PECO STATEMENT NO. 1

PENNSYLVANIA PUBLIC UTILITY COMMISSION v.
PHILADELPHIA ELECTRIC COMPANY
Docket No. R-850152

DIRECT TESTIMONY OF
VINCENT S. BOYER

LIMERICK 1 AND COMMON PLANT
OVERVIEW AND DECISIONS
RESPECTING SCHEDULED COMPLETION

September 27, 1985

TESTIMONY OF VINCENT S. BOYER

Q. Please state your name and address for the record.

A. Vincent S. Boyer, 2301 Market Street, Philadelphia, Pennsylvania.

Q. By whom are you employed, Mr. Boyer, and in what capacity?

A. I am Senior Vice President, Nuclear Power, of Philadelphia Electric Company (PECO).

Q. What is your educational background?

A. I received a Bachelor of Science Degree in Mechanical Engineering from Swarthmore College in 1939. I received a Master of Science Degree in Mechanical Engineering in 1944 from the University of Pennsylvania. I have also taken graduate courses in nuclear reactor engineering and nuclear instrumentation at the University of Pennsylvania and Drexel University.

Q. Please describe your experience prior to your present position.

A. In 1939, I joined PECO as Engineer of Plant Tests in the Electric Operations Department. Following service in the United States Navy from 1944 to 1946, I returned to PECO and served in various supervisory positions in power stations, where I had responsibility for the maintenance and operation of boiler plant equipment. In 1951, I was transferred to the Mechanical Engineering Division, where I was engaged in power station design. I was appointed Assistant Superintendent of the Company's Cromby Station in 1953 and I assisted in directing the operator's training program and in placing the two units of the Cromby Station in service. In 1956, I was appointed Superintendent of the Cromby Station. In 1960, I was designated Superintendent of the Company's Peach Bottom Atomic Power Station, and, in 1963, I was appointed Manager of Nuclear Power in the Electric Operations Department. In January 1965, I was designated Manager of the Electric

Operations Department. In October 1968, I was appointed to the position of Vice President, Engineering & Research. I was elected to my present position of Senior Vice President, Nuclear Power in January 1980.

Q. Are you active in any professional organizations?

A. I am a Fellow of the American Society of Mechanical Engineers and past Chairman of its Philadelphia Section. I am a Fellow of the American Nuclear Society, a past President and Director of the Society and have served as Chairman of its Reactor Operations Division. I have also served as President of the Philadelphia Post of the Society of American Military Engineers. I am a registered Professional Engineer and a member of the National Society of Professional Engineers.

Q. Have you served or do you presently serve on any industry committees?

A. Yes. For the Edison Electric Institute, I served as Chairman of the Utility Occupational Radiation Exposure Group and Chairman of the Nuclear Power Executive Advisory Committee. For the Atomic Industrial Forum, I serve as Chairman of the Committee on Three Mile Island Unit 2 Recovery and as a member of the Policy Committee on Nuclear Regulations. For the Gas-Cooled Reactor Associates, I serve as a Chairman of the Management Committee. I was also the American Nuclear Society representative to the Coordinating Committee on Energy of the Association for Cooperation in Engineering and Chairman of the Public Policy Committee, and am presently a member of the Honors and Awards Committee of the Reactor Operations Division. I am a member of the Steering Committee of the BWR Owners Group and a past member of the Mark II Owners Group, and was Chairman of the American Society of Mechanical Engineers Committee on Industry Relations.

Q. Have you previously testified in other proceedings?

A. I testified in every PECO electric rate proceeding conducted before the PUC between the years 1971 and 1977 (i.e. a total of 4 cases). In addition, I presented testimony in the 1980 Limerick Investigation and the current Limerick 2 Show Cause proceeding. My testimony in these proceedings addressed such subjects as the capacity need and economic advantage of completing additional generating capacity including Limerick, the processes employed by the Company to plan additional capacity, the reasons for and process for planning plant retirements, anticipated nuclear plant capacity factors and other similar subjects.

Q. What is the purpose of your testimony?

A. My testimony is divided into three sections:

First, I will (a) describe the main characteristics of the Limerick Generating Station, Unit No. 1 and Common Plant which is being included in PECO's rate base for the first time in this proceeding; and (b) summarize PECO's involvement and experience in nuclear power.

Second, I will briefly review the decision to build the Limerick Generating Station both at its inception and in the continued justification analyses performed through the 1970s and early 1980s. I will also explain, from a construction manager's viewpoint, the several scheduled completion dates adopted for the plant during this period.

Finally, I will support the Company's request that all of the Limerick Station Common Plant be included in rate base upon the commercial operation of Unit 1, and will explain the engineering and practical reasons why such plant is used and useful.

1. DESCRIPTION OF LIMERICK STATION AND PECO NUCLEAR EXPERIENCE

Q. What has been your involvement with the Limerick Generating Station?

A. I have been involved in the management decisions concerning the Limerick Generating Station since its inception.

This project, as well as all nuclear fueled electric generating stations, falls within my area of responsibility as Senior Vice President, Nuclear Power. Additionally, the Engineering & Research Department, which I headed from 1968 until January 1980, has cognizance over the design and construction of all new electric generating plants, whether fossil-fueled, nuclear-fueled or hydroelectric.

Q. Please describe briefly the Limerick Generating Station.

A. The Limerick Generating Station consists of two 1055 MW turbine generator units, each of which operates at 1800 rpm and is served by its own nuclear steam supply system - a single cycle, forced circulation, boiling water reactor system - capable of producing 14,156,000 pounds/hour of steam at 1000 psig and 550° F. Unit No. 1 is currently undergoing pre-commercial testing and is scheduled to be in commercial operation in the first quarter of 1986. The major features of the station include the main generating station building which houses the turbine generator units, the reactors and their associated equipment, and the administrative and maintenance areas; two cooling towers; a river water intake and pumping structure; and a circulating water pump structure. Adjacent to the generating facilities there are two electric substations, one of 500 kV and the other of 220 kV, each with conventional substation equipment such as circuit breakers, buses and supporting structures, switch gear, transformers, and control buildings.

Q. Mr. Boyer, please describe the water supply system which will be used at Limerick.

A. The main condenser cooling water system for the Limerick Generating Station is a recirculating, closed system with cooling towers. Makeup rates to replenish cooling tower water lost due to evaporation at the cooling towers must be supplied from an adequate source on a continuous basis during plant operations. The primary source of this makeup water will be the Schuylkill River. However, the Delaware River Basin Commission ("DRBC") has imposed restrictions that limit withdrawal of water from the Schuylkill River during periods of low flow and high river water temperature. Therefore, a supplemental supply is needed to augment water taken from the Schuylkill River to meet these restrictions. This additional water is to be diverted from the Delaware River to the Perkiomen Creek, and then pumped to the Limerick Generating Station through the Perkiomen Pumphouse and Pipeline.

Construction of the water diversion facilities began in January 1983. These facilities were initially scheduled for completion by late July 1984. However, construction has been delayed by litigation. On January 3, 1985, the Court of Common Pleas of Bucks County - Civil ruled that the Company's existing contract rights are enforceable and, therefore, Bucks County is contractually obligated to "operate and maintain the Point Pleasant Pumping Station and combined transmission main." On February 27, 1985 in its Opinion Sur Exception, the Court denied the County's exception to the decision. The Court's decision enables the Company to proceed with the construction of the facilities. The County and other defendants have filed appeals to the appellate court.

The Company has aggressively sought to enforce its contractual rights and expedite completion of the Point Pleasant facilities. While this litigation continues, PECO is actively pursuing short-term solutions to assure water availability. The Company on March 15, 1985 submitted an application to the DRBC for approval of the temporary substitution of in-stream monitoring of dissolved oxygen levels in the Schuylkill River in place of the 15°C temperature constraint on withdrawals. This request was approved on May 29, 1985.

In addition, on May 30, 1985, PECO filed with the DRBC an application for the consumptive use of water allocations of Metropolitan Edison's Titus Station Units No. 1, 2 & 3, and PECO's Cromby Station Unit No. 2. This request was approved on August 9, 1985.

On July 3, 1985, the Company filed with the DRBC an application for temporary withdrawal of water released under a variance from the Beechwood Pit, owned by the Reading Anthracite Company. The water supply from this source alone equals approximately 2.2 billion gallons, and would be a sufficient quantity to meet Limerick's consumptive needs through early commercial operation when the Schuylkill River is otherwise unavailable. On September 20, 1985, the Company filed a letter with the DRBC modifying this request. This request has not yet been acted upon by the DRBC. Finally, also on September 20, 1985, the Company filed an application with the DRBC requesting a modification of the flow restrictions imposed on Schuylkill water use from 530 cfs to 415 cfs. This request has also not yet been acted upon. Additional sources of interim water supply are available and requests for their use can be presented to the DRBC as required. Moreover, the various approvals described above, which are presently limited to 1985 operations, can be extended.

The Company believes that, based upon these and other on-going efforts, an adequate supply of water to permit full commercial operation of Limerick is or will be available.

Q. What background and experience does PECO have in the use of nuclear energy for the generation of electricity?

A. PECO has been active in the development of atomic energy generation for over thirty years. In 1952, PECO became a charter member of the Dow Chemical - Detroit Edison Nuclear Power Development Project, which subsequently became Atomic Power Development Association, Incorporated (APDA).

This organization designed and developed a fast breeder power reactor for the Atomic Energy Commission's ("AEC's") Power Demonstration Program. The Company also participated in the formation of Power Reactor Development Company, which was organized to finance, construct, own and operate the fast breeder reactor designed by APDA for the Enrico Fermi Atomic Power Station. The Company's engineers have participated at various times on a full-time basis in many phases of nuclear projects undertaken by the electric utility industry in the 1950s and 1960s, including the development and implementation of plant design and operation.

In 1958, in response to invitations from the Federal government for the industry to participate in the development of nuclear energy for the generation of electricity, PECO, supported by 52 other electric utilities, submitted a proposal for the construction and operation of the world's first high-temperature, helium-cooled reactor. Following approval of the proposal by the AEC, the plant, now known as Peach Bottom No. 1, was constructed and successfully operated for a period of seven years, during which time 1.2 million net electrical MWh were produced for the PECO grid over a lifetime of 1349 equivalent full-power days. Peach Bottom No. 1 was retired in 1975, having very successfully fulfilled its role as a prototype reactor.

In 1974, following the appropriate regulatory approvals, we placed in operation Units 2 and 3 at Peach Bottom, each with a design electrical rating of 1065 MW electric. These units, owned jointly with Public Service Electric and Gas Company, Delmarva Power and Light Company, and Atlantic Electric Company, use boiling water reactors and have been providing reliable, low-cost energy for our customers. Together with the three other utilities just mentioned, we are also joint owners of Salem Units 1 and 2. These units, which employ pressurized water reactors and are similar in size to the Peach Bottom Units, are located in Salem County, New Jersey, were placed in service in 1977 and 1981, and are operated by Public Service Electric and Gas Company.

2. INITIAL DECISIONS TO CONSTRUCT, CONTINUED JUSTIFICATION ANALYSES AND SCHEDULED COMPLETION DATES

a. Initial Decisions to Construct

Q. What was the basis for the Company's initial decision to build additional nuclear capacity and to locate such generation at the Limerick site?

A. I responded to that question in detail in the first Limerick Investigation at Docket No. I-80100341. Instead of repeating my answer here, I have attached the pertinent portion of my testimony in that proceeding as Appendix A.

As explained in Appendix A, the load/capacity forecasts, the PJM reserve obligations, and the social and regulatory pressures of the late 1960s prompted the initiation of the Limerick Generating Station. Because the Company had sufficient generation for cycling and peaking service, it was clear that the new facility should be for base-load operation. After careful and repeated analyses of various fuel sources, it was concluded that nuclear generation was the most economic alternative. The Limerick site was chosen after a thorough investigation by PECO and outside consultants of alternatives compared on the basis of economic, environmental and social factors. Selection of the Limerick site curtailed the use of Pennsylvania land resources, avoided adverse environmental impacts, and minimized the capital investment in the project while enhancing overall system reliability and service to the Company's customers.

The PUC, in the first Limerick Investigation, expressly approved the Company's initial determination that additional capacity was needed, its selection of the nuclear alternative and its choice of the Limerick site. The Commission found that "PECO's decision to build a nuclear station at Limerick was reasonable at the time it was made, and was a valid exercise of managerial discretion." Further, the PUC stated: "We agree with the finding of the Nuclear Regulatory Commission that the site chosen was the best available." Finally, the Commission noted its prior granting in 1971 of an application for a finding of necessity for certain site construction activities.

After the decision was made to construct a nuclear plant, the Company requested and evaluated bids from NSSS suppliers and Architect-Engineer firms to supply the equipment and assist in the engineering and construction of the plant. General Electric was selected as the NSSS supplier based upon cost considerations and our preference for BWR technology. Bechtel Corporation was selected as the A/E because its bid was cost competitive, it was the most experienced firm in the nuclear area and it agreed to transfer experienced engineers from the Peach Bottom Project to the Limerick Project. In addition, as both General Electric and Bechtel had participated in the construction of Peach Bottom, we believed that substantial cost savings would be realized by replication of this prior effort.

Q. When was the formal capital authorization for the Limerick plant approved by Company management?

A. The Limerick project was developed and approved in concept by Corporate Management in the 1968 Construction Budget. Meetings were then held with the AEC, the Pennsylvania PUC and Department of Forests and Waters, the DRBC and various vendor and Architect-Engineer firms leading to a definition of the project with more complete cost estimates. With the award of the design-construction contract to Bechtel, the Preliminary Safety Analysis Report was prepared and submitted to the AEC in February 1970. In June 1970, a request for an Environmental Report was received from the AEC in conformance with the National Environmental Policy Act ("NEPA") of 1969. The formal capital authorization for Limerick's construction was approved by Corporate Management in January 1971.

