic abuse of the interchange agreement to evade responsibility for building economic capacity. For PJM, the issue concerns whether PJM members are contributing their "fair share of baseload capacity needed for the future" (Id.). As concluded by Dr. Hieronymus, it would be necessary for PJM to induce its members to contribute baseload capacity to the system if its members all avoided capacity deficiency charges simply by purchasing peakers or retaining other uneconomic sources of generation (Id.). Yet this short-sighted course of action is precisely that recommended by the opposing parties, going so far as to recommend adding new CT's which are rarely ever run, to the PECO system (UUC/UP, St. 1, p. 15; see PECO St. 14, p. 8, discussing the rare use of PECO's peaker CT's). UUC/UP Witness Chernick has also recognized PJM's vulnerability to this problem:

> "Unfortunately, the PJM agreement does not reflect well the relative reliability value of various kinds of capacity, which varies with the size and maintenance requirements, as well as the forced outage rates of each unit, so a member utility may meet its capacity requirement without really providing its share of reliability support for the pool as a whole."

(UUC/UP St. 1, p. 11, fn. 3).

It is this concern that Dr. Hieronymus' presumed added capacity charge is reasonably addressed. A higher rate for chronically energy-short utilities would be required since the current split savings formula utilized by PJM is insufficient to compensate selling utilities for the cost of constructing new baseload and intermediate facilities to provide energy to the PJM system. Dr. Hieronymus explains this dual purpose for the increased PJM capacity charges as follows:

> "Given the manifest intent of the parties to the PJM Agreement that its members be self-supporting in terms of capacity, it is highly unlikely that had PECO embarked on a deliberate program of becoming a "PJM junkie" the other utilities would continue to make capacity and energy available on favorable terms. It is far more likely that rates would be raised to a penalty level sufficient to induce PECO to add capacity or, failing that, to more fully compensate other members for the capacity provided." (Emphasis added).

(PECO St. 15A, p. 23).

Dr. Hieronymus elaborates on this assumption and suggests a formula similar to that which now applies to split savings on energy but, in order to adequately compensate suppliers of power from baseload and intermediate facilities," concerns itself additionally with split savings on capacity (PECO St. 15A, p. 25). Dr. Hieronymus calculates that, under this formula, the present value of PECO's avoided capacity costs would be $1.849 million, approximately 60% higher in present value than capacity payments based solely on the carrying cost of a peaker. This amounts to approximately an additional $0.75

billion in the net present value benefit of Limerick 1 (PECO St. 15, p. 57).

Dr. Hieronymus also points out that what Mr. Chernick is essentially doing by assuming that in the "Limerick 1 out" case PECO embarks on a plan of life extensions and CT rental or ownership is positing a new alternative resource plan for PECO. This violates the "valuation" intent of the "with versus without" study performed by PECO. Clearly, any number of hypothetical scenarios can be envisioned in which the Company replaced Limerick 1 with some alternative form of generation. However, these "with versus with something else" scenarios are simply a backdoor attempt to evade the stricture against hindsight of the prudence standard on an even more fundamental level than does the "with versus without" comparison. The latter comparison asks simply, "Will Limerick pay for itself?" In constructing an alternative set of capacity options, Mr. Chernick is asking "Would it be cheaper if PECO had not built Limerick 1 but instead were to rely on a program of life extensions and CTs based on 1986 forecast assumptions?" Such a method of "valuation" is quite obviously an after-the-fact, hindsight-based prudence test, and should be dismissed.

G. A Discount Rate Based On PECO's After-Tax Incremental Cost Of Capital Should Be Employed In Calculating The Present Value Of Revenue Requirements In The Lifecycle Economic Analysis.

In order to assess the present value of Limerick 1's lifetime costs and benefits, the Company used a discount rate of 9.7%, which is the Company's average after-tax incremental cost of capital anticipated over the 1986-2024 period (GEC Ex. 3, Att. IR-OCA-2-25(b), Item 5). This discount rate was derived by calculating the weighted average of PECO's forecast incremental cost of new funds raised through long term debt, preferred stock, and common stock, with the incremental cost of long term debt reduced to reflect the tax deductibility of its associated interest expense (Id.).

In contrast, PAIEUG witness Falkenberg uses the pre-tax incremental cost of funds in his life cycle analysis, which he estimates to be 14.3% (PAIEUG 1, p. 29; PAIEUG St. 1A, p. 11). UUC/UP witness Chernick uses a 10 percent rate but argues that "15% is probably a minimum reasonable discount rate, and a value of 20% or more may be appropriate" to use in this cost-benefit analysis (UUC/UP St. 1, p. 81). This range of discount figures was suggested by Mr. Chernick based on a variety of factors: 1) his estimated "private" discount rate for PECO's consumers; 2) his concern that the discount rate reflects what he believes is the project risk associated with Limerick 1; and 3) his proposed adjustment to long term debt rates based on tax considerations

(Id., pp. 77-78, 81).

These differences in discount rate assumptions account, in large part, for the dramatic range of life cycle presentations in this proceeding (PECO St. 15A, p. 21). Mr. Falkenberg's use of a 14.3% discount rate, for example, results in a $2.6 billion dollar difference between his result and the Company's life cycle analysis, fully accounting for the "loss" which he proposes to impose on PECO's shareholders (PAIEUG St. 1, p. 24). Therefore, it is important to dispel the conceptual errors and the reliance upon outdated and irrelevant information employed in the derivation of discount rates presented by Messrs. Chernick and Falkenberg. Because only PECO's discount rate assumption rests on appropriate conceptual grounds and applicable information, the flawed discount rates proposed by Messrs. Chernick and Falkenberg should be rejected.

1. The Appropriate Discount Rate Is PECO's Discount Rate, Not The Average Discount Rate Of Its Customers.

Mr. Chernick argues that the discount rate of PECO's customers, and not the Company's discount rate, should be utilized in its life cycle analysis (UUC/UP St. 1, p. 78). He argues that "[t]his discount rate is being used to discount cash costs and benefits to customers, not PECO's cash outlays, and therefore should reflect the time and risk preferences of the customers, rather than of PECO itself, or of its shareholders."

(Id.). In addition, he argues that PECO's discount rate is materially lower than the discount rates of its customers and, therefore, is not a reasonable approximation of its customers' discount rates (Id., p. 79). Mr. Chernick bases this latter assertion on "a telephone survey of some of my clients, who report required paybacks [for non-productive investments, like conservation investments] on the order of 2 to 5 years: none of the enterprises surveyed indicated a discount rate of less than 20%" (Id.).

PECO witnesses Hill, Perl, and Hieronymus provided convincing evidence in this proceeding demonstrating that, because the Company can borrow on behalf of its customers and pass on the attendant savings, it is the Company's discount rate of 9.7% which is the relevant measure of life cycle costs and benefits. As stated by Mr. Hill:

> "It is Mr. Chernick who is confused as to the proper discount rate to be employed when evaluating the cost of Limerick 1 versus alternatives. PECO's costs of capital and related tax rates are clearly relevant to an economic evaluation respecting customer benefits. It is the Company's cost of financing those investments and alternative investment proposals, including applicable tax effects, which the customer will pay. Thus, in evaluating the impact of alternative courses of action involving different capital investment programs upon the ratepayer, utility capital cost rates and related tax effects are the proper discount rate."

(PECO St. 18H, p. 4).

Dr. Perl's analysis also confirms Mr. Hill's position using accepted financial theory. As discussed by Dr. Perl, a customer's discount rate reflects his preferences for various patterns of present versus future consumption. That is, the pure "psychological" discount rate is "the rate at which the customer would be willing to trade consumption today for consumption tomorrow" (PECO St. 11A, pp. 9-10). When the effect of an investment on a customer's consumption both in the near term and in the longer term is known, then the customer's pattern of consumption preference can be used to evaluate and choose between various investment options (Id., p. 10). However, if the customer can borrow or lend funds at a market interest rate which is lower than his private "psychological" rate, the customer's decision rule in evaluating options, and his subsequent choice, changes (Id., p. 11). If a customer can borrow or lend in order to optimize the timing of his consumption expenditures, the rate at which customers can borrow and lend funds is the appropriate rate to be used in judging alternatives. Since PECO borrows and lends funds on behalf of its customers when it constructs generating facilities for their use, it is PECO's discount rate which is the appropriate rate at which to evaluate generating options (Id., p. 12). Dr. Hieronymus agrees with Dr. Perl's analysis, noting that "[t]he fact that the utility can borrow money at rates below customer rates makes the customers' cost of money irrelevant" (PECO St. 15A, p. 48).