Q. Was the Construction Permit issued within the time frame originally anticipated by PECO?

A. No. The issuance of the Construction Permit was substantially delayed because of new environmental evaluations which the AEC was required to make under NEPA and because of an extended hearing process. Consideration of the application was suspended for some time to comply with these requirements which were not considered applicable at the time of its filing. The Construction Permit was not issued until June 1974.

b. <u>Continued Justification Analyses</u>

Q. Please describe the analyses which PECO conducted during Limerick's construction to assure that its continuation was justified.

A. The Company, throughout the 1970's, continuously analyzed the need for the additional generating capacity represented by Limerick through its annual capacity planning process. This process begins with the forecast of future annual sales and peak demands. At least once a year, the sales and peak demands are estimated for up to twenty years into the future. In addition, the reserves necessary to reliably supply these forecasted demands are calculated. The amount of generation reserves required depends on the desired reliability of the system. The PJM Interconnection reliability criterion, which is widely used by many other electric utilities, is that customers will not experience a curtailment in electric service more often than one day every ten years because of an inadequate supply of generation. For Philadelphia Electric Company and other members of the PJM Interconnection, the required reserve generating capacity has been recently calculated to be approximately 25% of the estimated annual peak demand.

The combination of the Company's peak load demand plus reserve requirements yields the total future generation required. This generation requirement is compared to the installed generation, which is calculated by deducting scheduled retirements and adding in commitments to new capacity. When the total forecasted generation requirement exceeds the projected supply, additional capacity is planned. This process is described in greater detail by Mr. Rush.

Table 1 illustrates the results of these annual capacity planning analyses. As shown, in the early 1970s, projected reserves even with the Limerick Units were at or below the target reserve margin required to assure service reliability. Required reserve levels were obtained only by planning and initiating construction of additional major stations, including the Fulton and Summit nuclear stations. As projected load levels declined, these stations as well as proposed coal and oil plants, all of which were substantially less progressed than Limerick, were cancelled. In the later years, the numbers above the line in the Limerick service years indicate what the reserves would have been without the proposed Limerick Units. These reserves are all at or below the current 25% reserve criteria, thus indicating continuing need for both Limerick Units.

The Company also continuously examined the economics of nuclear generation against other types of capacity. Both oil and coal-fired generation were compared to nuclear. These analyses, more fully described by Mr. Rush, indicated that nuclear capacity was substantially more economic than fossil for our service territory. In fact, between 1974 and 1978 the average total cost of coal and oil-fired generation exceeded nuclear capacity by 36% and 46% respectively. I should note that these analyses do not reflect the substantial advantage of continuing with the Limerick Project in light of the substantial investment already made in the Project at the time of analysis. The combination of these analyses (i.e. of comparative generation plant economics) and our studies described above showing the need for additional capacity demonstrated to us throughout the late 1970s and early 1980s that continued construction of Limerick was both necessary and desirable.

In addition to these Company studies, the superiority of nuclear generation was consistently confirmed by independent sources. In 1976, for example, Mr. Leonard Reichle, Senior Vice President of Ebasco Services, Inc., presented a paper on "The Economics of Nuclear Power" in which he compared nuclear and coal-fired generation at a hypothetical 2-unit 2400 MW station in the Central Atlantic region with service dates of 1987 and 1989, and concluded that nuclear power was 27%

cheaper than the coal alternative. Another comparative generation study was performed by the National Academy of Sciences in 1979 ("Energy in Transition 1985-2010"). This analysis concluded:

> "National policy should support the continued use of nuclear power for the next few decades. The rationale for such support rests on the availability of nuclear power as a domestic energy resource whose risks are at worst comparable to those of other energy sources, its competitive economics, and the undesirability of relying too heavily on coal or nuclear power, to the exclusion of the other, until the risks of each are better understood."

In addition, the Company performed two separate computer analyses in 1979 and 1980 which further confirmed the continuing need for and economic desirability of the Limerick capacity. Our 1979 study was performed in response to an analysis presented by the Pennsylvania Consumer Advocate in our 1979 rate case and was itself presented to the Commission in that case. Even employing assumptions suggested by the Advocate, it demonstrated the desirability of continued Limerick construction.

The 1980 study was entitled "Comparison of the Limerick Nuclear Station With Other Alternatives Updated to September 1980", and consisted of a computer based analysis of Limerick's economics under a number of alternative assumptions, including such unfavorable assumptions as

- zero PECO load growth;
- reduction of Limerick capacity factor from 70% to 60%;
- reduction in fossil fuel cost escalation rates from 12% to 8%; and
- an increase of Limerick nuclear capacity costs of $1 billion over the then current estimate.

The 1980 analysis concluded as follows:

"The Limerick nuclear project should be completed as fast as possible because it is in the national and PECO customers' interest. It will reduce the consumption of oil and will result in lower PECO revenue requirements from its customers than any other alternative available to PECO. The abandonment of the Limerick project will not only leave a large debt to be amortized, but also lose the benefits of oil conservation and lower revenue requirements. Detailed economic analyses have brought out that under reasonable assumptions and unfavorable departures from them, the Limerick nuclear plant will result in lower annual PECO revenue requirements than the following situations:

1. PECO had not started Limerick or any other alternative generation plant.

2. PECO had not started Limerick and started at the end of 1980 to install an alternative coal generation plant.

3. PECO had started at the end of 1980 to convert the Limerick nuclear plant to coal fired operation.

4. PECO abandons at the end of 1980 the Limerick nuclear project."

Thus, the Company has conducted a number of analyses throughout the 1970s and early 1980s, all of which have confirmed the continued need for and economic superiority of the Limerick plant.

Q. Did the PUC review the continuing need for the Limerick Generating Station during its construction?

A. Yes. In both the Company's 1979 Rate Case at RID 865 and the first Limerick Investigation at Docket No. I-80100341, the Commission was presented with extensive data indicating that there was a continuing economic justification for the Limerick plant. In the 1980 Limerick Investigation, the ALJ concluded that

"(T)here can be no doubt as to the economics of and need for the completion of both Limerick units. There has been no analysis presented which, using plausible assumptions, has shown Limerick to be uneconomic. Rather, all reasonable analyses have shown that Limerick will produce economic benefits to ratepayers over any proposed alternative."

Although the Commission ultimately determined that immediate construction of Limerick Unit 2 should not be continued for financial reasons, it found that "customer savings associated with the completion of the units still do exist" and "encourage[d] the Company to complete [Unit 1] as rapidly as possible consistent with the public safety . . . to retain for ratepayers the lower future revenue requirements and customer savings." Requests by opposing parties in each proceeding that the Company be directed to cancel the units were rejected.

c. Scheduled Completion Dates

Q. Mr. Boyer, the Company announced deferrals in the completion of Limerick 1 and Common in 1974, 1976 and 1978. What was the effect of these announcements upon the Limerick Project as perceived by the construction organization which you headed at the time?

A. As construction managers, the role of the E&R Department was to develop construction schedules and programs which would implement management's funding and completion date directives. In performing this function, consistent with management's objectives, we sought: (1) to minimize funding requirements in the early years of construction as required by financial constraints; and (2) to retain the option of accelerated completion of the project as compared to the announced completion dates in the event additional funding became available and such completion were to appear desirable. Of course, we also sought to construct the plant as efficiently and promptly as possible.

In performing our function, we developed construction schedules. These schedules are shown on Table 2 along with the associated announced completion schedules. As there shown, our construction target completion date was almost always earlier than the announced schedule. This reflected two objectives of ours and of Senior Management. First, throughout this period, i.e. the mid and late 1970s, we sought to employ the available cash to achieve the greatest overall schedule progress. Further, we developed our construction schedules on the assumption that additional funds would be available in later years to permit the plant's completion as planned. Through this process, we preserved for as long as possible the option of earlier than announced plant completion.

Second, we maintained early construction target completion dates in order to place maximum pressure upon our contractors and their craft laborers to progress construction efficiently and rapidly. Throughout this period, the projected completion date as shown in the construction schedule was only deferred after every attempt had been made to meet the earlier target date. As I explain below, cash unavailability, recognition of additional work scope due principally to new NRC requirements, labor unavailability and reduced labor effectiveness were the principal causes of these schedule extensions.

Q. Please describe in greater detail the effects upon the construction schedule of the 1974 public announcement?

A. As shown in Table 2, we started 1974 with a projected Limerick 1 fuel load date of January 1979. By mid-year, delay in the receipt of the Construction Permit made it apparent that fuel load would probably not occur before June 1979, though no public announcement of this date was made. In September 1974, as described by Mr. Paquette, the cash budgeted for Limerick in future years was reduced and the publicly announced fuel load date for Limerick was postponed until October 1980. Pursuant to the objectives which I have described above, the construction target fuel load schedule was retained as June 1979. However, by May 1975, lack of sufficient funds and early recognition of the possible effects of changing NRC regulatory requirements necessitated a construction target fuel load postponement to August 1980.

Q. What were the effects upon the construction schedule of the 1976 public announcement?

A. Throughout 1975 to May 1976, we continually reviewed the need for and financial implications of keeping Limerick 1 on a 1980 fuel load schedule. Due to the Company's poor financial condition, the 1975 budgeted cash for Limerick direct costs was reduced from $179 million to $113 million. Maintaining the 1980-81 fuel load dates, it was recognized, would require $186 million in 1976 and $251 million in 1977. By mid-1975, consideration was being given to reducing Limerick expenditures still further. Contingency plans were thus developed with Bechtel to hold Limerick direct costs at $125 million per year.

In April 1976, revised PECO forecast plans held 1976 Limerick expenditures to about $150 million, and overall PECO annual total construction expenditures to about $400 million. As shown on Table 2, in May of 1976, the Company announced a two-year delay in the Limerick fuel load date, i.e. from October 1980 to October 1982. However, again pursuant to the objectives described above, the construction target fuel load date was extended only from August 1980 until October 1981, a period of 14 months.

Q. Please now describe the effects upon the construction schedule of the 1978 deferral announcement?

A. The 1977 cash budget for Limerick included sufficient funds, i.e. $155 million, to maintain the then construction target fuel load date, i.e. October 1981. However, our analysis (i.e. in Spring 1977) showed that this fuel load date would require significant increased revenues in the immediate years following the placement of the plant in service (i.e. a net of capital charges and fuel savings of $187 million), which increase would not be offset by savings of advanced plant completion for eight years. Our calculation of net lifetime ratepayer savings of this completion advancement was only $159 million. A further study made in the fall of 1977 produced similar results, i.e. a $159 million initial net cost penalty of advancement, with a break even point from plant cost savings of 6 years and a total net lifetime ratepayer savings of about $123 million. Yet a further study, described by Mr. Paquette, was conducted early in 1978 with similar results.

During January 1978, it became apparent that increased funding to meet an October 1981 construction target fuel load date would not be forthcoming, and the target date was slipped to March 1982. In April 1978, a preliminary construction forecast for the years 1978 through 1982 was prepared, on the basis of holding to a construction target fuel load of October 1982. In view of anticipated depressed earnings, a revised forecast with Limerick postponed two years to 1984-1986 fuel load and with a reduction in financing needs of $139 million in 1979 to 1981 was also prepared. Following extensive analysis, the revised forecast (i.e. 1984-86 fuel load dates) was adopted. This plan minimized the financing requirements in the 1978 through 1982 period, and had minimum revenue requirements through the 1983-87 period. Thus, in May 1978, PECO publicly announced the stretched out fuel load date of 1984. In conjunction with this announcement, and in recognition of the effects of increased work scope due principally to changed NRC requirements as described below, the construction target fuel load schedule for Limerick 1 was slipped to October 1982.

Q. Please continue with your discussion of events as they unfolded in 1978 through 1980.

A. By mid-1978, we were following a construction cash forecast based on 1984-86 Limerick fuel load dates, but with sufficient cash in 1978 to permit a two-year advancement if additional funding were available beginning in 1979. In October, 1978, a draft five-year construction forecast was prepared with the Limerick fuel load dates of 1984-86. A back-up forecast was also prepared with 1982-84 fuel load dates.

The PECO 1979 cash construction budget was approved in January 1979. This provided for $118 million for Limerick in 1979. In March 1979, special approval from the Board of Directors was sought and obtained for an additional $18 million so as to be able to maintain the possibility of 1982-84 Limerick fuel load dates. Indeed, throughout the 1978 to 1980 period, this target was the completion date to which we were working. This schedule was viewed as achievable throughout most of this period. However, a number of factors combined such that in 1980 we realized that this schedule could not be achieved. It became clear at that time that manpower availability and labor effectiveness in the installation of bulk commodities such as conduit and pipe were not meeting the target values. The manhours to install the seismic design of pipe hangers and restraints proved greater than estimated, and interferences introduced by these hangers to duct work and cable trays also required additional manhours to resolve. As the NRC action items resulting from Three Mile Island were issued and as additional NRC required design changes were recognized, significant additional manhours of job effort were added such that a lengthened project schedule became necessary. In June 1980, the construction target fuel load date was delayed from October 1982 to October 1983 due to the recognition of additional work scope associated with new NRC requirements, the TMI accident and a shortage of pipefitters.

In view of this revision in the field construction schedule and an associated cost increase, a meeting was held in Philadelphia with Bechtel Power Corporation at which the background and basis for the revisions were presented and discussed. This meeting was held on July 15, 1980, and in attendance were the Vice Presidents of the Bechtel Power Group, Project Management and Construction as well as their staff representatives. Philadelphia Electric Company was represented by the Senior Vice President, Nuclear Power, the Vice President of Engineering & Research, the Project Manager, and appropriate Construction and Engineering personnel. Immediately following this meeting, a presentation and summary were presented to our President, Mr. Everett.

In October 1980, Forecast 5 was developed and presented to PE by Bechtel. This forecast recommended a fuel load date of October 1984, based on an evaluation of bulk commodity installation rates, required manual staffing levels and the impact of project scope increases caused by regulatory changes. The recommendation for a construction target fuel load date of October 1984 was adopted.

Following the issuance of this Forecast, a complete review of the Limerick costs and schedules was presented by Bechtel and the E&R Department to the Company President and Executive Vice President on December 19, 1980. The meeting was attended by the appropriate PECO Vice Presidents and Project Managers, as well as the Bechtel Project Manager and scheduling personnel. Reasons for the schedule extension and projected plant cost increase were the subject of detailed inquiry.

To emphasize the Company's concern over the schedule extensions and cost increases, in January 1981, the Board of Directors visited Bechtel in San Francisco and General Electric in San Jose. A full day's program was presented to the Board by the responsible personnel of Bechtel, Philadelphia Electric and General Electric. Corporate management of both Bechtel and General Electric participated in the meetings. In addition to a review of the project, the Board received a thorough discussion of the work schedules and costs for the effort remaining to place the plant in commercial operation. Emphasis was placed upon the Company's concern that completion of the project be expedited and that costs be held to the minimum possible level.

Q. Mr. Boyer, at several places in your testimony, you have stated that funding levels were requested to permit earlier than publicly announced Limerick completion (i.e. 1976-1980). In retrospect, with the knowledge that you have gained by completing the construction of the plant, were these funding levels sufficient to permit plant completion upon the proposed dates?

A. No, they were not. Our judgments respecting the cash required for plant completion were based upon our understanding of the Project scope in those years. As I have explained above, and as is explained in greater detail by Mr. Kemper and Mr. Clarey, the Project's scope as we understood it in 1976 to 1980 turned out to be greatly underestimated. Because of new and changed NRC design requirements, the Mark II containment new loads problem, reduced labor effectiveness as compared to our estimates due principally to increased congestion and enhanced QA/QC requirements attributable to new or revised NRC requirements, labor unavailability and other factors, the funding levels provided would not have permitted Project completion by the earlier target dates. Indeed, even as late as 1980, we did not fully appreciate the scope of work required on the Project. Substantially greater work has been performed in the last four years of Project construction than we anticipated would be the case in 1980 when the October 1984 fuel load schedule was adopted.

Q. Why was the Company unaware in the 1976 to 1980 period of the full scope of work which was ultimately required to complete Limerick 1 and Common Plant's construction?

A. We were unaware of the full scope of work because the plant which we have constructed is not the plant which we had designed or planned to construct during that period. As described in PECO Exhibit 2, which Exhibit will be discussed in detail by others, substantial additional commodities, engineering and craft manhours, additional testing and equipment installation were required principally by changing NRC requirements for the design of a licensable plant. We did not and could not forsee that these requirements would be imposed.

Q. Mr. Boyer, could the Company have completed Limerick 1 and Common Plant any earlier than it did?

A. Obviously, that is a very hypothetical question. My answer is that no, given the circumstances that we faced and the resources that we had available, we could not have completed the plant earlier than we in fact did. As explained by Mr. Paquette, during the early years of the Project the amount of money which we could spend had to be restricted. Moreover, the amount of money which we needed grew substantially because of the NRC-imposed changes in the plant, further exacerbating our cash constraint problems. As described in PECO Exhibit 2, a number of those changes were imposed very late in the Project, in 1980 to as late as 1983. For instance, new NRC requirements resulting from the TMI accident in March of 1979 were issued through May of 1983. Compliance with these requirements delayed engineering completion until mid-1983. Consequently, related construction activities could not be completed until mid-1984. Another example of these late-imposed regulatory changes is the NRC's fire protection requirements. Although some of these requirements were imposed in 1975-1976 following the Brown's Ferry fire, the major fire protection regulations such as Appendix R were not issued until 1981. Engineering for these regulatory changes was not completed until mid-1984, while construction of additions and modifications could not be completed until September 1984.

Because of these and other late additions to work scope as a result of NRC requirements, substantial rescheduling had to be done and inefficiencies were generated in startup and system completion activities. In light of all of these factors, many of which are more thoroughly described in other testimony, and including the licensing delay I describe below, I do not believe that we could have significantly shortened the Project's duration.

Q. Please discuss the delays in the Limerick licensing process and its impact on the project's duration?

A. A further cause of delay in Limerick 1's commercial operation has been the protracted NRC licensing process. PECO submitted its application for an Operating License for Limerick on March 17, 1981. From July 1981 to mid-1983, PECO responded to more than 1200 questions concerning the environmental and safety aspects of the plant. Hearings on the application commenced in October 1982, and were subject to extensive intervention. The hearings were not concluded until July 1985.

A major cause of the licensing delay was the development of the Radiological Emergency Response Plans (RERP's) for the counties, municipalities and school districts surrounding Limerick, which was not within the control of the

Company. The Company did, however, engage the services of Energy Consultants to assist the responsible governmental units in developing their RERP's. However, the development of these plans was substantially delayed by a number of factors.

First, the state agency responsible for emergency planning — the Pennsylvania Emergency Management Agency ("PEMA") — changed its RERP policy which resulted in plan revisions and resultant delays. For example, PEMA was initially undecided regarding acceptable plan formats. In addition, PEMA realized after considerable delay that it was having difficulty fulfilling some of its commitments to RERP development. Energy Consultants and PECO then provided assistance in satisfying the requirements. Moreover, the implementation of new state and federal RERP program guidance increased the scope of the work involved and necessitated plan revisions. For instance, the Commonwealth policy to plan for day care centers necessitated consultant involvement and resulted in significant additional planning requirements. At the federal level, the criteria for developing the RERP's was repeatedly revised by the Federal Emergency Management Agency ("FEMA") during the 1982 to 1984 period. For example, FEMA-43 issued in September of 1983 resulted in substantial additional requirements for offsite emergency planning. Furthermore, disagreements in RERP policy between PEMA and FEMA resulted in additional plan changes. Also, PEMA and FEMA reviews were protracted due to inadequate agency staffing levels.

Thus, the development and finalization of the RERP's was substantially delayed by procedural problems at both PEMA and FEMA. It was not until January of 1984 that the Atomic Safety and Licensing Board ("ASLB") issued an order setting a schedule for submittal of Offsite Emergency Planning contentions, and the hearings on the contentions could not commence until November of 1984. These hearings lasted until the end of January 1985. It was May of 1985 before all of the contentions regarding the RERP's -- excluding the Graterford contentions discussed below -- were resolved.

The NRC issuance of a Commercial Operating License for Limerick Unit 1 has been further delayed by the specific contentions as to the RERP for the State Correctional Institution of Graterford ("Graterford"). On June 1, 1982, the ASLB admitted the Graterford inmates as a party to the NRC licensing proceeding. On April 20, 1984, the ASLB granted the inmates 20 days after receipt of their RERP to submit specific contentions. Development of the Graterford plan, which was the responsibility of PEMA and the Pennsylvania Bureau of Corrections, was significantly delayed. It was not until December 13, 1984 that the Commonwealth sent counsel for the inmates an expurgated copy of the Graterford RERP. On December 19, 1984, the Graterford inmates moved for an order requiring full disclosure by Pennsylvania of the Graterford Plan. On January 29, 1985, the Board denied this motion and gave the inmates 20 days in which to submit specific contentions.

Recognizing that the Graterford issues would be the only remaining obstacle to full commercial operation of Limerick 1 and that litigation of these issues could significantly delay such commercial operation, we moved on February 7, 1985 for an exemption from NRC emergency planning regulations to permit issuance of the full power license prior to the litigation of the Graterford issues. This motion was granted by the ASLB on May 24, 1985. However, on June 11, 1985, the NRC ordered the Atomic Safety and Licensing Appeal Board (ASLAB) to expeditiously consider the inmate's appeal of the ASLB's exemption, and on June 17, 1985, the ASLAB vacated the ASLB's May 24 Order.

On June 24, 1985, we filed a second request for exemption with the ASLB. At the same time, we filed a Petition with the NRC requesting that they either reverse the Appeal Board's June 17 Order and reinstate the earlier exemption or assume jurisdiction and expeditiously grant the requested exemption. The ASLB hearings were held on July 15 - July 17, 1985. On July 22, the ASLB issued its Fourth Partial Initial Decision authorizing the NRC to issue an Operating License to PECO. On August 8, 1985, the NRC issued the Limerick full power Operating License. All of these delays in receipt of our operating license were due to factors which were not within our control.

Q. What role did you play in the preparation of PECO Exhibit 2?

A. I was responsible for providing information on the project impact of the Mark II phenomenon. This included a description of the development of NRC requirements associated with Mark II, the substantial increase in the design and construction effort resulting from these new requirements, and the impact of these changes on project cost.

3. <u>RATE BASE INCLUSION OF COMMON PLANT</u>

Q. Has the Company included all Limerick "Common Plant" in its rate base claim for Limerick 1?

A. Yes, the Company has included all of Limerick "Common Plant" in rate base for the following reasons: (1) the use of Common Plant at Limerick was a prudent and reasonable decision designed to produce substantial cost savings to ratepayers; (2) the construction and completion of Common Plant was required either for the actual operation of Limerick 1 or for the efficient and cost effective completion of the plant; and (3) the inclusion of all Common Plant in rate base will reduce the total cost of Limerick.

Q. Why was the Company's decision to employ Common Plant in the construction of Limerick prudent and cost effective?

A. As set forth above in Section 2 of my testimony, the Company requires the capacity of Limerick Units 1 and 2 to meet its future demand for electricity reliably and economically. Once it is determined that two units are required, the use of Common Plant allowed the Company to avoid duplicate construction of numerous facilities, buildings and systems that could be "shared" between the two units. Indeed, as shown in the examples discussed below, a principal advantage of a dual-unit power plant such as Limerick is that the sharing of certain facilities, buildings and systems permits efficiencies which produce a lower cost per unit than would be possible for two single-unit power plants. Various studies and experience have shown that the use of Common Plant is cost effective and can be expected to produce cost savings on the order of 10% in the total cost of a multiple unit plant.

Q. Please explain why the Common Plant included in the Company's claim is required either for the actual operation of Limerick 1 or for efficient construction of the project.

A. In this context, Common Plant can be classified into four categories:

First, certain items of the Common Plant will be employed in operating both Limerick Units 1 and 2, but would have been required in the same size, design and cost even if Limerick 1 had been constructed from the start as a single unit plant. These facilities and systems include the Administration Building (including the security facilities), Emergency Public Notification Facility, Sewage Treatment Plant, Exclusion Area, Technical Support Facilities, Clarified Water System, Domestic Water System, and the Generator H2 and CO2 System.

Second, certain items of Common Plant would have been required to operate a single-unit plant, but could have been designed somewhat smaller and constructed at a somewhat lower cost as part of a single unit facility. However, each of these items will be required to operate Limerick 1, and as set forth above, the use of Common Plant will produce substantial cost savings for PECO's ratepayers. These facilities and systems include the Off-Gas Facility, Circulating Water Pumphouse, Spray Pond Pumphouse, Control Room, RHR Service Water System, Yard Piping, Emergency Service Water System, Cable Spreading Room, Emergency Switchgear and Batteries, and the Liquid and Solid Radioactive Waste Storage Systems.

Third, a portion of Common Plant will be used solely for the operation of Limerick 1. These facilities and systems include the Unit 1 portion of the Circulating Water System, Off-Gas System and Service Water System.

Fourth, a portion of Common Plant will be used solely for operation of Limerick 2, but installation and completion of these facilities during Limerick 1 construction was required to construct and complete the Limerick plant efficiently and cost effectively. These facilities and systems include the Unit 2 Circulating Water System, Off-Gas System, and Service Water System.

The use of the first three types of Common Plant set forth above is necessary for the actual operation of Limerick 1. Completion of the fourth category during Limerick 1 construction was required for the cost effective construction of Limerick for the benefit of ratepayers. Therefore, in my opinion, all of the Company's Common Plant investment is used and useful and should be included in rates.

Q. Have you assessed the costs associated with your second and fourth types of common plant?

A. Yes. We have reviewed facility drawings and piping and instrumentation drawings to identify those portions of the plant which should be considered in these categories and have developed estimates of their cost. The results indicate that only $15.3 million, or approximately 2% of Common Plant is solely for the operation of Unit 2 and that only $47 million, or approximately 6% of Common Plant cost is attributable to larger sizing due to construction of Unit 2. Added to these direct costs should be AFUDC, overheads, and taxes in the amounts of $8.8 and $26.9 million, respectively.

Q. How will the inclusion of Common Plant in rate base reduce the cost of Limerick?

A. If one-half of Common Plant is excluded from rate base, the Company will continue to accrue AFUDC on this excluded amount until 1990, when Limerick 2 goes into service. These additional AFUDC accruals would add $330.4 million to the total cost of the Limerick plant. By including all of Common Plant in rate base with Unit 1, this increase in capital cost is avoided, although current rates are increased.

Q. Mr. Boyer, does this conclude your testimony?

A. Yes, it does.

APPENDIX A

EXCERPT FROM THE TESTIMONY OF VINCENT S. BOYER IN DOCKET NO. I-80100341

Q. When did PECO initially project the need for the capacity additions which were subsequently to be provided by the Limerick Generating Station?

A. In 1967.

Q. Please describe in general terms the climate of the electric utility industry during the 1960's and early 1970's.

A. The 1960's and early 1970's were characterized by electrical demand exceeding forecasts, inadequate reserve margins, brownouts and blackouts, expressions of regulatory concern about adequate and reliable electric power systems and power plant siting delays. Electric utilities were and are mandated by statute to provide reliable service and thus to overcome any electric power shortage by installing facilities which will be necessary to meet anticipated customer demand. The Limerick Generating Station was initiated to fulfill PECO's statutory obligation. The load/capacity forecasts, the PJM reserve obligations, and the social and regulatory pressures of the late 1960's prompted the initiation of the Limerick Generating Station.