Dr. Hieronymus also identifies demonstrable errors in Mr. Chernick's assumption that PECO's customers' discount rates are significantly higher than PECO's discount rate. For instance, he noted that the industrial "hurdle rates" indicated in Mr. Chernick's survey are "notoriously unreliable measures of the opportunity cost of capital" and are "used to evaluate returns on a pre-tax basis and/or before allocation of overheads" (PECO St. 15A, p. 49). He also points out that "[h]igh hurdle rates are used to counter optimism in forecasting project flows" (Id.). He concludes that Mr. Chernick's evidence of high discount rates is unreasonable on its face:

> "If hurdle rates were meaningful measures of the opportunity cost of capital, no investments yielding after-tax returns below 25 percent would be made and the average return on capital invested in U.S. business therefore would be at least 25 percent. Of course, this is not the case."

(Id.).

Finally, Dr. Hieronymus argues that the whole concept of market prices and interest rate means that "[w]hile some customers unquestionably have higher opportunity costs of capital, it is quite inappropriate to use the highest discount rate for any customer to represent ratepayers as a group" (Id.). As a factual matter, he questioned the premise that the customer's market cost of capital was higher than PECO's in the relevant sense. Mr. Chernick's estimated customer capital cost fails to recognize that "current money market yields are below 8

percent" even before tax (taxes would reduce these yields further), while "mortgage rates are currently around 11 percent" (and again would be lower after-tax, because of the tax deductibility of interest expenses) (Id., p. 48).

2. A Discount Rate Based On PECO's Cost Of Capital Must Be Reduced To Reflect The Tax Benefit Of The Deductibility Of The Interest Expense Associated With Long Term Debt.

The discount rate used by the Company in its life cycle analysis was based on the Company's net of tax cost of capital, in which the cost of long term debt was reduced to reflect the tax benefit of the deductibility of the associated interest expenses. Mr. Chernick agreed with the Company that "tax effects must be considered in establishing a discount rate," although he asserted that, for a regulated utility, the cost of debt capital should be increased by tax impacts, rather than reduced (UUC/UP St. 1A, p. 24; UUC/UP St. 1, p. 80-81). Mr. Falkenberg argues, further, that a cost of capital uncorrected for the deductability of interest should be used as the basis for the discount rate used in the cost-benefit analysis (PAIEUG St. 1A, p. 11).

As Mr. Hill and Drs. Perl and Hieronymus testified, the Company's after-tax cost of capital, reflecting the benefits of the tax shields of interest expense, is the appropriate basis for the discount rate to be used in this proceeding. Mr. Hill confirms PECO's use of this figure, noting that utility capital

cost rates and related tax effects, which determine the company's net cost of financing, provide the proper discount rate (PECO St. 18H, p. 4). Mr. Hill's analysis that the appropriate discount rate is based upon PECO's cost of capital is further confirmed by ALJ Klovekorn's analysis in the 1980 Limerick Investigation:

> "In building and operating electric generating plants, the utility essentially functions as a financial intermediary, borrowing money from investors and loaning it to consumers. As long as the rate at which the utility can borrow is below the consumer's own discount rate, alternative investment programs should be evaluated at the cost of money to the utility."

(Limerick Nuclear Generating Station Investigation, PUC Docket No. I-80100341, Initial Decision of Administrative Law Judge Joseph J. Klovekorn, p. 215, March 26, 1982.) Dr. Hieronymus also supports Mr. Hill's conclusion, asserting that "[s]ince raising capital to build and carry the capital cost of Limerick generates tax shields, these should be figured into the cost of capital used in evaluating the investment" (PECO St. 15A, p. 48). He also quoted a recent draft EPRI report, Choice of Discount Rates in Utility Planning: The Revenue Requirements Method, which states:

> "The discount rate may also include an adjustment for financing side effects. An example of a financing side effect is the tax shield provided by interest expense. Debt financing may generate project value over and above net operating cash flows because interest payments are deductible for corporate tax purposes. This side effect can be reflected directly, by adjusting cash flows,

or indirectly, by adjusting discount rates.

> The "weighted average cost of capital" is an opportunity cost of capital adjusted to account for interest tax shields."

(PECO St. 15A, p. 47).

This position is supported still further by Dr. Perl, who also testified that "the after-tax cost of money, and not the simple weighted average cost, is the rate at which the Company can borrow and lend funds on behalf of consumers" (PECO St. 11A, p. 9). Dr. Perl illustrates the appropriateness of this conclusion, showing that, when investments are capitalized and subsequently recovered over multiple periods, rather than immediately passed through (expensed) in a single period, the amounts to be recovered in the subsequent periods are paid back by consumers at an interest rate which exactly equals the after-tax cost of money (Id.). He concluded that "[a]ny adjustments to accounting conventions, which either defer revenues into the future or accelerate them into the present, occur at an interest rate which equals the after-tax cost of money" (Id.). Therefore, this is the rate of which investment options should be evaluated.

Mr. Falkenberg's conclusion that the average pre-tax cost of capital of utilities, estimated at 14.3%, is the appropriate discount rate is based primarily on a survey performed by the Edison Electric Institute (EEI) Finance Committee. Mr. Falkenberg relied on his interpretation of a summary of responses to an EEI survey to conclude that 75% of the

investor-owned utilities in the U.S. used the incremental cost of capital, without adjustment for the tax deductibility of interest, as their discount rate in internal economic evaluations (PAIEUG St. 1, p. 29). It is clear, however, that Mr. Falkenberg's conclusion is based on his misreading of the demonstrably ambiguous survey. The EEI survey form asked utilities to report whether they used incremental or non-incremental (i.e., embedded) costs of capital in internal economic evaluations (Id., p. 2). If the utility used non-incremental capital cost, the form also asked them to identify whether they used a net-of-tax (i.e. after-tax) figure. However, if the utility indicated that they used incremental capital cost, there was no question on the form to identify whether they used pre-tax or after-tax incremental capital cost. Therefore, there was no way to determine conclusively if the utility had supplied a pre-tax or after-tax incremental capital cost figure.

In addition, Mr. Falkenberg also mistakenly assumed that the figures supplied by the survey respondents were their discount rates. However, as Mr. Falkenberg himself concedes, the words "discount rate" do not appear anywhere in the survey upon which he relies (PAIEUG St. 1A, p. 12). As an example of the survey questionnaire, PECO witness Hill provided the Company's response to the survey (PECO St. 18D, Schedule 1). As Mr. Hill pointed out, PECO answered the survey providing its pre-tax incremental cost of capital, despite the fact that PECO

"consistently employs an after-tax discount rate for all economic evaluations and has done so for at least 30 years" (PECO St. 18D, p. 9). Therefore, Mr. Falkenberg clearly misinterprets the survey in assuming that all utilities that responded that they use an "incremental cost of capital for economic internal evaluations" use a pre-tax calculation of that cost as their discount rate (PECO St. 18D, p. 8 and PECO St. 18H, p. 5).

Despite the questionnaire's failure to ask specifically for a utility's discount rate, or the tax basis of its incremental cost of capital, Mr. Falkenberg asserted that "the survey is absolutely absurd unless the term 'cost of capital' is interpreted as a discount rate" and that it "makes absolutely no sense to interpret the after-tax cost of capital as the cost of capital for internal revenue requirements analysis in any sense other than as a discount rate" (PAIEUG St. 1A, p. 12). In so asserting, he is merely assuming the correctness of his own position. As Dr. Hieronymus points out, and as Mr. Falkenberg himself recognizes, a pre-tax cost of capital "used as an input to revenue requirements analyses" (such as reported in the survey) must be adjusted for tax effects before it can be used in a revenue requirements analysis (PECO St. 15B, p. 3; PAIEUG St. 1A, p. 12). Therefore, Mr. Falkenberg implicitly admits what he originally denies: that utilities would have reasonably interpreted the questionnaire as asking for a cost of capital, which is an input to analysis, including both calculation of

revenue requirements and discount rates, rather than as asking for the discount rate figure itself (PECO St. 15B, p.3). Therefore, Mr. Falkenberg's rhetoric is simply unfounded, and his reliance upon the EEI survey to support his use of a pre-tax cost of capital as a discount rate must be dismissed.