In the decade 1960-1970, the number of residential customers served by PECO grew some 17 percent from about 913,000 to 1,070,000. Average annual kilowatt-hour consumption per residential customer in the 1960-1970 decade rose by over 77 percent from 3,373 kilowatt-hours per residential customer to 5,990 kilowatt-hours, and total residential consumption grew by over 108 percent. Commercial and industrial use of electricity in the area served by PECO rose 79 percent in the 1960-1970 decade. As described more fully by Mr. Hoch and Mr. Kasum, we anticipated substantial further growth in the 1970-1980 decade.

In the early and mid 1960's, 12 to 15 percent of the estimated annual peak was considered an adequate generation reserve. As a result of the northeast blackout on November 9, 1965, the Pennsylvania Public Utility Commission and the Federal Power Commission stimulated the electric utilities to increase their generation capacity to meet anticipated load growth and future demands. On March 31, 1966, the utilities were told that immediate preparations should be made to increase installed capacity until a reserve of 20% above forecasted annual peak loads was reached. The utilities agreed to accept the Commissions' proposals and institute construction programs that would meet the stated goal. A few of the expressions of concern during this period by the Federal Power Commission and the Pennsylvania Public Utility Commission are set forth in Exhibit VCB-1, Section A. In 1972, the regulatory concern over the continually increasing load growth and the lack of sufficient reliable capacity culminated in the entry of an order by the Pennsylvania Public Utility Commission on March 12, 1972 initiating an investigation to determine the need for additional electric generating and transmission facilities during the next decade.

Q. What was the basis for the Company's decision that Limerick was needed to provide new capacity?

A. The Company's decision to build Limerick rested on its determination made in 1967 and 1968 that additional generating capacity would be required beginning in 1975 to meet its customers' needs. The planning process which led to this decision was much the same in 1967 as it is today. Although Mr. Kasum will testify in detail regarding the Company's capacity planning, an overview of the process and the factors influencing the Company's decision in 1968 may be helpful at this juncture.

Generation planning begins with the forecast of future annual sales and peak demands. At least once a year the sales and peak demands are estimated for up to twenty years into the future. In addition, the reserves necessary to reliably supply these forecasted demands are calculated. The total generation required--peak load demand plus reserve requirements--is compared to the installed generation, which is calculated by deducting scheduled retirements and adding in commitments to new capacity. When the total forecasted generation requirement exceeds the projected supply, additional capacity is planned.

From 1961 through 1969, the Company had witnessed a 5.9% increase per year compounded in residential consumption of electricity, and a 6% increase in commercial and industrial use of electricity. The demand for electricity in fact outstripped available capacity during 1967, 1968, and 1969 which necessitated the voltage reductions and voluntary customer load curtailments experienced during those years.

Thus, when the Company prepared its 1967 and 1968 forecasts of future capacity requirements, it confronted pressures to add capacity both to meet its projected load growth plus the increased reserve target of 20%. Although the Company had planned new generating capacity to come into service between 1971 and 1974, the May 1968 forecast revealed that this new capacity would not be enough to meet the targeted 20% reserve margin beginning in 1975. As is more fully explained by Mr. Kasum, the reserve requirement would have been 11.5% in 1975, 6.0% in 1976, and 0.9% in 1977 unless additional capacity was added in these years.

The alternatives to adding new capacity in 1975 and 1977 were to plan for voltage reductions and/or service curtailments to customers, or to purchase power from other sources. The former option was unacceptable given the Company's obligation to its customers as a public utility and the pressures then being exerted by regulatory authorities. The purchase of power from other PJM companies similarly was unacceptable because those companies were facing increased demands on their own systems, possible delays in construction of new capacity to meet those demands, and current voltage reductions and load curtailments similar to those being experienced by the Company. Thus, Philadelphia Electric could not reasonably rely on the availability of excess power among PJM members to purchase electricity rather than add its own new capacity.

Q. What were the alternatives to nuclear generation considered by the Company and why were these alternatives not selected?

A. Once the need for additional capacity in 1975 had been determined, the Company decided that the new facility should be for base-load operation because the PECO system already had sufficient generation for cycling and peaking service. Peaking capacity of 260 megawatts recently had been added at Conowingo in 1964, an additional 880 megawatts was under construction at Muddy Run in 1969, and an additional 500 megawatts of combustion turbine capacity was also in the process of construction.

Once it was determined that base load generation was required, the selection was limited to nuclear, oil or coal-fired plants (i.e., mine-mouth or local area). Hydroelectric generation was not an available alternative because the only locations capable of significant generation had been or were being fully developed, while natural gas did not present a prudent alternative for economic reasons and due to the then-emerging uncertainties associated with future supply.

Of the fossil fuels, coal was preferred to oil generation in the mid 1960's for several reasons. First, throughout the 20th century coal rather than oil had been the dominant fuel used by utilities. This historic emphasis on coal produced a highly-refined and efficient coal technology which perpetuated coal as the principal alternative. Furthermore, oil prices in the mid-1960's were slightly higher per million BTUs than coal prices, which made the oil-fired plants more costly to operate even though the capital costs of the plants were comparable. The Company predicted that the disparity in prices between coal and oil would continue, in part because the demand for residential use of oil was increasing and in part because the transport of coal, which constituted nearly half of its price, was becoming cheaper with the introduction of the unit train method of shipment. As a result of these factors, oil was the least preferred alternative for base load generation.

With respect to coal-fired generation, the Company explored the possibility of mine-mouth sites, but rejected this alternative because sites near large coal reserves within reasonable proximity to the Company's service territory were already being developed. Moreover, transmission limitations necessitated the construction of extensive additional transmission facilities to bring the power to the Company's service territory. More distant locations would have necessitated the construction of hundreds of miles of transmission lines with the concomitant costs and environmental problems incurred in obtaining rights-of-way. Accordingly, this alternative also was viewed as being uneconomic.

Given the inappropriateness of these various alternatives, we focused principally on the choice between nuclear and coal generation (i.e., with the latter located in the Company's service territory). A series of studies were performed in the 1965 to 1970 period which established that nuclear represented the more economic alternative. The most detailed of these was conducted jointly in 1965 by Philadelphia Electric and the Public Service Electric and Gas Company prior to the commitment decisions for the Peach Bottom and Salem units. The specific purpose of this study was to recommend the type, location, and basis of ownership for new generating capacity to be installed jointly by the companies beginning in 1971. Coal and nuclear units of 900 MW net output were compared from the stand-point of reliability and system-wide production cost calculations. The fossil unit did not include the costs of coal and ash handling facilities or stack heights which vary with the location of the plant. Moreover, the extensive environmental equipment which after 1970 began to be required on local generating facilities was, of course, also not considered.

As stated in the report, portions of which are attached as Exhibit VSB-1, Section B, a two-unit 1800 MW nuclear station would provide electricity at a total cost, excluding transmission, of 3.63 mills per kilowatt hour levelized over the 1971 - 1990 period. A fossil fuel plant would provide power at a cost of 4.71 mills per kilowatt hour over the same period. The capital costs of the nuclear units ranged from $206 to $230 million, depending upon the location of the facility, while the coal plant capital costs ranged from $176 to $205 million. The initially higher capital costs of the nuclear plant would be recaptured within three years because of the operating savings derived from the lower cost of nuclear fuel compared to coal. Over its life, the nuclear plant would produce a levelized annual revenue savings to the ratepayers of $6,500,000 over the coal alternative.

In further analyzing the nuclear and fossil alternatives during the late 1960's, the Company updated the 1965 analysis to reflect known changes in construction and fuel costs affecting a choice between nuclear and fossil fuel generation. By the end of the decade, as the Company noted in its first Environmental Report submitted in support of its application for the Limerick Construction Permit, the analyses indicated that oil generation was the preferred fossil fuel alternative to nuclear power because no appropriate sulfur dioxide removal process was available to meet the emerging pollution requirements for coal generation. However, both fossil fuel options reflected higher fuel costs than the nuclear alternative, which continued to make nuclear generation the most economic of the three options.

Q. Please explain the basis for the Company's selection of the Limerick site.

A. The preliminary objective of the site selection process was to locate new generating capacity near the area to be served, thereby minimizing transmission costs and improving overall system reliability by placing generating units close to the load center. In the late 1960's, 48% of the Company's generating capacity was outside or on the periphery of the service area. Moreover, this capacity represented the newer base load generation of the Company. To achieve more balance, the first criterion of the selection process was to locate additional capacity inside the service area.

Within the service territory, nuclear units were planned in the south for capacity additions in 1972 and 1973. The northern portion thus represented the logical location for capacity additions to be provided in 1975 and 1977, especially given the expanding populations in Montgomery and Bucks counties. About nineteen sites were originally considered, but these were quickly reduced to five sites in the desired northern service area: Sanatoga Crossing (Limerick Township), Washington Crossing (Bucks County), Buckingham (Bucks County), Tohican Creek (Bucks County) and Pine Forge (Berks County). (See Exhibit VCB-1, Section C.)

In 1969 Philadelphia Electric hired Gilbert Associates to perform a systematic appraisal of ten alternatives based on these five sites. The Gilbert analysis was supplemented by Company analyses of the same and additional factors affecting the desirability of these alternatives. These analyses were designed to compare site alternatives on the basis of costs and methods for the development of each site. Factors considered in the detailed evaluation included: topography, access to road and rail facilities, availability of water supply, land procurement costs, general geology and seismology, population density and proximity, meteorology, costs of transmission rights-of-way and facilities, and improvements to roads and bridges necessary for the transport of the reactor vessel and other super-heavy components to the site.

Among the principal advantages of the Limerick site was the existence of a 500 KV transmission line crossing the site. Because additional new transmission rights-of-way would not have to be purchased, the site presented the most economical of the five alternatives from this standpoint. Furthermore, the availability of the transmission line avoided the adverse environmental effects associated with the construction of lines over new rights-of-way which the other sites would have imposed. In the same manner, access to the Limerick site from existing roads and railroad spurs was via significantly shorter routes than most of the other sites considered, which produced corresponding cost savings and environmental benefits favoring the Limerick site. Land procurement cost comparisons were also favorable to selection of the Limerick site.

The issue of the availability of water also was considered by the Company in the 1969 study of possible sites. The analysis of the Sanatoga site in Limerick Township recognized that the water from the Schuylkill River would not supply the total requirements of the generating station. The study considered the possibility that a reliable water supply would depend upon fulfillment of plans by the Delaware River Basin Commission to build dams on the Schuylkill upriver from the plant. To avoid reliance on the DRBC plans, the study also considered an alternative design which included the costs of an impounding reservoir. Even taking into account the costs of a reservoir, the Limerick site remained the most economical of acceptable sites according to total site costs because of the low transmission costs.

After the preliminary desirability of the Limerick site was determined, Philadelphia Electric again engaged Gilbert Associates to conduct a detailed evaluation of the site and plant design, the summary section of which is attached as Exhibit VCB-1, Section D. This second 1969 study encompassed a more detailed review of the hydrology, water supply facilities, geology, meteorology, land use and recreational activities in the area, population patterns, and manufacturing and commercial uses of the surrounding area. The study found, among other conclusions, that the Limerick topography was ideal, that the geology was favorable to this type of facility, that no major residential, commercial, or manufacturing complexes were closer than 1.5 miles to the site, that the site was removed from heavily traveled highways, and that population density was not a bar to the site's employment.

In short, the Company reached its decision to locate the generating station at Limerick only after thorough investigation of alternatives compared on the basis of economic, environmental, and social factors. The final selection of the Limerick site curtailed the use of Pennsylvania land resources, avoided adverse environmental impacts associated with other sites, and minimized the capital investment in the project while enhancing overall system reliability and service to the Company's customers.

TABLE 1

PHILADELPHIA ELECTRIC COMPANY

PERCENT RESERVE PLANNED 1970-1990

Year Est. Prepared	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1970	8.2	8.5	10.1	18.2	11.1																
1971		10.7	2.9	-1.4	9.2	20.4	10.6	15.9	19.8	12.4	15.6										
1972			4.6	3.7	4.9	11.3	15.7	20.9	11.3	17.1	11.1	15.2									
1973				6.5	14.3	23.7	14.1	11.3	11.2	15.0	18.8	23.1	17.0								
1974					20.1	15.1	13.2	11.6	11.9	17.7	12.1	17.5	21.6	17.2							
1975						19.6	18.2	17.4	10.2	10.0	4.5	12.5	16.6	11.1	17.0						
1976							34.0	30.8	24.1	24.5	18.3	[12.3] 25.9	[5.3] 18.2	[0.4] 25.0	[-5.6] 17.9	[2.1] 24.6					
1977								37.0	30.0	32.0	26.0	20.0	15.0	[9.6] 23.0	[5.5] 19.0	[0.3] 25.0	[-3.2] 21.0				
1978									36.0	40.0	36.0	31.0	24.0	23.0	19.0	[12.6] 27.0	[9.6] 24.0	[6.7] 35.0			
1979										36.0	40.0	36.0	31.0	27.0	24.0	[18.4] 34.0	[14.9] 30.0	[11.6] 42.0	[8.5] 38.0		
1980											33.0	36.0	33.0	31.0	29.0	[23.9] 41.0	[21.9] 38.0	[7.7] 40.0	[6.1] 38.0	[4.5] 36.0	

NOTE

20.4 Indicates Limerick 1 in service.

15.9 Indicates Limerick 2 in service.

[ ] Reserve w/o both units.

TABLE 2

Limerick No. 1 Fuel Load

Date	Construction Target Date	Publicly Announced Date
1/74	1/79	1/79
9/74	6/79	10/80
5/75	8/80	10/80
5/76	10/81	10/82
1/78	3/82	10/82
5/78	10/82	10/84
6/80	10/83	10/84
10/80	10/84	10/84

PECO STATEMENT NO. 2

RECEIVED

SEP 27 1985

SECRETARY'S OFFICE
Public Utility Commission

PENNSYLVANIA PUBLIC UTILITY
COMMISSION v. PHILADELPHIA ELECTRIC
COMPANY, Docket No. R-850152

DIRECT TESTIMONY OF
JOHN S. KEMPER

LIMERICK 1 AND COMMON PLANT
PROJECT MANAGEMENT

September 27, 1985

R 2

TESTIMONY OF JOHN S. KEMPER

Q. Please state your name and business address for the record?

A. John S. Kemper, 2301 Market Street, Philadelphia, PA 19103.

Q. By whom are you employed, Mr. Kemper, and in what capacity?

A. I am Vice-President of the Engineering and Research Department for Philadelphia Electric Company.

Q. What is your educational background?

A. I received my Bachelor of Science Degree in Electrical Engineering from the University of Pennsylvania in 1950. In 1959, I attended the Nuclear Power Station Training Program for Reactor Supervisors at the Shippingsport Atomic Power Station in Shippingsport, PA.

Q. Please describe your work experience prior to your current position.

A. In 1950, when I joined Philadelphia Electric Company, I was assigned to the Southwark Generating Station as a Test Engineer. In late 1950, I was inducted into the Army and, after serving for two years, returned to PECO where I was assigned to the Schuylkill Generating Station also as a Test Engineer. In this position, I performed and evaluated tests on the major equipment and control systems at the Schuylkill Station. After almost a year, I was transferred to the Cromby Generating Station where two major generating units were under construction. At Cromby, I managed construction of the plant's control systems and acceptance tests and was promoted to Results Engineer with supervision over all Test Engineers in the Station.

In 1957, I was transferred to the Eddystone Generating Station as Plant Engineer and became involved in the construction of that station. My specific duties included the development of operator training procedures, alarm lists and maintenance and lubrication programs, as well as the supervision of all startup testing activities. Two years later, I was assigned to take the Nuclear Power Station Training Program at the Shippingsport Atomic Power Station. On completion of that program, I was temporarily assigned to the Detroit Edison Company for three years where I worked as a Shift Supervisor at their Enrico Fermi Atomic Power Plant. In 1962, I was transferred to General Atomic Company and while there worked with the designers of the Peach Bottom Atomic Power Station, Unit No. 1.

In 1963, I returned to PECO as Plant Superintendent of Peach Bottom Unit 1 with complete responsibility for the operation and maintenance of the station, which was nearing completion at that time. While on this assignment, I successfully passed the Atomic Energy Commission's Senior Licensed Operator examination. In 1967, I was transferred to PECO's main offices in Philadelphia and was named Superintendent of the Station Economy Division of the Station Operating Department. In 1968, I was appointed Manager of the Engineering and Research Department and served in that position for 12 years until January of 1980, when I was elected Vice-President of that Department.

Q. Please describe your experience and responsibilities in your prior position as Manager and your current position as Vice-President of the Engineering and Research Department.

A. As detailed above, prior to my appointment as Manager of the Engineering and Research Department, I had direct experience with the engineering, construction, startup testing, operations and maintenance of nuclear, fossil and hydro generating units. As Manager and now as Vice-President of the Engineering and Research Department, I have been generally responsible for the design and construction of all of the Company's generating facilities, as well as its Research and Development Program. My experience includes direct management responsibility for design and construction of the Peach Bottom Atomic Power Station - Units 2 and 3, including engineering, construction, procurement, quality assurance, licensing and startup activities. I have been and am similarly responsible for recommending and implementing necessary capital modifications made after the commercial operation of those units. Also, I have had and currently have direct management responsibility for the engineering design and construction of the Limerick Generating Station. All such functional management organizations on the Limerick project operate under my immediate direction and supervision and I in turn report to Senior PECO Management, including the Board of Directors and the President.

During the period that I was Manager of the Engineering and Research Department, I shared these responsibilities and reported to the then Vice-President, Mr. Vincent S. Boyer. Since Mr. Boyer's election as Senior Vice-President - Nuclear Power, I have consulted with him in the development of major programs and the resolution of difficulties respecting Limerick licensing, engineering and construction. I have concentrated primarily on direct management of contractors and site activities, while Mr. Boyer has concentrated on the licensing process and relationships with regulatory agencies having jurisdiction over the Project.

Q. Have you been active in any professional organizations?

A. Yes, I have worked on committees of and been affiliated with the American Nuclear Society, the Electric Power Research Institute, the Institute of Electrical and Electronic Engineers, the Association of Edison Illuminating Companies, the

Engineers Club of Philadelphia and other organizations. A list of these committees and my positions in them are attached as Schedule 1. I am also a Registered Professional Engineer in the Commonwealth of Pennsylvania.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to describe the project management organization used at the Limerick Project, to describe the management tools and systems employed to monitor and control cost, schedule and construction quality of the Project, to explain the reasons why Project cost and schedule duration have exceeded our original estimates and to provide an overall assessment of the performance of Project management at Limerick.

1. Summary of Limerick Project Management

Q. Please describe PECO's objective in managing the Limerick Project and whether it achieved that objective.

A. 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. Although we have relied on outside consultants to provide both technical expertise and management services, we have always recognized that we must maintain close control and supervision over the Project. In addition, the Company has maintained a high commitment to quality at Limerick in order to ensure plant safety, reliability and licensability.

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.

2. Limerick Project Management Organization.

Q. Please describe the management organization which you employed at Limerick.

A. Responsibility for management of the Limerick Project was assigned to the Vice-President of the Engineering and Research Department by Corporate Management. My and my predecessor's role was to manage and coordinate the activities of the various departments at PECO which were charged with the day-to-day management of all functional areas of the Project. These departments included Engineering and Research, Purchasing and General Services, Electric Production, Finance and Accounting, and Legal. The organization chart set forth in Schedule 2 provides an overview of this management organization.

Q. Please describe in greater detail your role and responsibilities in managing the Limerick Project.

A. My primary function has been to provide overall guidance and direction for the Limerick Project and day-to-day control over the resolution of significant Project related matters. I have been responsible for making major policy determinations which affect various functional areas of Project management, i.e. construction, engineering, quality assurance, etc. A substantial portion of my time has been devoted solely to managing the Limerick Project. As described below, I have maintained daily communication with the Company's Project Managers, participated in and directed major management meetings and regularly reviewed a substantial number of Project reports in order to obtain necessary information concerning Project status and to provide management direction.

Q. Please describe the functions of the several Company Departments who participated in the management of the Limerick Project?

A. Following the Limerick commitment decision and the selection of General Electric Company and Bechtel Power Corporation as the major contractors, the Engineering and Research Department created a Project management organization to manage future Limerick planning, design and construction activities. The focal point of this group was the Limerick Project Manager, who was responsible on a day-to-day basis for Project administration and coordination. The Project Manager reported administratively to the Chief Mechanical Engineer, but, as respects significant Limerick Project matters, he communicated directly with me. The Project Manager's responsibilities included the following: 1) coordination of Company groups involved in the design, procurement and construction of Limerick, including groups located both within and outside of the Engineering and Research Department; 2) coordination of the development of Project schedules, budgets, forecasts, capital authorizations and supplemental capital authorizations; 3) monitoring Project costs, schedules and performance; 4) establishing priorities for review of Project documents; 5) establishing and maintaining an interface between PECO and Bechtel, General Electric and other equipment suppliers; 6) conducting periodic and ad hoc meetings to review Project status and resolve Project difficulties; and 7) preparation of reports, meeting minutes, memoranda and other documents required to keep appropriate PECO personnel abreast of Project status. The Project management group also included the Resident Project Manager, located in Bechtel's San Francisco home office, who provided additional monitoring and control over engineering activities.

The Mechanical Engineering Division was responsible for reviewing the mechanical design work of Bechtel and General Electric to ensure a safe, operable, reliable and economical plant. Additionally, the Mechanical Engineering Division was responsible for plant licensing, nuclear fuel procurement and fabrication, and environmental considerations.

The Electrical Engineering Division was responsible for electrical design review and for instrument and control systems review. Such reviews were directed and administered by the Electrical Project Engineer. These reviews entailed a detailed assessment of the plans for safety, system operability, reliability and economy.

The Construction Division, through the Limerick Project Manager - Construction was responsible for monitoring all Limerick site construction activities, including cost and schedule, and for development and implementation of a Quality Control System which was applied to non-nuclear equipment and systems. Actual day-to-day control over construction activities was maintained by the site management team, the organization and responsibilities of which are described at greater length by Mr. Clarey. I communicated with Mr. Clarey on almost a daily basis as to significant Project matters.

The System Planning Division was responsible for issuing periodic reports on costs, preparing and updating budgets, reviewing capacity needs and making economic evaluations related to the generation of electricity by various methods. With input from various Project entities which report costs, this division monitored all billings both by account and in the aggregate and continually made comparisons with budget amounts. The results of these activities were set forth in Monthly Expenditure Reports. In addition, the System Planning Division developed a computer program to calculate taxes, overhead and AFUDC which were necessary for preparation of total Project cost estimates.

The Engineering Design Division was responsible for reviewing drawings, maintaining records and files, and receiving the many thousands of drawings at the completion of the Project.

The Research and Testing Division served as a consultant on metallurgical and welding concerns and tested and calibrated plant instrumentation.

Finally, the Quality Assurance Section was responsible for ensuring that the design and construction of Limerick met the requirements of 10 CFR 50, Appendix B. In implementing its program, this Section conducted numerous inspections, audits and surveillances of PECO and contractor activities. The results were forwarded to the appropriate Project entity, usually Bechtel or General Electric, under the Project Manager's signature. In the few cases where significant problems were discovered, reverification of the corrective action was performed through the audit process.

The Company's Purchasing and General Services Department was responsible for reviewing and approving recommendations generated by various Project entities for the purchasing of equipment and materials and for the awarding of contracts and subcontracts for services. Insurance requirements as well as stores and salvage needs were also directed to this department. Purchasing personnel have a diversity of technical experience, including engineering, construction, production, and electric and gas distribution, as well as experience in finance and accounting.

The Electric Production Department, through the Station Superintendent, reviewed plant equipment and systems design, as well as arrangements of plant facilities. Based upon his broad operating experience, the Superintendent frequently forwarded comments and recommendations on matters of improved plant safety, reliability and operability through the Project Manager to the appropriate Engineering and Research Department group for action and resolution. In addition, as described further below, the Electric Production Department had primary responsibility for organizing and controlling startup and preoperational testing activities.

Finance and Accounting provided accounts payable, plant accounting and internal auditing functions. The Accounts Payable Division was responsible for payment of vendors' invoices after appropriate review and approval by project entities. The Plant Accounting Division was responsible for the proper accounting and record keeping as prescribed by the Federal Energy Regulatory Commission, including the additions made by the Company in plant and equipment for the

Limerick Project. The Internal Auditing Division performed audits of Bechtel and vendor billings and subcontract amendments, which entailed detailed verification of reported work completion, material delivery and accuracy of the billings or amendments. These audits were performed by four resident auditors who were stationed at the Limerick site on a full-time basis because of the size and importance of that Project. The auditors performed over 70 detailed audits, the results of which were reported directly to the Manager of Internal Auditing in PECO's Finance and Accounting Department, who in turn submitted monthly reports to PECO's Chairman of the Board and met personally with the Chairman twice a year.

Finally, the Legal Department served as the interface between PECO and various regulatory agencies with respect to licensing and other matters.

Q. Please describe the use of outside contractors by the Company as part of the Limerick Project management organization.

A. Outside contractors were hired where it was determined that additional technical expertise or specialized management services were needed that were not available from within the Company. On this basis, the Company hired Bechtel, General Electric and various other subcontractors as needed. Although relying on these outside experts, we have always retained ultimate control over the Project and have closely supervised their activities through an experienced Project management organization and a comprehensive cost and schedule control system. Daily supervision of and communication with these contractors was primarily the responsibility of the Limerick Project Manager, the Resident Project Manager, the Project Manager-Construction and the Startup Director.

Q. Why did you adopt this organization?

A. 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.

3. Description of Limerick Project Management by Functional Project Area.

Q. What is the purpose of this section of your testimony?

A. This section describes specific management tools and processes which we employed to manage major Project areas, i.e. engineering, procurement, construction, licensing, startup and quality assurance.

A. Engineering Management

Q. Please describe those controls and processes used in engineering management.

A. Throughout the Project, we maintained a competent engineering staff which was responsible for monitoring engineering activities and establishing and maintaining high standards of design quality. Indeed, we directly managed many technical programs, defined requirements, established technical and schedule objectives, monitored engineering costs and progress, and managed consultants with specialized experience in the investigation and resolution of work tasks requiring such experience.

The conceptual design of the Project, completed in 1969-1971, was developed in conjunction with Bechtel and General Electric. Our original purpose was to duplicate the Peach Bottom design at Limerick with certain modifications to reflect site-specific conditions. This approach was adopted because use of a standardized design would result in a significant reduction in the amount of engineering and original design work to be performed. It was estimated that the design for 33 systems at Peach Bottom could be directly transferred to Limerick, resulting in substantial savings. Further, standardization of our nuclear plant designs would result in significant operating and maintenance cost savings over their lifetime.

Prior to the receipt of a construction permit in 1974, a significant amount of engineering was performed. During the pre-construction period, engineering management was primarily achieved through quarterly Project status review meetings and reports which began in 1969. These meetings were the predecessors to the Monthly Project Status Review Meetings and Reports discussed later in my testimony, and were used to discuss key events, schedules, procurement, subcontracts, costs and any other subjects that required immediate action or decision. In attendance at these Project status review meetings were myself and/or my predecessor, the division heads of the Engineering and Research Department, the PECO Project Manager and Project Manager - Construction, PECO Quality Assurance management, Bechtel's and General Electric's Project

Managers, Bechtel Engineering and Procurement Management, and Bechtel's Field Management.