In addition, even if Mr. Falkenberg's interpretation of the questionnaire had been correct, it would be highly inappropriate to use a discount rate derived from EEI data which was collected in 1984 (PECO St. 15B, p. 4). As Dr. Hieronymus noted:

> "Exhibit WHH-53 shows the PECO response to the survey, its then-cost of capital as reflected in financial markets, and its current market cost of capital. As the Exhibit shows, PECO's then-estimate of its incremental cost of debt and preferred was closely related to its market return on such instruments. Since that time, its cost of debt has fallen by 300 basis points, preferred by 200 to 350 basis points, and equity by 110 basis points. Presumably, were PECO to respond to a similar survey today, its implied net-of-tax cost of capital would be 9.86 percent, essentially identical to the 9.7 percent used in my direct testimony."

(Id., p. 4)

Mr. Falkenberg also briefly refers to an EPRI TAG report as support for the use of pre-tax incremental cost of capital as the discount rate. He asserted that the TAG report "states that EPRI uses the incremental cost of capital as a discount rate because it is in more general use in American utilities" (PAIEUG

St-1A, p. 16). However, as stated by Mr. Hill, "[t]his EPRI report really indicates that there is no concensus within the utility industry as to whether the discount rate should be based upon a before-tax or after-tax cost of capital. The survey also concludes that neither method is completely appropriate under all circumstances for all electric utilities (PECO St. 18H, p. 6). Therefore, the EPRI TAG report by no means supports Mr. Falkenberg's position.

In his third line of argument, Mr. Falkenberg asserts that the Company's use of the after-tax discount rate based on Dr. Perl's testimony, which stated that the after-tax discount rate was appropriate to use because it was neutral as to alternative accounting conventions, such as straight-line versus sinking fund depreciation, is inconsistent with PECO's opposition to basing recovery of Limerick 1 costs on sinking fund depreciation (Id., p. 9). Mr. Falkenberg asserts that "Mr. Farling has a higher discount rate than Dr. Perl or Dr. Hieronymus. His discount rate is apparently equal to an after-tax cost of capital plus some additional risk premium which accounts for the uncertainty of future cost recovery" (Id., p. 10).

Mr. Falkenberg's interpretation of PECO's preference for certain accounting conventions as an indication of higher discount rates is without any basis. As stated by Mr. Farling:

> "[M]y concerns over the sinking fund method of depreciation as a generally accepted accounting method were not based on any analysis of a proper discount rate. Depreciation is the allocation of utility plant cost over its estimated useful life in a systematic and rational manner. My conclusions as to the acceptability of sinking fund depreciation have nothing to do with a particular discount rate."

(PECO St. 16B, p. 3). Therefore, Mr. Falkenberg has clearly misstated the Company's position on this issue.

Dr. Hieronymus noted that Mr. Falkenberg now appeared to be willing to accept an after-tax basis discount rate, but only if PECO is "accounting neutral" and expenses are in fact capitalized. However, he observes that "[o]n this point [Mr. Falkenberg] parts company with current finance theory which instructs that the discount rate to be applied to these expenses is invariant with respect to whether they are in fact capitalized or not, unless the fact of capitalization changes their risks" (PECO St. 15B, p. 6).

In his final line of argument, Mr. Falkenberg analyzes the lifecycle cost-benefits of Limerick assuming 0% and 35% income tax rates, and concludes that if tax rates were reduced through new legislation, reducing Limerick revenue requirements, use of an after-tax discount rate would nonetheless show a lower net benefit. He stated that "[t]he absurdity of this result points out the unreasonableness of the use of the after-tax discount rate" (PAIEUG St. 1A, p. 15).

Dr. Hieronymus demonstrates that Mr. Falkenberg's analysis is flawed, since it erroneously assumes that the pre-tax weighted average cost of capital is unaffected by a reduction in corporate tax rates (PECO St. 15B, p. 5). Because of Mr. Falkenberg's faulty premise, his analysis implies that "if corporate income taxes were eliminated, the effective (i.e. net-of-tax) cost of borrowed funds would double and the cost of equity would remain unchanged" (Id., p. 5). Dr. Hieronymus argues that in reality "[w]hile the response of the economy to an elimination of or major reduction in corporate income taxes is complicated, ... it is quite probable that the qualitative effect would be to reduce the pre-tax cost of both debt and equity" (Id.). This would in turn, reduce the discount rate, increasing Limerick's net benefit as intuition suggests should happen. Therefore, Mr. Falkenberg's demonstration of the "counterintuitive result" was based upon an improper formulation of the problem and is not persuasive.

Mr. Chernick, while recognizing that tax effects must be considered in establishing a discount rate, argues that PECO's discount rate calculation, which calculated the after-tax cost of money by considering the tax benefits of interest deductions, is appropriate for calculating corporate discount rates but inappropriate for regulated utilities, for whom revenues vary with financial costs (UUC/UP St. 1, p. 80). He concludes that "the net effect of taxes is to reduce the financing costs of

competitive industries, and increase the financing costs of regulated utilities" (UUC/UP St. 1A, p. 25). Mr. Hill points out that this factual premise is simply wrong: "the discount rate, as formulated by PECO, is not only correct in non-regulated industries but is appropriate in the regulated sector, i.e. $2.00 worth of revenue is required to pay $1.00 worth of earnings in either sector" (PECO St. 18H, p. 3). Mr. Chernick has confused the calculation of capital-related revenue requirements, which require that costs be increased by a multiplier to provide revenues sufficient to recover capital costs and taxes (for both regulated and unregulated businesses), with the calculation of the discount rate (PECO St. 11B, p. 2). As Dr. Perl has established, since the utility can borrow or lend funds to consumers (i.e. defer or accelerate revenue requirements) at the after-tax cost of money, this is the appropriate discount rate to be used to evaluate alternative generating options. Dr. Perl also points out a telling inconsistency on Mr. Chernick's part in that Mr. Chernick recognizes that the utility's after-tax cost of money is the appropriate rate to use in calculating AFUDC, but then denies that it is appropriate for discount rate purposes (PECO St. 11B, p. 3). Since the AFUDC rate is the rate that consumers pay to defer annual capital charges from the construction period to the operating period, Dr. Perl concludes "this illustrates that the after-tax rate is the rate at which utilities borrow on behalf of customers, and should be sufficient

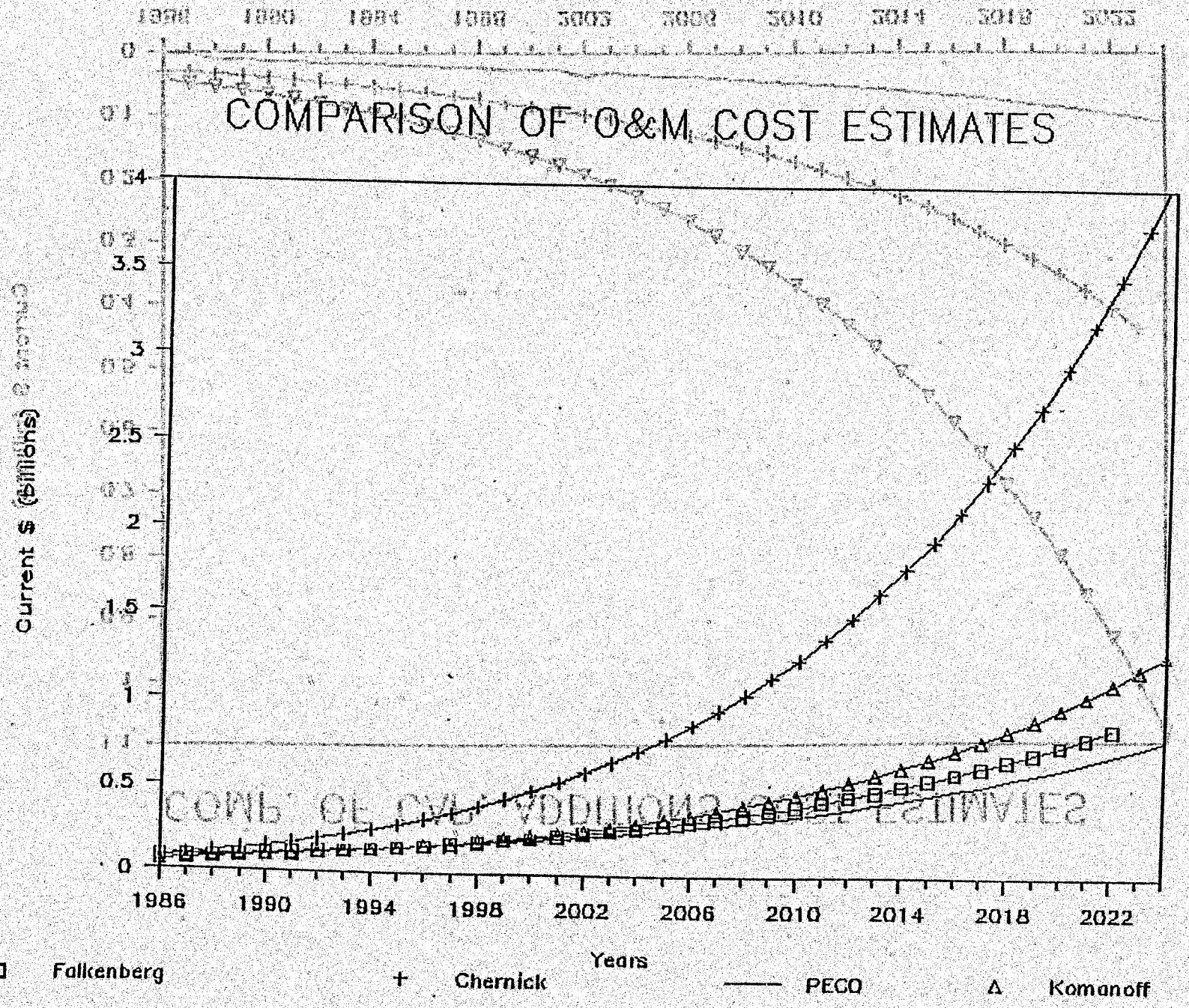
to convince Mr. Chernick that it is the appropriate discount rate for use in this analysis" (Id.).

3. The Company's Discount Rate Should Not Be Adjusted For Alleged Limerick 1 Specific Risks.

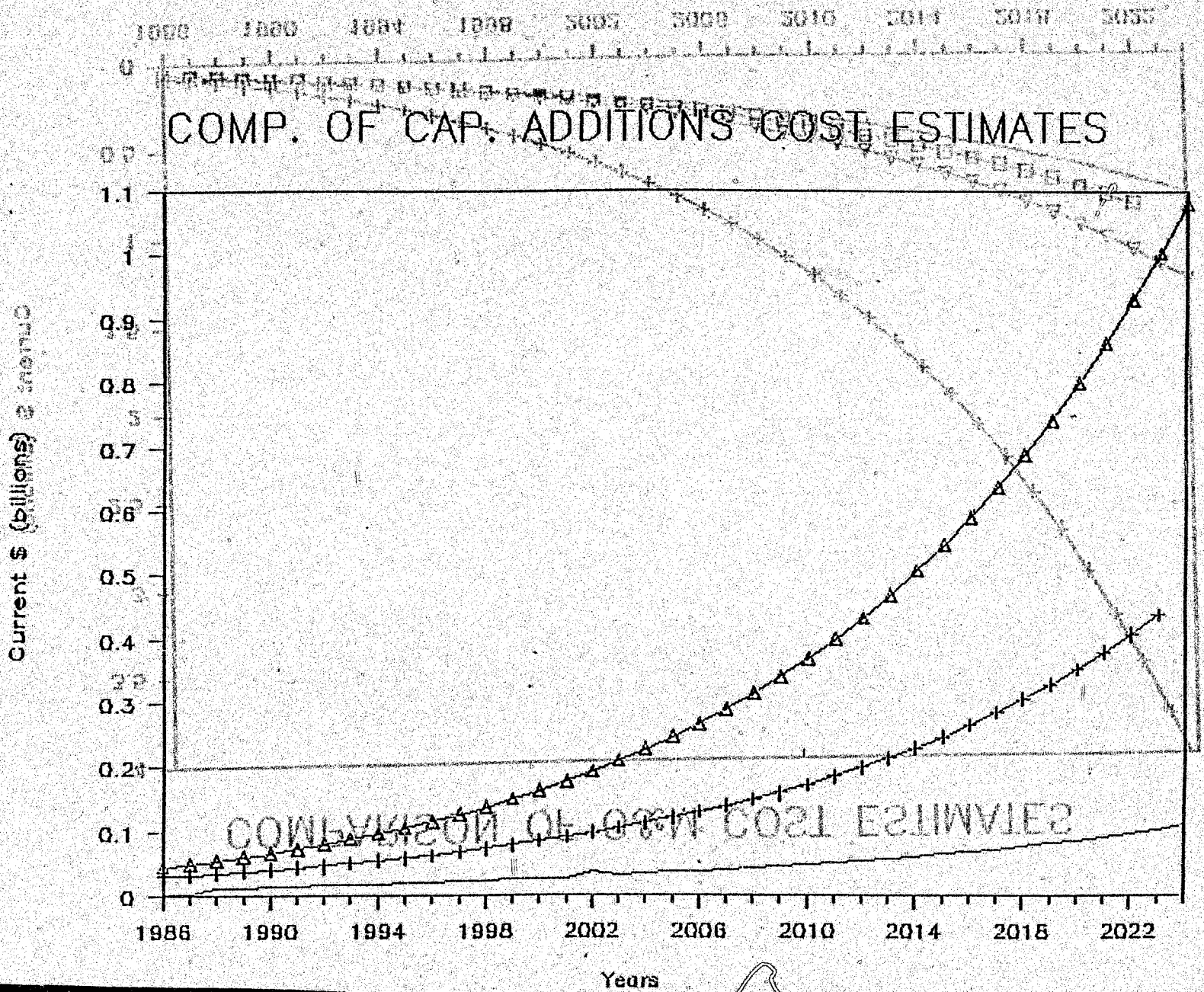
Mr. Chernick's final argument that PECO's 9.7% discount rate is too low is based on his assertion that Limerick 1 is riskier than PECO's average business risk (UUC/UP St. 1, pp. 79-80). Mr. Falkenberg also implies that PECO's discount rate is higher than 9.7% because of the risks involved in future cost recovery (PECO St. 15B, p. 2). Dr. Hieronymus demonstrates that Mr. Chernick's proposal, which advocates both adjusting individual operating factors (such as future fuel savings or operating costs) for risks that PECO's forecast will not be realized as well as using a higher discount rate, would result in the "double-counting" of risks. Moreover, he testifies that finance theory mandates that risks not already captured in the market-based costs of debt and equity should be accounted for in an economic analysis by adjusting the specific factors for risk or by using an explicit risk assessment methodology, not by adjusting the discount rate (Id.).

The plain sense of the Company's position in this dispute is summarized by Dr. Perl:

"The after-tax cost of money is the rate at which utilities can borrow or lend funds on behalf of their customers. As such, it is the



Schedule D-1
(Exhibit WHH-36)



Schedule D-2
(Exhibit WHH-37)

Schedule D-3
(Exhibit WHH-43)

TABLE BWR CAPACITY FACTOR PROJECTIONS FOR LIMERICK 1
CHERNICK PROJECTIONS WITH 95% CONFIDENCE INTERVALS

PECo Calendar Year	YEAR of Experience	Chernick Point Forecast	Conf. Interval Point Forecast	Upper	Lower
		[1]	[2]	[3]	
1986	1	65.0%	48.8%	79.6%	18.0%
1987	2	65.0%	40.8%	71.6%	10.0%
1988	3	65.0%	44.3%	75.1%	13.5%
1989	4	65.0%	59.3%	90.1%	28.5%
1990	5	65.0%	51.3%	82.1%	20.5%
Mature Average		65.0%	56.8%	87.6%	26.0%

Notes: [1] From Chernick Table 4.4. Chernick averages his forecasts using Equations 2 and 4, and makes a -0.27% adjustment based on his interpretation of 1985 BWR performance. (See Chernick text, p. 58-59, and Table 4.4, fn. [3].)
[2] Chernick point forecast + (1.96* std. error), with std. error = 0.157 (see Chernick text).
[3] Chernick point forecast - (1.96* std. error).