Monthly meetings and reports by the PECO Mechanical and Electrical Engineering Divisions were also begun in 1969. These meetings were conducted by the Project Manager or Electrical Project Engineer, and were attended by the Section heads from the Mechanical and Electrical Engineering Divisions and covered a variety of topics, including property acquisition, site investigation, PSAR development, quality assurance, design studies, licensing, procurement, engineering status, construction activities, and cost estimates and control. These meetings, in addition to providing a forum for more detailed discussion and resolution of Project difficulties than was available in the quarterly and later monthly Project meetings, generated data and proposals for consideration at those later meetings. Also, numerous meetings were held between PECO and Bechtel engineers on an as-needed basis to review the design of various systems and components that were of particular concern. Although infrequent in the beginning, these latter meetings were held more often as the plant design progressed and the need for them occurred.

Q. Please describe how management of the engineering function evolved after receipt of the construction permit.

A. During the period 1974-1980, the design of the plant became more complete and the engineering forces were faced with the task of analyzing and incorporating the increasing multitude of regulatory imposed design changes.

In response to these needs, the position of Resident Project Manager was established in October 1975. This position formalized a function which had been performed by PECO personnel since 1973. The Resident Project Manager was resident in the Bechtel San Francisco Home Office where the great majority of design work was performed. His function was to provide Bechtel and General Electric with a direct channel of communication to PECO Management, to provide a local source of authoritative guidance as to PECO Management policy, and to monitor Project activities occurring at Bechtel and General Electric home offices. Specifically, the Resident Project Manager participated in substantially all Bechtel engineering meetings and reviewed most of the Bechtel internal engineering reports dealing with engineering staffing, cost and schedule progress, and resolution of technical problems. The Resident Project Manager provided our management with a direct and contemporaneous source of information as to the performance of Bechtel and General Electric engineering forces.

During this period and through the end of the project, overall Project performance was monitored and coordinated through the Monthly Project Status Review Meeting, which is described in greater detail later in my testimony. All major Project organizations participated in this meeting and engineering status was a major topic of discussion. The Limerick Project Manager's Bi-weekly Meeting was a further means of controlling engineering cost, schedule and quality. This meeting was divided into two portions, the Project Manager's Report and the Mechanical Engineering Section Head Reports. Engineering topics covered in this meeting included engineering cost and schedule performance, design change and modification control, NRC concerns and action items identified by the Resident Project Manager or other management groups. Another control tool, initiated in 1982, was a weekly conference between the Project Manager and the Bechtel and General Electric Project Managers located either at the construction site or in San Francisco in order to review engineering progress and any major design problems. As described above, special purpose meetings were also held as needed to facilitate Project progress.

As engineering design was completed, it became necessary to expand our design control mechanisms. Accordingly, a special mechanism was created, i.e. the Notice of Change in Design ("NCD"), to achieve such control. The NCD was used to document changes to the original engineering scope that required engineering manhours over and above those budgeted. Significant increases in estimated engineering manhours required the approval of the PECO Chief Electrical or Mechanical Engineer prior to Bechtel proceeding with the work.

In 1980, with planned design work approaching completion but with the need for substantial additional design efforts to satisfy new regulatory requirements, further control efforts were imposed. A policy was established by PECO whereby all design changes, regardless of origin, would be minimized through the use of detailed categorization, prioritization and approval procedures. As a general matter, design changes were proscribed unless required for licensing, or to achieve clearly apparent and needed plant safety, operability and reliability benefits. Approval for such changes had to be obtained from the Chief Mechanical or Electrical Engineer and was subject to my concurrence. In 1982, design changes were further scrutinized through the use of the Jobsite Review Board which was comprised of representatives from Bechtel field forces, startup and PECO construction. The purpose of the Jobsite Review Board was to control implementation of all design changes to ensure timely turnover of systems from construction to startup. Similar procedures were in existence in the Bechtel organization, and significant Bechtel proposed changes were subject to our approval.

Q. How did PECO ensure that adequate technical quality was attained in the design of Limerick?

A. Based on our experience at Peach Bottom and at other projects, we recognized that a high degree of technical quality in engineering design was required to obtain a safe, reliable and licensable plant. To achieve such quality, we developed an extensive design review program which consisted of three levels. At the first level, Bechtel prepared specifications, drawings, procedures and inspection plans to include all applicable regulatory, code and Safety Analysis Report requirements. The preparation of these design documents was closely coordinated so that collectively the documents formed an effective, cohesive program which provided the construction forces with clear and detailed work instructions.

The second level consisted of design verification by individuals or groups within Bechtel, other than those who performed the original design. The scope and depth of this design verification by Bechtel was detailed in its quality assurance manuals, which were consistent with our imposed quality requirements. The third level was performed by us. We independently reviewed Bechtel's design documents to assure that they met our stringent quality requirements. This third level of review was, to the best of my knowledge, more extensive than was typical in the industry. I have provided in Schedule 3 a list of the many Bechtel design documents which we reviewed. Through the combined efforts of PECO and Bechtel in the preparation, review and approval of the above documents, I believe that a high degree of quality in engineering design has been attained.

Q. Have there been any independent reviews of Limerick engineering management and, if so, what was the result of these reviews?

A. Yes, there have been such reviews. For example, in the November 1984 Independent Design Verification of the Limerick 1 core spray system performed by Torrey Pines Technology, it was concluded that "an adequate documented design control procedural system existed for the designers of the Limerick Generating Station Unit No. 1, mainly Bechtel and G.E." (Vol. 2, p. 80). Torrey Pines further concluded that implementation of the design control process was adequate, that construction generally conformed to the requirements of design documents and that an adequate design resulted from the implementation of the design control procedural process.

The Company's efforts to resolve important technical engineering issues were also praised in the NRC's Systematic Assessment of Licensee Performance ("SALP") Report, dated April 18, 1983, as follows:

> "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." (p. 7)

Similarly, in the next SALP Report, dated January 16, 1984, the NRC concluded:

> "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." (p. 20)

B. Procurement Management

Q. How was the procurement of equipment and materials managed?

A. Management of procurement was delegated to our Purchasing Department with Bechtel serving as procurement agent to take advantage of its substantial expertise. The types of purchases made during the Project included bulk materials, equipment and various services. The general procedures used for procuring materials and equipment were developed early in the Project. Bechtel defined material and equipment needs in the form of specifications, developed bidders lists and prepared bid analyses and award recommendations. We approved all initial purchase orders exceeding $100,000 and change orders in excess of $25,000. All Bechtel-developed specifications, bidders lists and award recommendations also required our review and approval.

In addition, PECO assumed direct responsibility for handling the purchase of certain major pieces of equipment. Based upon our success in managing the procurement of equipment at Peach Bottom, we elected to act as our own purchasing agent for a number of major items. These are listed on Schedule 4. For these major pieces of equipment, Bechtel prepared all necessary material requisitions and specifications, performed all engineering analyses and submitted bid recommendations to PECO. After PECO approved the recommendation, Bechtel then prepared engineering and drawing schedules for the selected bidder and forwarded these materials to PECO for inclusion in the purchase order. PECO would then issue a revised material requisition for purchase and negotiate any differences in the commercial terms and conditions.

To assist in monitoring and controlling the procurement process, a computerized tracking system was developed. This system was patterned after a similar system employed at Peach Bottom and was implemented at Limerick in 1973-1974, or prior to the receipt of a construction permit. This system used a comprehensive database which permitted tracking of all engineered plant equipment components from purchase order to installation. Our construction site management team was responsible for managing the procurement of bulk materials and also relied upon several generally accepted state-of-the-art control tools, such as construction schedules identifying additional items needed, material expediting "buck sheets", management attention lists identifying equipment problems that might cause delay, and material receiving reports. The purpose of these control tools was to assure that engineered equipment and materials/construction supplies were obtained at the lowest reasonable cost level and in time to support construction activities. In my opinion, as the result of these efforts, no significant procurement problems were experienced at Limerick.

C. Construction Management

Q. Please describe the management of construction at Limerick.

A. In order to manage construction, we established a site management organization with extensive construction experience gained in building the Peach Bottom Station and other power projects. This site organization monitored and controlled costs, schedule and quality through careful review and evaluation of Project data, attendance at meetings with contractors and subcontractors (i.e. both meetings which we instituted and those held by Bechtel) and by direct observation of construction activities. The results of these efforts were reported to me by Mr. James J. Clarey, Project Manager - Construction.

To assist in the management effort, we implemented a comprehensive and sophisticated control system. This system included computerized and manual databases that permitted the development of materials and manhour forecasts and the monitoring of actual performance against those forecasts. In addition, a multilevel scheduling program was developed to ensure that construction would be supported by other project functions such as engineering and procurement, and would be supportive of system turnover and startup testing activities. Variances from forecasts and schedules, as well as other problems with a potential cost or schedule impact, were identified through the Project Trend Program, meetings and reports prepared by both Bechtel and our site organization. Recommended solutions were developed by our site team, by contractors and jointly at Project construction meetings. The status of any corrective measures underway were reported on a regular basis through various reports and at the meetings I have described. One of the most important of these reports was the Philadelphia Electric Schedule Analysis Report which provided an overview of construction progress and was a significant input into the Monthly Project Status Review Meeting. As was true with engineering, this monthly meeting was the central management tool at which construction status was communicated, problems were identified and corrective action was implemented.

A more detailed description of our site management organization and the management tools used to monitor and control the construction process is presented by Mr. Clarey.

D. <u>Startup Testing Management</u>

Q. Please describe the management of startup testing.

A. PECO's Limerick Station Superintendent had the overall responsibility for all startup activities, reporting to the Vice-President, Electric Production Department. PECO's Startup Director, who reported to the Limerick Station

Superintendent, was responsible for directing and coordinating day-to-day startup activities. Below the Startup Director was an integrated startup organization in excess of 300 PECO and Bechtel personnel at its maximum size. The startup organization was structured to most effectively monitor and manage progress in startup activities through the use of an integrated team approach. It must be noted that although startup was primarily the responsibility of the Electric Production Department, the construction organization played a significant role in ensuring the completion of startup activities on schedule. A particularly useful tool in achieving this objective were completion schedules for individual plant systems whose completion was important to achieving startup milestones.

Once systems were turned over to the startup organization, a number of management tools were used to manage and control startup activities. Startup management attended the Monthly Project Status Review Meeting and a Startup Status Summary and addendum report was contained in the meeting handouts. Startup management also attended or conducted numerous other meetings to communicate and receive pertinent information. For example, the Assistant Project Startup Engineer conducted daily a "3 day plan of the day" meeting utilized for detailed planning and coordination of working level activities. This meeting was attended by personnel from construction, engineering and operations as well as startup. Management of startup activities also used a variety of computerized and other control processes to manage costs and achieve schedule progress.

Q. Did changes in regulatory requirements adversely affect startup activities?

A. Yes, they did. Regulatory change seriously impacted the Project during the 1979 to 1982 time frame, imposing new and unanticipated design and construction requirements, adversely impacting the cost and rendering more difficult the achievement of startup schedule objectives. This occurred for three reasons: 1) these new requirements, along with other construction activities, delayed the completion of construction, thus compressing the time available for startup and necessitating the use of overtime and increased contractor personnel to maintain schedule; 2) certain retrofits were required to previously tested systems, therefore necessitating retesting of these systems; and 3) certain regulatory changes directly impacted the cost of startup by increasing its complexity and documentation requirements, and requiring procedure redrafting and additional testing time. Examples of regulatory changes which had a significant impact on startup included modifications to fire protection systems, changes resulting from equipment qualification requirements, human factors requirements which resulted from TMI, modifications to the PGCC control panels resulting from TMI, ATWS and Regulatory Guide 1.97, and changes to Regulatory Guide 1.68 which established additional requirements for startup testing procedures and training.

Despite these problems, the October 1984 fuel load schedule was maintained. Innovative management efforts which achieved this result included: 1) specialists and consultants in various fields were brought to the site to assist in the resolution of special and significant startup problems; 2) the pre-operational test procedure writing effort was moved from San Francisco to the Limerick site; 3) a systems completion group and post turnover completion group were organized in the construction organization to minimize startup work lists and construction punch lists at turnover; 4) special training and qualification programs were initiated at appropriate times to maximize startup activity, and improve productivity and quality; 5) portable water demineralizer plants were brought to the site and were utilized to supplement installed equipment, speeding completion of the required flushing activities; and 6) integrated Project management teams were formed of construction, startup, operations and scheduling organizations to resolve startup worklist activities. Also, the Superintendent of the Electric Production Department-Nuclear Generation Division, the Bechtel Project Manager and I were in residence at the site during the critical preoperational test interval (i.e. May-October 1984) to assist site management with timely decisions and bring the necessary resources to bear to assure achievement of the fuel load date.

Through these innovative and extensive efforts, we were successful in overcoming regulatory changes and other problems. PECO succeeded in completing all startup activity from initial equipment energization to fuel load in 27 months. This startup duration is among the shortest recently achieved in the industry.

Q. Have there been any third party reviews of startup management and, if so, what have been their conclusions?

A. In the 1984 and 1985 SALP Reports, the NRC concluded that:

> "As systems entered their construction completion phase and were subsequently turned over from Construction to the Startup Organization, the two organizations developed controls to effect the turnover in the form of site job rules and administrative procedures. System turnovers are well managed and assured system quality. By established policy and management direction, systems were not accepted unless they were completed to the extent required to support required test activities." (January 16, 1984 Report, p. 9).

> "The preoperational test program was completed during this assessment period, with the exception of closing test exceptions. 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." (January 14, 1985 Report, p. 12).

E. Licensing and Regulatory Relations Management

Q. Please describe how licensing activities and regulatory relations were managed and controlled.

A. Early in the Project, PECO established an organization to closely monitor and control the licensing process by coordinating, tracking and monitoring the numerous regulatory commitments and proposed requirements. This organization evolved over time to meet the increasing demands placed upon the Project by the regulatory environment.

During the construction permit application phase, PECO dedicated two full-time engineers from the Mechanical Engineering Division who had previous licensing experience at Peach Bottom to monitor all licensing activities. Bechtel, General Electric and other contractors provided resources to assist in preparing the Preliminary Safety Analysis Report ("PSAR") and developing the licensing schedule.