Exhibit WHH-56

Comparison of Post-TMI Capacity Factors to Chernick's Limerick 1 Forecast

	Age				
	1	2	3	4	5
PWRs					
Capacity Factor	62.3	58.2	62.6	61.6	77.9
Number	13	10	7	6	2
BWRs					
Capacity Factor	51.6	54.6	—	—	—
Number	4	2	—	—	—
Total					
Capacity Factor	59.8	57.6	62.6	61.6	77.9
Number	17	12	7	6	2
Limerick Forecast	49.1	41.1	44.6	59.6	51.5

APPENDIX E

Response to ALJ
March 4, 1986 Order

Development of Effective Tax Rate
and Allocation Factors
(Ex. TPH-2A, pp. B-17 and B-18)

Philadelphia Electric Company - Combined Operations

DEVELOPMENT OF FACTORS FOR ALLOCATING COMMON TO ELECTRIC, GAS, & STEAM OPERATIONS

June 30, 1986

Basic Data	Plant in Service (1) (Thousand $)	By Total Revenue (2) (Thousand $)	By Total Customers (3) (Number)	Average (4)=(1)+(2)+(3) / 3
Electric	$8,726,738	$2,528,293	1,343,513	
Gas	485,912	450,484	309,770	
Steam	53,080	62,075	515	
Subtotal	$9,265,730	$3,040,852	1,653,798	
Common	142,487			
Total	$9,408,217	$3,040,852	1,653,798	

Allocation Factors				
Electric	94.183%	+	83.144%	= 81.238%	86.188%
Gas	5.244%	+	14.814%	= 18.731	12.930
Steam	0.573%	+	2.042%	= 0.031	0.882
Total	100.000%		100.000%		100.000%

Philadelphia Electric Company - Combined Operations

CALCULATION OF EFFECTIVE INCOME TAX RATE

The effective income tax rate developed below combines into a single rate the effects of the federal income tax rate of 46% and the Pennsylvania income tax rate of 7.5%. The Pennsylvania income tax rate of 7.5% is the rate in effect prior to 1971 and is used here to reflect the level of Pennsylvania income taxes collectible through base rates. Changes in the Pennsylvania income tax rate since 1970 are collected through operation of the State Tax Adjustment Clause.

This effective income tax rate is intended for application to incremental changes in taxable income which result from 1) changes in revenue, less gross receipts taxes, associated with ratemaking adjustments, 2) changes in tax deductible expense associated with ratemaking adjustments and 3) additional revenues yielded by proposed rates. Because the effective income tax rate is applied to incremental changes in taxable income, it is independent of the overall average income tax rate experienced during the test year.

In 1970, prior to the establishment of the State Tax Adjustment Clause, Pennsylvania income taxes were deductible in determining both state and federal taxable incomes. Consequently, the effective state, federal or combined income tax rates must be determined by use of algebraic formulae. The algebraic formulas used here act to determine an effective income tax rate to be applied to changes in taxable income before payment of both Pennsylvania and federal income taxes.

Pennsylvania Effective Income Tax, s:

$$s = 0.075 \times (\text{taxable income} - s)$$
$$s = (0.075 \times \text{taxable income}) - (0.075 \times s)$$
$$s + (0.075 \times s) = (0.075 \times \text{taxable income})$$
$$s \times (1 + 0.075) = (0.075 \times \text{taxable income})$$
$$s = \frac{0.075 \times \text{taxable income}}{1.075}$$
$$s = 0.06977 \times \text{taxable income}$$

Federal Effective Income Tax, f:

$$f = 0.46 \times (\text{taxable income} - s)$$
$$f = (0.46 \times \text{taxable income}) - (0.46 \times 0.06977 \times \text{taxable income})$$
$$f = (0.4600 - 0.03209) \times \text{taxable income}$$
$$f = 0.42791 \times \text{taxable income}$$

Summary:

	Rate		
	Statutory	Effective	Effective In % of Total
Pennsylvania	7.5%	6.977%	14.019%
Federal	46.0%	42.791	85.981
Total		49.768%	100.000%

Revised 6/17/86

C-12

Pennsylvania Electric Company - Electric Operations
Cash Working Capital
June 30, 1986
(Thousands $)

Additional information regarding the Company's cash working capital claim is contained in the Direct Testimony of R. M. Mojdehi.

Operating and Maintenance Expense	(C-13a)	$1,354
Taxes	(C-13b)	23,501
Interest Payments	(C-13c)	(22,489)
Preferred Dividend Payments	(C-13d)	62
Average Bank Balances (a)		3,709
Total (pp C-3 to C-5)		56,487 *

(a) Average Monthly Bank Balances
for the future test year are
anticipated to be $11.3 million(11-3-3) of
which $6.1(3-T) or $0.7 million is
allocated to Electric Operations
Total Company (Ex. TPH-2A, pp. C-12 to C-12d)

Development of Cash Working Capital Requirement

Total	($2,138)
Preferred Dividend Payments	112
Interest Payments	(22,489)
Taxes	2,504
O&M Expenses	150

* The Numerical Components are as follows:(Testimony of T.P.Hill,Jr.)

Philadelphia Electric Company - Electric Operations
Cash Working Capital
June 30, 1986
(Thousands $)

Additional information regarding the Company's cash working capital claim is contained in the Direct Testimony of R. W. Wright.

Operating and Maintenance Expense	(C-12a)	91,954
Taxes	(C-12b)	33,201
Interest Payments	(C-12c)	(38,489)
Preferred Dividend Payment	(C-12d)	85
Average Bank Balances	(a)	9,700
Total (to A-2)		96,451 *

(a) Average Monthly Bank Balances

for the future test year are expected to be $11.3 million(II-B-5) of which 86.188%(B-17) or $9.7 million is allocated to Electric Operations

* The Limerick components are as follows:(Testimony of T.P.Hill,Jr.)

O&M Expenses	750
Taxes	5,504
Interest Payment	(19,555)
Preferred Dividend Payment	115
Total	(13,186)

Revised 2/14/86

Philadelphia Electric Company
Cash Working Capital Required for
Operating and Maintenance Expense
June 30, 1986
($000)

Average Lag in Receipt of Revenue	46.0	(a)
Average Lag in Payment of O&M Expenses	21.7	(b)
Average Lag in Days Between Receipt of Revenue and Payment of Expenses	24.3	
Proforma Test Year O&M Expenses	1,381,755	
Average Daily Expenses	3,786	
Working Capital Requirement	91,924	

a)

Class of Service	Dollars	Lag Days	Lag $
Residential	928,292	48.6	45,114,991
Small Comm. &Ind.	359,462	48.2	17,325,068
Large Comm. &Ind.	1,174,680	44.1	51,803,388
	2,462,434		114,244,448 46.0 Days

(b) Average Lag in Payment of Expenses

	Actual	Pro Forma Adjustments	Pro Forma Expenses	Lag Days	Lag Dollars
Payroll	275,564	5,270(C)	280,834	10.5	2,948,757
Net Interchange	421,472	(196,960)(d)	224,512	33.0	7,857,920
Nuclear Fuel	136,823		136,823	46.5	6,362,270
Coal	84,660		84,660	31.2	2,641,392
Coal Freight Bills	16,766		16,766	15.0	251,490
Oil	120,360		120,360	19.3	2,322,948
Benefits	19,276	6,194(C)	25,470	1.8	45,846
Pensions	29,009	639(C)	29,648	15.0	444,720
Other Invoices	315,051	59,719(e)	374,770	15.4	5,771,458
A&G Expenses and Rents	87,912		87,912	15.4	1,353,845
Total O&M Expenses	1,506,893	(125,138)	1,381,755		30,000,645
					21.7

Average Lag in Payment of Expenses

(c) D-5	5,655	
D-18	6,408	
(d) D-3	13,805	
D-13	0	
D-19	(3,775)	
D-21	(206,990)	
	(196,960)	
(e) D-10	10,614	
D-11	(11,135)	
D-12	(5,480)	
D-15	8,026	
D-16	3,803	
D-18	70,233	
B-13	(16,472)	(uncollectible accounts)
D-22	667	
D-23	(537)	
	59,719	

Revised 2/14/86

Philadelphia Electric Company
Cash Working Capital Required For
Payment of Taxes
June 30, 1986
(Thousand $)

Average Lag in Receipt of Revenue	(a)	46.0 (a)
Average Lag in Payment of Taxes	(b)	29.0 (b)
Average Lag in Days Between the Receipt of Revenue and Payment of Taxes		17.0
Proforma Test Year Taxes		712,811
Average Daily Taxes		1,953
Working Capital Requirement		33,201

Note a) See C-12a

Note b) Average Lag in Payment of Taxes

	Actual	Pro Forma Adjustments	Pro Forma Taxes	Lag Days	Lag Dollars
Ad Valorum	69,124	1,212	70,336	25.2	1,842,603
Other Taxes Other Than Income	130,713	34,013 (c)	164,726	(30.8)	(5,073,561)
State Income Taxes	26,900	48,299 (d)	75,199	63.6	4,782,656
Federal Income Taxes	105,773	296,777 (d)	402,550	47.0	18,919,850
Total Taxes	332,510	380,301	712,811		20,471,749
Average Lag in Payment of Taxes					29.0

Note (c) Taxes Other Than Income

A-4 (GRT @ 4.5%)	41,255
D-2 (GRT @ 4.5%)	0
D-3 (GRT @ 4.5%)	1,750
D-14	741
D-21 (GRT @ 4.5%)	(9,753)
	34,013

Note (d) Income Taxes

	State	Federal
A-4	61,057	374,479
D-2	0	0
D-3	1,588	10,351
D-5	(397)	(2,437)
D-7	5,418	33,226
D-9	(13,692)	(83,975)
D-10	(741)	(4,542)
D-11	777	4,765
D-12	(259)	(1,040)
D-13	0	0
D-14	(52)	(317)
D-15	(560)	(3,434)
D-16	(265)	(1,628)
D-18	(5,347)	(32,796)
D-19	767	4,707
D-22	(47)	(285)
D-23	(85)	(518)
D-28	37	230
Total	48,299	296,777

Listing of Philadelphia Electric Company Exhibits

LISTING OF PHILADELPHIA ELECTRIC COMPANY EXHIBITS INTRODUCED INTO THE RECORD

I. Hearing Exhibits		Date Introduced
1.	Information submitted pursuant to Section 53.51 with Commission filing, including: General Filing Information; Rate Base and Operating Income; Rate of Return, Rate Structure and Cost Allocation; Plant and Depreciation Data; Unadjusted Comparative Balance Sheets and Operating Income Statements	December 16, 1985
2.	Reasons for Cost and Schedule Growth (Limerick 1 and Common Plant)	December 18, 1985
3.	PECO electric operations Statement of Reasons	December 11, 1985
4.	IR-PECO 3-1 to IR-PECO-3-5, IR-PECO-5-4	February 6, 1986
5.	IR-PECO-OCA-4-1 to IR-PECO-OCA-4-21	February 7, 1986
6.	Memorandum from S.H. Hanauer to J.F. O'Leary, F.E. Kruesi and L. Rogers 9/20/72	February 7, 1986
7.	Memorandum from S.H. Hanauer to J. Hendrie 6/20/78	February 7, 1986
8.	Major Commodity Manpower by Facility (Source: Limerick Generating Station: Project Status Review Meeting - August 27, 1981)	February 10, 1986
9.	Excerpt from NUREG-0487	February 7, 1986
10.	Interrogatory Responses - IR-PECO-OCA-9 (Revised); IR-PECO-OCA-3-2, 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 20, 21, 24, 39, 40, 41, 44, 45, 46, 47 and 47 Revised, 50, 52, 56, 58; IR-PECO-OCA-5-1; IR-PECO-OCA-10-1, 2	February 10, 1986
11.	IR-PECO-OCA-9-9	February 11, 1986

Cash Working Capital
Interest Payment Offset
(Thousand $)

Consistent with the Commission Order at Docket R-842590, the Company is including an interest payment offset in its cash working capital claim.

Rate Base (A-2) 6/30/86	6,943,888
% Financed by Debt	50.90
Rate Base Financed by Debt	3,534,439
Cost of Debt per B-19a	10.86
Interest Allocated to Rate Base	383,840
Average Daily Interest	1051.6
Net Lag Days (a)	36.6
Decrease in Cash Working Capital	38,489

(a) Lag in Payment of Interest = 82.6 days
Lag in Receipt of Revenue = 46.0 days
Net Payment Lag = 36.6 days

Cash Working Capital
Preferred Dividend Payment Requirement
(Thousand $)

Consistent with the Commission Order at Docket R-842590, the Company is including a preferred dividend payment requirement in its cash working capital claim.

Rate Base (A-2) @ 6/30/86	6,943,886
% Financed by Preferred	10.70
Rate Base Financed by Preferred	742,996
Cost of Preferred per B-20	10.50
Dividends Allocated to Rate Base	78,013
Average Daily Dividends	213.7
Net Lag Days (a)	(0.4
Increase in Cash Working Capital	85

(a) Lag in Payment of Dividends = 45.6 days

Lag in Receipt of Revenue = 46.0 days
Net Lag Days = (0.4) days

Hearing Exhibits	Date Introduced
12. Limerick Net Present Value of Benefits Less Costs Per OCA St. 6 Direct Testimony of Charles Komanoff	February 11, 1986
13. IR-PECO-8-14	February 11, 1986
14. IR-PECO-OCA-9-16	February 11, 1986
15. IR-PECO-OCA-9-14	February 11, 1986
16. IR-PECO-OCA-9-15	February 11, 1986
17. IR-PECO-OCA-9-17	February 11, 1986
18. IRA-PECO-OCA-8-18	February 11, 1986
19. IR-PECO-OCA-8-19	February 11, 1986
20. IR-PECO-OCA-8-22	February 11, 1986
21. IR-PECO-OCA-9-15 to 21	February 11, 1986
22. Wharton PMW Report No. 8618 "A Model to Analyze the Regional Economic Impact of Electric Rate Increases" by Schinnar & Duromgkaveroj, a technical report on the adaptation of the Philadelphia STARLOC model, prepared by the City of Philadelphia	February 13, 1986
23. IR-PECO-CITY-6-5	February 13, 1986
24. IR-PECO-CITY-6-8	February 13, 1986
25. 1981 Dollar Deliveries of Fuel to Sector 1981 Dollar Gross Output of Sector	February 13, 1986
26. IR-PECO-CITY-6-3 and 4; Attachment to 6-4	February 13, 1986
27. IR-PECO-CITY-2-7	February 13, 1986
28. Portion of PP&L Electric Tariff (Territory Covered by this Tariff)	February 13, 196
29. Portion of Computer Printout	February 13, 1986
30. IR-PECO-CITY-2-2 and 5	February 13, 1986
31. IR-PECO-PAIEUG 3-2 and 26	February 14, 1986

Hearing Exhibits		Date Introduced
32.	IR-PECO-PAIEUG-3-35 and 39	February 14, 1986
33.	Excerpt from article - "Can Electric Utilities Improve their Forecast Accuracy? The Historical Perspective" by William R. Huss, Public Utilities Fortnightly 12/26/85	February 14, 1986
34.	1984 Survey of the Cost of Capital for Economic Evaluations by Edison Electric Institute	February 14, 1986
35.	IR-OCA-7-7,8,11,13a,14 and 15	February 14, 1986
36.	IR-GSA-2-10	February 14, 1986
37.	Excerpts from the 1980 Limerick Investigation Record	March 21, 1986

II. Witness Exhibits

Witness	Exhibit	Date Introduced
Boyer	VSB-1	March 17, 1986
Brennan	JFB-1	December 10, 1985
	JFB-2	January 28, 1986
	JFB-3	February 26, 1986
	JFB-4	February 26, 1986
Clemente	FC-1	March 12, 1986
	FC-2	March 12, 1986
	FC-3	March 12, 1986
Carroll	JJC-1	January 28, 1986
	JJC-2	March 12, 1986
	JJC-3	March 20, 1986
Clarey/Coughlin	JJC-1/JRC-1	March 17, 1986
	JJC-2/JRC-2	March 17, 1986
(Clarey)	JJC-2	March 17, 1986
	JJC-3 Revised	March 20, 1986
(Coughlin)	JRC-2	March 17, 1986
English	PXE-1	March 11, 1986
	PXE-2	March 11, 1986
	PXE-3	March 11, 1986