As the level of complexity and number of safety and environmental requirements increased, so did the Company's management efforts. After receiving the construction permit, PECO developed a status summary tracking program for licensing activities. This system tracked NRC I.&E. Bulletins, Circulars and Notices, and findings of NRC site inspections. The system identified the responsible Project organization, the licensing commitment and the response date. Information from this system was widely distributed throughout the Project to attract significant management attention. This system ensured a timely and effective response to an increasingly complex body of regulatory requirements.

Moreover, between 1974-1981, PECO benefitted significantly from Peach Bottom experience. Normally, a construction permit holder receives little information or guidance from the NRC on new regulatory interpretations during the construction period. It is only when an application for an operating license is filed and the Final Safety Analysis Report ("FSAR") containing the "as-built" description is reviewed by the NRC, that the licensee through questioning becomes fully aware of the extent to which newly generated design criteria or regulatory interpretations must be backfit to the plant. PECO received information from the NRC during this interval because of operation of the Peach Bottom units. PECO continually reviewed this information and guidance for applicability at Limerick.

The operating license phase at Limerick occurred subsequent to the TMI accident in March 1979. As a result of this accident, the NRC Staff did not review any post-TMI operating license applications between March 1979 and early 1981. Thus, when the Limerick application was filed for predocketing review in March 1981, it was caught in a backlog of applications. It was not until March 1982, that questions on PECO's docketed FSAR from the NRC Staff branches were received. PECO responded to the questions by providing information in FSAR Revisions. The process of responding to NRC questions through FSAR Revisions continued until December 1982, at which time a majority of the more than 1,200 questions asked by the NRC Staff on Limerick had been received. It was during this time that PECO recognized that some extraordinary steps would have to be taken if the NRC Staff review was to be completed in time to support the scheduled fuel load date.

First, a computer program was developed by PECO to replace the manual system of scheduling and tracking the progress of each question. This computer system identified each open question, scheduled the development of responses based on commitment dates, grouped the questions by NRC branch, FSAR Revision and the PECo inter-disciplinary team responsible for providing a response, and identified any potential problem areas. We soon recognized the benefits of this computer program and expanded it to monitor all licensing activities. In addition, Bechtel's home office in San Francisco was provided a terminal to access this system in order to ensure that the current status of all licensing activities was maintained. This computer system enabled PECO to manage the flow of NRC questions and other open licensing items without substantially increasing the personnel devoted solely to licensing activities.

Second, PECO recognized that the answers supplied to the NRC Staff had to be fully responsive to the NRC Staff's concerns since the fuel load schedule did not permit an iterative process of NRC letters requesting additional detailed information. Accordingly, licensing management developed an innovative and aggressive program to meet this challenge. To assure accurate and thorough responses to NRC questions, PECO organized inter-disciplinary teams of in-house and contractor licensing and technical experts to prepare the needed responses. The results of these efforts were that over 90% of the responses were accepted by the NRC Staff without further inquiry.

Third, PECO's licensing management maintained continuous contact with the NRC Project Manager and Staff reviewers responsible for the Limerick Project. In addition, individuals within the Company's licensing group were assigned to act as liason with each NRC Staff branch to assure timely and complete resolution of that branch's concerns. PECO Licensing Coordinators contacted the NRC Staff upon receipt of questions to gain clarification of the precise information that the Staff needed in order to complete their review and to advise the NRC Staff of the PECO schedule for providing information to facilitate scheduling of NRC review efforts.

Fourth, as responses to NRC questions became available for incorporation into an FSAR Revision, a letter was transmitted to the NRC Staff containing the requested material. By providing the Staff with the same information which would appear in a subsequent FSAR Revision, elimination of up to a month delay was achieved. Partial responses to questions were also provided where appropriate, thus enabling partial Staff review while the remainder of requested data was in preparation.

Finally, meetings were held frequently with various NRC Staff branches for the purpose of resolving differences between the Limerick design and current NRC Staff requirements. PECO, Bechtel and General Electric technical experts, licensing personnel, and Project management attended these meetings. Senior PECO management also attended these meetings when critical path activities were involved. In nearly every instance, licensing issues were resolved in PECO's favor.

Q. Have the Company's licensing efforts been evaluated by independent third parties and with what result?

A. The NRC has repeatedly evaluated PECO's licensing management process. For example, it recognized the value of the computer tracking system in its April 18, 1983 SALP Report: "For NRC questions and PECO responses, PECO has implemented a computerized tracking system that enhances the ability for improved responsiveness to NRC initiatives." (p. 17) This report further stated:

> "Management involvement in assuring quality is evidenced by attendance by middle and upper level managers at the appropriate technical meetings, the evidence of prior planning and adequate management review of decisions related to the goals to be attained in these meetings, the generally thorough and technically sound presentations made in these meetings and related submittals, and the high quality of communications from the PECO licensing staff."

Additionally, the January 16, 1984 SALP report stated, in part:

> "...Management involvement has been evidenced by the appropriate level of management attendance at technical meetings, prior planning and review of the preparations for these meetings, the thorough and technically sound presentations made in related submittals, and in the quality of communications from the PECo licensing staff..." (p. 20)
>
> ...Staffing has been sufficient to meet the licensing needs for the Limerick plant during this period. The training and qualifications of the applicant's staff in the licensing functional area has resulted in a well prepared and professional organization." (p. 21)

Similarly, in the Jaunary 14, 1985 SALP Report, the NRC stated:

> "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.
>
> * * * *
>
> The licensee's management consistently exercised firm control over the licensing activities performed by its contractors and maintained effective communications between its contractors, its own staff, the NRC staff and the NRC staff's contractors.
>
> The success of the licensee's effort to assure quality is evident in that the many submittals made during this period have been virtually always submitted in a timely manner, have been complete and thorough (requiring very few revisions for correction of errors) and is reflective of a power plant design that is well controlled and verified by licensee personnel prior to submittal to NRC." (p. 31)

F. Quality Assurance and Quality Control

Q. Please describe the management of quality assurance and quality control.

A. Philadelphia Electric Company's experience in nuclear construction at Peach Bottom provided the basis upon which the Company established and implemented a quality assurance program for Limerick. The formal PECO nuclear plant quality program started with the construction of Peach Bottom and began evolving before the formalization of quality requirements contained in 10 CFR 50, Appendix B, which became law in 1970. The Company realized that the achievement of plant safety and reliability could be assured only through the imposition of high quality standards, both during the construction process and when the plant became operational.

An indication of PECO's commitment to quality is its development, for Limerick, of an expanded quality program. This expanded program applied to systems and components beyond those which were required by regulation to be covered. The expanded program covered Balance of Plant Systems such as radwaste and other nonsafety systems which could interact with safety systems. It was recognized that, in addition to assuring safe and reliable operations, such a quality assurance program was cost effective because the required quality measures were achieved through prevention rather than the more costly subsequent detection and rework. Further detail as to this program is presented by Mr. Clarey.

In addition to the design review program previously discussed, the Company developed a construction quality assurance/quality control program. This program embraced a "defense in depth" concept and was comprised of three levels. The first level, defined as the quality control inspection function, was performed by

Bechtel's Quality Control organization, which was independent from its construction forces. Quality Control was responsible for assuring that the final end product met the specified requirements. The second level, defined as the quality assurance surveillance function, included the auditing and/or surveillance performed by Bechtel's Quality Assurance organization, which was independent from the construction and Quality Control forces.

The third level, defined as the quality assurance auditing function, was performed by PECO's Quality Assurance organization, which was entirely independent from all Bechtel organizations. This organization was comprised of two groups. First, PECO's home office Quality Assurance group was responsible for the quality of work performed by both its own and the major contractors' home offices, and for audits of vendors which provided equipment or services for the Limerick Project. Second, the Company established a Quality Assurance group at the construction site which was responsible for work performed by PECO, Bechtel and General Electric site forces. Through these organizations, the Company performed quality assurance audits and surveillances to assure that the quality assurance programs of all Project groups were actually functioning as required. Moreover, PECO's Quality Assurance group reviewed specifications, site procedures and other required documents furnished by Bechtel to assure that the necessary quality requirements were incorporated into these documents.

From the program's beginning, PECO has, through the development of quality assurance procedures, ensured that quality personnel would have the power to require that technical requirements be met. In any quality assurance program, it is essential to verify that plant systems are constructed in accordance with the approved design. An effective work product acceptance program was thus developed at Limerick and resulted in the timely identification of nonconforming conditions which required corrective action. This avoided increased costs resulting from late, unnecessary rework and schedule slippage. In cases where the quality organizations considered an item to be a major problem, they had the authority to issue a "stop work order". Significantly, this action was taken at Limerick only in a relatively few number of limited situations, and it was never necessary to issue a general stop work order that applied to the total Project.

The results of our dedication to quality are exemplified by the fact that, unlike other nuclear plants, we have experienced no major work interruptions related to quality over the duration of the Project. All allegations of quality deficiencies brought forth by intervenors in public hearings associated with our operating license application have been considered by the NRC Atomic Safety and Licensing Board ("ASLB") and found to be without merit. As a result of this commitment, systems constructed at Limerick have generally performed as they were designed without failure, which in turn has resulted in a very short startup period, thus enabling the Company to achieve fuel load on schedule.

Q. How have independent third parties viewed the management of quality assurance at Limerick?

A. The Company's efforts in this area were generally found to be reasonable and appropriate. The NRC Region I Office of Inspection and Enforcement has consistently ranked the quality of construction at Limerick above average. Additional indications of satisfactory quality assurance are the Independent Design Verification Program findings of adequate design processes and a high appraisal of the quality program which consistently appears in the NRC's Limerick SALP Reports. For example, in evaluating the quality of the Company's piping system and pipe supports, the January 16, 1984 SALP report concluded:

> "Strong management attention was evident in the resolution of concerns identified by both the licensee and the NRC. The licensee's follow-up in handling of [NRC requirements] is a good example of management's attention and commitment to quality.
>
> * * *
>
> "Observation by the resident inspector and the Construction Inspection Team indicated that a strong construction QC program was in place. In addition to the A-E's well-staffed and trained QC organization, the licensee's QA organization is also staffed by well-trained and knowledgeable QA engineers. The resident inspectors have noticed that the licensee's QA engineers have performed more than the required amount of inspections and surveillances in this area." (pp. 12-13).

Similarly, this report further noted:

> "With other safety-related components, NRC inspections also indicated that the program was well-managed with adequate consideration of quality assurance. The installation of components were well-planned, installation requirements were properly implemented, and inspections were satisfactorily performed.
>
> The licensee has a strong training and qualification program. Welder qualification has been above Code requirements. Both engineering and craft personnel have a structured program to improve their skills. Additionally, licensee's senior management receive monthly training progress reports. In-process and final quality control inspections have been properly documented and [are] readily retrievable. A large and well-trained staff of QC engineers, technicians, and inspectors also indicated licensee's commitment to the assurance of quality.
>
> 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." (pp. 15-16)

Q. How have changing regulatory requirements impacted the quality program at Limerick?

A. Throughout the Project, the stringency of enforcement and interpretation of NRC quality assurance requirements increased dramatically, resulting in substantial increases in quality staffing levels, documentation requirements and the number and intensity of quality inspections. This escalation in quality requirements was primarily the result of operating and construction problems at other plants (i.e. TMI-2, Zimmer, etc), as well as the general proliferation of additional regulatory requirements. This increase is clearly demonstrated by Schedule 5, which provides a summary of increases in quality assurance and quality control staffing levels from 1975 to 1984. As indicated by this Schedule, PECo quality assurance staffing at the site increased by a factor of 5 during this period, while Bechtel quality assurance/quality control field forces more than quadrupled in size.

The increase in the number of NRC site audits and inspections is shown on Schedule 6. While these NRC audits did not add any significant manual labor costs to the Project, the number of audits reflect the increase in the number and intensity of required PECO and contractor-conducted quality inspections over that which was initially anticipated to satisfy NRC requirements. For example, as shown, the number of NRC site audits was 8 in 1974, varied between 16 and 23 from 1980 to 1983, and, finally, peaked at 74 in 1984. These audits and the efforts to meet the stricter quality assurance requirements substantially slowed the construction effort.

G. Cost and Schedule Control

Q. Please describe, to the extent you have not already done so, the major management control tools used to monitor and control cost and schedule.

A. Overall cost and schedule planning at Limerick was achieved through the Project Forecasts and Trend Reports. As a general matter, Forecasts incorporated management's best judgement as to future cost, schedule and cash flow projections in order to provide an overall Project budget. Two important sources of Project data used to develop the Forecasts were the Limerick Resource Management System, a computerized database that maintained current estimates of quantities to be installed, and the Forecast and Control Updating System ("FOCUS"), which developed forecasted manhours and unit rates for each commodity. These Project databases and their use in developing Forecasts are more fully described by Mr. Clarey.

Information from the Project Forecasts was used in the various cost and schedule control systems as the standard against which actual performance was measured and evaluated. Variations from the Forecasts and other changes in the Project that had a potential cost or schedule impact were identified through the Trend Program. This program was an early warning system through which Project management identified changes at an early stage, prepared order of magnitude estimates of any potential cost or schedule impact, and highlighted these changes for corrective action. These trends were then incorporated into the Forecasts and, where significant even prior to incorporation into the Forecasts, reflected throughout the functional control systems. All Forecasts and Trend Reports were carefully reviewed by PECO's site team and the Limerick Project Manager, and a detailed report of their review was provided to me for further action.