Witness	Exhibit	Date Introduced
Guth	LAG-1	December 17, 1985
	LAG-2	December 17, 1985
	LAG-3	December 17, 1985
	LAG-4	December 17, 1985
	LAG-5	December 17, 1985
	LAG-6	December 17, 1985
	LAG-7	December 17, 1985
	LAG-8	December 17, 1985
	LAG-9	December 17, 1985
	LAG-10	December 17, 1985
	LAG-11	December 17, 1985
	LAG-12	December 17, 1985
	LAG-13	December 17, 1985
	LAG-14	December 17, 1985
	LAG-15	March 11, 1986
Harris	AGH-1	January 28, 1986
Hieronymus	WHH-1	December 16, 1985
	WHH-2	December 16, 1985
	WHH-3	December 16, 1985
	WHH-4	December 16, 1985
	WHH-5	December 16, 1985
	WHH-6	December 16, 1985
	WHH-7	December 16, 1985
	WHH-8	December 16, 1985
	WHH-9	December 16, 1985
	WHH-10	December 16, 1985
	WHH-11	December 16, 1985
	WHH-12	December 16, 1985
	WHH-13	December 16, 1985
	WHH-14	December 16, 1985
	WHH-15	December 16, 1985
	WHH-16	December 16, 1985
	WHH-17	December 16, 1985
	WHH-18	December 16, 1985
	WHH-19	December 16, 1985
	WHH-20	December 16, 1985
	WHH-21	December 16, 1985
	WHH-22	December 16, 1985
	WHH-23	December 16, 1985
	WHH-24	December 16, 1985
	WHH-25	December 16, 1985
	WHH-26	December 16, 1985
	WHH-27	December 16, 1985
	WHH-28	December 16, 1985
	WHH-29	December 16, 1985
	WHH-30	March 12, 1986
	WHH-31	March 12, 1986
	WHH-32	March 12, 1986

Witness	Exhibit	Date Introduced
Hieronymus (cont.)	WHH-33	March 12, 1986
	WHH-34	March 12, 1986
	WHH-35	March 12, 1986
	WHH-36	March 12, 1986
	WHH-37	March 12, 1986
	WHH-38	March 12, 1986
	WHH-39	March 12, 1986
	WHH-40(a),(b),(c)	March 12, 1986
	WHH-41	March 12, 1986
	WHH-42	March 12, 1986
	WHH-43	March 12, 1986
	WHH-44	March 12, 1986
	WHH-45	March 12, 1986
	WHH-46	March 12, 1986
	WHH-47	March 12, 1986
	WHH-48	March 12, 1986
	WHH-49	March 12, 1986
	WHH-50	March 12, 1986
	WHH-51	March 12, 1986
	WHH-52	March 12, 1986
	WHH-53	March 12, 1986
	WHH-54	March 12, 1986
	WHH-55	March 12, 1986
	WHH-56	March 12, 1986
Hill	TPH-1	December 10, 1985
	TPH-2	December 10, 1985
	TPH-2a	March 6, 1986
	TPH-3	December 10, 1985
	TPH-4	March 6, 1986
Hoch	WCH-1	March 11, 1986
	WCH-2	March 11, 1986
	WCH-3	March 11, 1986
	WCH-4	March 11, 1986
	WCH-5	March 11, 1986
	WCH-6	March 11, 1986
Hogan	WWH-1	March 12, 1986
	WWH-2	March 12, 1986
	WWH-3	March 12, 1986
	WWH-4	March 12, 1986
	WWH-5	March 12, 1986
	WWH-6	March 12, 1986
	WWH-7	March 12, 1986
Levy	SL-1	March 14, 1986
	SL-2	March 14, 1986
	SL-3	March 14, 1986
	SL-4	March 14, 1986

Witness	Exhibit	Date Introduced
Mattson	RJM-1	March 14, 1986
McLeod	NBM-1	December 10, 1985
Rush	CHR-1	March 11, 1986
	CHR-2	March 11, 1986
	CHR-3(a),(b),(c)	March 11, 1986
Schink	GRS-1	March 12, 1986
	GRS-2	March 12, 1986
	GRS-3	March 12, 1986
	GRS-4	March 12, 1986
Sundermeir	WFS-1	December 6, 1985
Williams	RCW-1	January 7, 1986
Wroblewski	AW-1	December 10, 1985
	AW-2	December 10, 1985
	AW-3	December 10, 1985

Witness	Exhibit	Date Introduced
Watson	RLW-1	March 14, 1986
Noland	NSN-1	December 10, 1985
Brush	CHB-1	March 11, 1986
	CHB-2	March 11, 1986
	CHB-3(a),(b),(c)	March 11, 1986
Schunk	GRS-1	March 12, 1986
	GRS-2	March 12, 1986
	GRS-3	March 12, 1986
	GRS-4	March 12, 1986
Sundermeir	WES-1	December 6, 1985
Williams		January 7, 1986
Woodward	AS-1	December 10, 1985
	AN-2	December 10, 1985
	AS-3	December 10, 1985

Development of Revenue Requirement
(Ex. TPH-2A, pp. A-1 to A-5)

Philadelphia Electric Company - Electric Operations
INCOME AVAILABLE FOR RETURN
12 MONTHS ENDED JUNE 30, 1986
(Thousands)

	Actual (B-9)	Adjustments (A-3)	Proforma Pres. Rates	Addl. Revs. (A-4)	Proforma Proposed Rates
Operating Revenue	2,528,293	(26,300)	2,501,993	681,760	3,183,753
Operating Expenses					
Operating & Maintenance Exp.	1,502,703	143,979	1,646,682	(206,990)	1,439,692
Depn. & Amort. (incl. salvage)	164,429	96,734	261,163		261,163
Provision for Taxes					
Taxes Other Than Inc.	199,837	(112,573)	87,264	13,635	100,899
Income Taxes	132,673	(97,160)	35,513	435,527	471,040
Provision for Deferred Taxes	107,815	(66,804)	41,011		41,011
Income Taxes Def.-Other	(14,033)	459	(13,574)		(13,574)
ITC Adjustments-(net)	5,912	(10,313)	(3,401)		(3,401)
Total Taxes	433,204	(286,391)	146,813	449,162	595,975
Total Operating Expenses	2,100,336	(45,678)	2,054,658	242,172	2,296,830
Operating Income Avail. for Return	427,957	(19,378)	447,335	439,588	886,923
Original Cost Measure of Value (A-2)			6,943,888		6,943,888
Return on Original Cost			6.44%		12.77

Revised 2/14/86

Philadelphia Electric Company - Electric Operations
MEASURES OF VALUE
AT JUNE 30, 1986
(Thousand $)

	Reference	Original Cost
Utility Plant in Service		
Electric	C-2	8,732,973
Allocated Common	C-2	122,807
Total O.C. Plant in Service		8,855,780
Less: Book Reserve on Plant in Service	C-2	1,656,500
		7,199,280
Plus: Non-Revenue Producing CWIP	C-8	4,616
Land Held for Future Use	C-9	8,651
Materials and Supplies	C-10	94,168
Nuclear Fuel in Reactor	C-11	76,488
Cash Working Capital	C-12	96,451
Total Additions		280,374
Less: Accumulated Deferred Inc. Taxes		
Accelerated Amortization	B-2	2,323
Liberalized Depreciation	B-16	525,327
Customer Deposits	B-2	7,682
Customer Advances	B-2	434
Total Deductions		535,766
Measures Of Value		6,943,888

Philadelphia Electric Company - Electric Operations

ADJUSTMENTS TO INCOME AVAILABLE FOR RETURN

12 Months Ended June 30, 1986

(Thousand $)

Test Year Adjustments	Section Page	Operating Revenues	Oper. Exp. Excl. Taxes	Taxes Other Than Income	State Share Income Taxes	Federal Share Income Taxes	Effect on Income for Return
Elimination of STAC Revenue and Taxes	D-1	(126,007)		(117,721)	(8,286)		0
Full Year Effect of Present Base Rates	D-2	0		0	0	0	0
Annualization for Growth and Customers	D-3	38,771	13,805	775	1,688	10,351	12,152
Elimination of Energy Cost Adjustment	D-4	53,711	51,291	2,460			0
Wage and Benefit Increases	D-5		5,695		(397)	(2,437)	(2,861)
Book Depn at Year End, including Salvage	D-6		91,747				(91,747)
Tax Depreciation and Amort. at Year End	D-7				5,418	33,226	(38,644)
Normalization of Tax Deferrals	D-8				0	(70,025)	70,025
Tax Savings on Proforma Interest	D-9				(13,698)	(83,975)	97,667
Nuclear and Steam Prod. O&M Exp. Adj.	D-10		10,614		(741)	(4,542)	(5,331)
Reduction in O&M exp. to Reflect Retirm.	D-11		(11,135)		777	4,765	5,593
Miscellaneous Adjustments & Amortization	D-12		(4,932)		362	3,474	1,076
Elimination of Lansdale Revenue and Fuel	D-13	0	0		0	0	0
Full Year Effect of Incr. in FICA Tax	D-14			741	(52)	(317)	(372)
Decommissioning Cost Adjustment	D-15		8,026		(560)	(3,434)	(4,032)
Spent Fuel Disposal Cost Adjustment	D-16		3,803		(265)	(1,628)	(1,910)
Damaged Nuclear Fuel Assmly. Amort.	D-17		310		(22)	(132)	(155)
Full Year of Limerick O&M Expense	D-18	0	76,641		(5,347)	(32,796)	(38,496)
Non-Jurisdictional Rate of Return	D-19	7,225	(3,775)		767	4,707	5,526
ITC Annualization	D-20				0	(10,313)	10,313
Adjustment to Roll Fuel Cut of Base Rate	D-21*	(211,214)	(206,990)	(4,224)			0
Adjustment to Reflect Storm Damage Exp.	D-22		667		(47)	(285)	(335)
Adjust. to Local RE Tax - MgO Facility	D-23			1212	(85)	(518)	(609)
Adjust. to Recover loss on Uranium Proj.	D-24		1,532		0	0	(1,532)
Delaware Station Term. Date Change Adj	D-25		(2,590)			32	2,558
Adj. to Eliminate Brandrum Reservoir	D-26		(438)		108	110	220
Adj. to Reflect CPR Audit	D-27		(11)		2	4	5
Adj. to Correct EEI Dues Overstatement	D-28		(537)		37	230	270
Total		(25,300)	240,713	(112,573)	(20,315)	(153,503)	19,378

* Not reflected in totals; included on A-4

Philadelphia Electric Company - Electric Operations
EFFECTS ON INCOME FOR RETURN
OF SUPPLEMENT NO. 15
12 Months Ending June 30, 1986
(Thousands $)

Increase in Base Rates

		Base Rate Increase prior To Fuel Roll-out	Fuel Roll-out From Base @ $.007505/kwh per D-21	Net Base Rate Increase
D-1	Elimination of ECC Energy Cost Adjustment	892,974	(211,214)	681,760
D-2	Fuel Tax Effect of Energy Rate Adjustment			
D-3	Base and Energy Increase		(206,990)	(206,990)
D-4	Tax Depreciation and Basis, at Year End			
D-5	Normalization of Tax Depreciation	875,113	0	875,113
D-6	Tax Savings on Pension Interest			
D-10	Nuclear and Steam Prod. O&M Exp. (A)	435,527		4,355,270
D-11	Reduction in O&M exp. to reflect returns			
D-12	Miscellaneous Adjustments & Reclassifications			4,355,270
D-13	Elimination of Lucasville Revenue and Fuel			
D-14	Fuel Tax Effect of Incr. in PIGA Tax			
D-15	Decommissioning Cost Adjustment			
D-16	Some Fuel Disposal Cost Adjustments			
D-17	Changed Nuclear Fuel Energy Incorp.			
D-18	Full Year of Limerick O&M Expense			
D-19	Normalized/Actual Rate of Return			
D-20	ITC Amortization			
D-21	Adjustment to Roll Fuel Out of Base Rate			
D-22	Adjustment to Reflect Storm Damage Exp.			
D-23	Adjust. to Local DC Tax - Red Facility			
D-24	Adjust. to Recover Loss on Leasing Act.			
D-25	Delaware Station Fuel Data Change Adj			
D-26	Adj. to Eliminate Pension Reserve			
D-27	Adj. to Reflect DCA Rate			
D-28	Adj. to Correct ECC Base Overstatement			
	Total			

Increase in Revenue (A-5)

Less: 5% Gross Receipts Tax

Less: Fuel Rolled-out of Base

Increase in Income before Taxes

Increase in Income Taxes @ 49.768%

Increase in Income for Return

* Not reflected in Schedule; included on A-4

Philadelphia Electric Company - Electric Operations
Kilowatt Hour Sales and Revenue by Tariff Subdivisions
Twelve Months Ended June 30, 1986
($1,000)

	mWh Sales Year Ended 6/30/86 (1)	Number of Customers 6/30/86 (2)	Total Book Rev (3)	Less: Book STAC (4)	Less: Book Energy Cost Rate Revenue (5)	Base Revenue (6)=(3)-(4)-(5)	Proposed Base Revenue Prior to Roll-Out (7)	Roll-out of .7505¢/kWh Per D-21 (8)=1x.7505¢	Proposed Net Base Revenue Supp.No.15 (9)=(7)+(8)	$ Increase (10)=(9)-(6)	% Increase (11)=(10)/(6)
R	6,465,900	1,120,500	$769,638	$40,779	($10,608)	$739,467	$1,007,200	($48,527)	$958,673	$219,206	29.6%
RH	1,543,300	97,300	131,968	7,025	(2,481)	127,424	172,009	(11,582)	160,427	33,003	25.9
OP-Off Peak (MH)	393,600	102,250 (a)	26,686	1,433	(736)	25,989	28,943	(2,954)	25,989	0	0
POL	8,320	3,430 (a)	1,596	84	(15)	1,527	1,589	(62)	1,527	0	0
GS	3,406,780	120,027	357,866	18,957	(5,929)	344,838	472,610	(25,568)	447,042	102,204	29.6
PD(Incl Riders)	2,241,000	2,620	197,446	10,497	(4,061)	191,010	264,458	(16,818)	247,640	56,630	29.6
HT(Incl Riders)	12,696,300	2,316	885,276	47,318	(23,025)	860,983	1,211,355	(95,286)	1,116,069	255,086	29.6
EP-A	431,500	1	32,567	1,696	(807)	31,683	36,392	(3,238)	33,154	1,471	12.7 (b)
EP-S	268,500	2	20,780	1,151	(476)	20,100	25,103	(2,015)	23,088	2,988	14.9
SLP	104,148	2	15,654	823	(162)	14,993	15,775	(782)	14,993	0	0
SLS	60,840	535	19,007	995	(117)	18,129	18,586	(457)	18,129	0	0
TL	32,880	205	3,620	191	(57)	3,486	3,733	(247)	3,486	0	0
BLI	62	3	7	-	-	7	10	(1)	9	2	28.6
Trans Rent Rider	-	(a)	323	17	-	306	395	-	395	89	29.1
Total Electric	27,653,130	1,343,511	$2,462,434	$130,966	($48,474)	$2,379,942	$3,258,158	($207,537)	$3,050,621	$670,679	28.2%
Other Elec. Operations	513,200	2	65,859	-	-	65,859	65,859	-	65,859	-	-
Total Electric	28,166,330	1,343,513	$2,528,293	$130,966	($48,474)	$2,445,801	$3,324,017	($207,537)	$3,116,480	$670,679	27.4%
Plus: STAC in Excess of STAC Related Taxes (D-1)						4,959	4,959	-	4,959	-	-
Plus: Revenue from Growth Adjustment (D-3)						38,771	53,529	(3,677)	49,852	11,081	28.6
Plus: Interest on ECR Overcollections (D-4)						5,237	5,237	-	5,237	-	-
Plus: Non-Jurisdictional Rates Adjustment (D-19)						7,225	7,225	-	7,225	-	-
Total Revenue						$2,501,993	$3,394,967	($211,214)	$3,183,753	$681,760	27.2%

(a) Duplicate customers not included in total.
(b) Percentage shown is based on comparison of proposed revenue and revenue associated with actual load characteristics reflected in the March 1985 contract agreement. Refer to the Company's proof of revenue calculations, Interrogatory response IV-C-1, for the details supporting this percentage.