A system was also established to control cash flow expenditures on a regular basis. Long-term cash flow projections were developed as part of the forecasting process. These projections were then incorporated into a monthly expenditure report prepared by the System Planning Division which compared actual monthly expenditures to budgeted amounts. Significant deviations were brought to the attention of the Project Manager for corrective action. Review of the major aspects of Bechtel's billing, submitted on a monthly basis, was conducted by on-site representatives of the Plant Accounting and Internal Auditing Divisions. The Project Manager reviewed and approved all billing which was submitted by vendors of equipment which PECO itself had purchased -- most notably the General Electric nuclear steam supply system -- and by consultants directly engaged by PECO. As previously mentioned, the Purchasing Department also reviewed Bechtel recommendations for procurement of equipment, for award of subcontracts and for the issuance of subcontract amendments. Detailed review of all Bechtel and vendor billings was performed by the site management team and by PECO's internal auditors.

Overall progress of Project activities was monitored and controlled through a comprehensive and integrated scheduling system. At the highest level, Project progress was controlled through a Milestone Summary Schedule which provided a summary overview of major events in engineering, construction and startup. In addition, numerous other schedules were employed within the specific functional areas of Project management. Project schedules and related control systems are more fully discussed by Mr. Clarey. Another important management tool for overall Project direction and control was the Project Status Review Meeting. This meeting was started in 1974 shortly after receipt of the construction permit, and was generally held at the construction site on a monthly basis. This monthly review was conducted under my direction and attendance customarily included the Engineering Division Heads, the Project Manager, the Resident Project Manager, the Project Manager for Construction, the Electrical Engineering Project Engineer, the Quality Assurance Manager, the Station Superintendent and appropriate representatives from Bechtel, General Electric and other contractors. The purpose of this meeting was to provide all management organizations with an update on the status of all key Project matters. Topics discussed typically included a Project Summary, Senior Management Attention Items, an Engineering Report, a Construction Report, a Procurement Report, a Quality Assurance Report and an Action Items Report (i.e. Action Items from the preceding meeting).

The specific functional reports were usually presented by Bechtel representatives, with appropriate responses, comments or direction provided by the PECO management personnel in attendance. Additional input was provided by PECO functional management groups through the submission of reports prior to the meeting. Action items or problems identified from discussion at these meetings were directed to the appropriate Project entities for resolution. Action items directed to PECo management groups were handled by the Project Manager through his Bi-weekly Meeting. The output of the Monthly Project Status Review Meeting was a comprehensive report which contained all the functional information discussed at the meeting. In addition, numerous other reports were prepared and meetings were held by all Project management organizations in order to further achieve control over the Project.

Q. Did Senior Management monitor the cost and schedule status of the Limerick Project?

A. Yes. In addition to monthly meetings at which a presentation was made to Senior Management covering the status and cost expenditures of all projects compared to budget, the Company's Board of Directors received complete reviews of the cost of the Limerick Project on at least two occasions each year. In May, a full presentation was made of major Company projects and their costs (including Limerick) for a five-year forecast period. In January, the projects' costs were updated and presented in written form to the Board. If significant project cost changes were recognized between budget periods, as, for example, when a Bechtel Forecast was revised, the Board of Directors was informed at this time.

Senior Management also participated in major control meetings and received frequent status reports on Project progress. For example, the Chairman of the Board, the President and the Senior Vice President - Nuclear Power periodically attended the Monthly Project Status Review Meeting at which detailed cost and schedule information was discussed. I personally provided a verbal report on cost and schedule progress and any other significant problems at the Chairman's weekly staff meeting. Finally, these senior officials received Project information through review of monthly progress and items of interest reports prepared by Bechtel and the Engineering and Research Department, respectively.

Through these meetings and reports, the Company's Senior Management was continually informed of the cost and schedule status of Limerick and actively participated in major decisions affecting the Project.

4. Explanation of Reasons for Cost and Schedule Growth.

Q. Please summarize the reasons for cost and schedule growth at Limerick.

A. The major reason for increased costs and schedule duration was changing regulatory requirements. Additional costs and schedule duration were incurred because of construction funding restrictions and labor unavailability. In addition, some increased costs were incurred as a result of design changes justified by improvements to plant safety, operability and reliability.

Q. How did changing regulatory requirements impact the Limerick Project?

A. During the 1970s and early 1980s, the number of NRC safety and environmental requirements and new interpretations of those requirements increased dramatically. These new regulatory standards imposed stricter design, manufacturing and construction requirements and greatly increased the Limerick Project work scope. In many instances, these new requirements were imposed after substantial construction and design had already been completed. This in turn resulted in extensive retrofitting and greatly increased the complexity of the Project and congestion in work areas, thus hindering construction performance. In addition, regulatory changes often imposed increased staffing and documentation requirements which further contributed to higher Project costs.

The overall result is that regulatory changes and changing regulatory interpretations were by far the single greatest reason for increased costs at the Limerick Project. Direct costs increased because of the additional engineering, equipment, materials, craft manhours and testing needed to meet the increased scope of the Project. Indirect costs resulted from less than optimal activity sequencing and reduced labor effectiveness caused by increased congestion, complexity and additional scope, and from the need to provide increased support services to the Project as the result of the regulatory imposed increased work scope.

Q. Please highlight the more significant regulatory changes that impacted the Limerick Project.

A. In 1970, Appendix B of 10CFR50 established eighteen broad criteria which applied to all safety-related items in all phases of nuclear projects from early site investigation to final decommissioning. To provide detail as to acceptable methods of compliance with Appendix B, the NRC issued a series of Quality

Assurance Documents in 1973-1974. It was not until the late 1970s and early 1980s, however, that the tremendous impact of these requirements upon design, procurement, fabrication and construction was recognized. Additional quality inspection and other requirements generated increased documentation requirements. The impact of documentation requirements was additional manhours to develop and process the documentation, additional manhours for training personnel to create the documents, additional hold points for inspections, and additional manhours to prepare already installed components for inspection against changed or more stringent applications of construction and installation criteria.

In 1971, the Advisory Committee on Reactor Safeguards ("ACRS") imposed a higher seismic criteria than anticipated at Limerick, in the form of a higher design ground acceleration and a modified frequency spectra of seismic events. This increase in seismic requirements resulted in additional engineering and construction manhours, equipment and component congestion and complexity.

In 1975, previously undefined hydrodynamic loads were identified which impacted wetwell structures as the result of Safety Relief Valve discharge and certain postulated Loss of Coolant Accident conditions in the Mark II containment. PECO took a lead role in addressing this problem. However, final resolution of the Mark II new loads was not achieved until 1981-1982, after an extended iterative process of analysis and testing. Although PECO successfully resolved this problem without impacting Project schedule, significant additional engineering manhours and costs were incurred in order to reach a resolution that was satisfactory to both the Company and the NRC.

Also in 1975, a fire at the Browns Ferry Nuclear Plant resulted in extensive damage to electric systems and control cables and ultimately led to increased fire protection requirements. Subsequent NRC regulatory changes such as Branch Technical Position 9.5-1 and Regulatory Guide 1.120 promulgated these requirements. The major modifications required to achieve a higher level of fire protection included increased electrical separation, penetration sealing, fire-proofing of exposed structural steel, additional detection and suppresion systems and encapsulation of safety-related electrical cable in certain plant areas.

Since many of these fire protection changes were identified toward the end of the project during the 1981-1984 time period, there was a substantial possibility that full compliance would impact the schedule. To avoid this schedule impact, PECO initiated several analyses to demonstrate that a safe plant shutdown could be achieved with reduced additional fire protection. The end result of these analyses was a substantial cost savings and minimized schedule impact. However, despite these efforts, substantial costs associated with additional engineering and construction activities were nevertheless incurred.

During the late 1970s and early 1980s, a number of additional regulatory changes had a substantial impact on the Project. The most significant of all regulatory changes occurred as a result of the accident at Three Mile Island ("TMI") Unit 2 in March 1979. In response to this accident, substantial new regulations were issued which greatly increased the scope of the Project by requiring significant engineering evaluations, hardware additions, related construction activities and other substantial changes. To further exacerbate the impact of TMI, many of these changes were imposed by the NRC late in the Project (i.e. as late as 1981-1982) and severely complicated the project's ability to meet schedule during the early 1980s. Moreover, the TMI accident substantially raised the level of safety consciousness of the NRC which resulted in increased enforcement and more stringent interpretations of numerous regulations unrelated to the accident. TMI requirements also substantially increased the staffing levels and training requirements for operations and startup personnel.

Regulatory requirements that impacted the later stages of the Project also included Anticipated Transients Without Scram modifications, further additions and changes to seismic requirements, changes in ASME Code requirements, highly disruptive control room panel modifications, increasingly stringent equipment qualification standards to satisfy hydrodynamic, seismic and environmental concerns, ALARA requirements, increased security, high energy line break concerns and others. Moreover, several significant and unanticipated engineering evaluations were required by the NRC as part of Project licensing. For example, in 1980, we were required to perform a Probabilistic Risk Assessment study to assure that the risk of a severe accident occurring and its probable effects were acceptably small. Indeed, this analysis, which had not previously been required by the NRC, established that "accident risks from Limerick are expected to be a small fraction of the risks the general public incurs from other sources." NUREG-0974, p. 5-126 (April 1984). Similarly, in 1984, we were required to perform an independent design verification program to demonstrate that the Limerick design as built complied with the licensing basis of the plant. This too was a new requirement.

Finally, disruption of the proper sequencing of work activities and a reduction in labor effectiveness were indirect impacts of regulatory change that resulted in additional costs and delay. A project which can plan its work activities based upon a firm and stable scope of work can complete its work in an economic and efficient manner. However, projects subjected to continuous increases in the scope of work because of regulatory change will find it impossible to complete work within estimated cost and schedule.

Increases in craft manpower represent a good example of the disruptive influence that regulatory change had on work sequencing at Limerick. When the Project plan called for a reduction in manpower at a certain point in time and an unexpected change created a need for additional manpower, it was often difficult to obtain sufficient, qualified personnel. Moreover, once additional manpower was obtained, a less efficient and more costly plan generally resulted. Construction manpower increases required to implement regulatory required design changes also increased construction congestion. Many of these design changes were located in areas that were already space limited, such as the Reactor and Control buildings, where the most critical schedule activities during the completion of the Project took place. These areas normally had high levels of construction manpower in order to minimize the duration of critical path activities. The design changes further increased the manpower congestion in these areas which resulted in lower than anticipated unit rates.

Q. Have you directed that additional data respecting the effects of regulatory change upon the Limerick Project be prepared and presented for the record?

A. Yes, I have. This data, which is set forth as Section III of PECO Exhibit 2, has been prepared by and its details are supported by testimony from various Company engineering and construction personnel. My comments above are intended merely as a brief overview of this data.

Q. What has been the Project management philosophy for non-regulatory imposed design changes.

A. From the start of construction at Limerick, it has been a Project philosophy to minimize non-regulatory design changes. Only those changes that provided cost effective operability, maintainability, reliability and safety enhancements were implemented. All of these changes were justified based on either Peach Bottom or other industry experience. Indeed, our experience in operating the Peach Bottom units has proven extremely valuable in improving the Limerick design.

The Peach Bottom units were placed into commercial operation in 1974. However, it was not until 1977 that the number of modifications at Peach Bottom increased to a significant level. In October 1977, PECO management initiated a program to assure that Bechtel was made aware of operating and/or design improvements being made at Peach Bottom which should be considered in the design of Limerick. For Peach Bottom modifications in progress or completed, Bechtel was directed to review design material provided by PECO. For additional modifications planned at Peach Bottom, PECO engineers submitted information to the Limerick Project Manager who transmitted the information to Bechtel.

In this way, Bechtel engineers had the opportunity to review the Limerick design in light of changes being made at Peach Bottom and to make changes or modifications to the Limerick design when necessary. This timely identification of changes in the Limerick design process minimized the total cost and schedule of Limerick. Examples of non-regulatory design changes include condenser modifications, solid radwaste system changes, and improved reliability and diversity of emergency core cooling systems and supporting systems.

Q. Mr. Kemper, have you directed that there be prepared an analysis of the additional cost to the Project of the several reasons for cost and schedule growth which you describe above?

A. Yes, I have. This analysis, which is set forth as Section II of PECO Exhibit 2, was prepared by TB&A based upon Project cost documentation (i.e. primarily Project Forecasts and associated documents), with assistance from our and Bechtel's Project personnel. The analysis was reviewed by Dr. Roger J. Mattson, a former NRC official and a witness in this proceeding, to assure the correctness of its treatment of NRC regulations and licensing requirements. I and my staff have also reviewed the analysis and believe it to be accurate.

Q. Please describe the analysis which you had performed and its result.

A. The analysis compares our 1970 Capital Authorization cost estimate for the Project, which was used as the basis of our initial capital authorization, with a near final Project cost estimate reflecting a Limerick 1 commercial operation in February 1986. Based on the Project forecast documents, the analysis develops the increase in Project cost which is attributable to specific regulatory and non-regulatory causes. Further details respecting the manner of the analysis preparation are presented by TB&A.

As shown on Schedule 7, of a total direct cost increase of approximately $2.005 billion, fully $1.362 billion or 68%, is due to new or revised regulatory requirements, or to other externally-imposed factors such as new or increased taxes (excluding PURTA), cash constraint or labor unavailability. An additional $111.9 million or approximately 6% is due to plant design changes made to enhance operability and/or reliability. The great majority of the remainder of the Project's cost increases are due to increases in escalation and AFUDC.

Q. Mr. Kemper, what do you conclude from your review of this analysis?

A. In my opinion, this analysis provides a further demonstration of the reasonableness and prudence of our management of Limerick's construction and of the Project's final cost. As I and others have described, we could not prevent the effects of externally imposed forces such as regulatory changes or inadequate cash resources. When confronted with these forces, our only recourse was to react to them with an approach which would limit to the extent reasonably possible their adverse effect upon Project cost and schedule. As indicated in my testimony and that of other witnesses, I believe that we achieved that objective. Accordingly, Limerick 1 and Common Plant's Project management has been reasonable and prudent, and the entirety of its costs should be allowed in rate base.

Q. Does this conclude your testimony?

A. Yes, it does.

List of Professional Committees And Industry Organizations

American Nuclear Society - Member
  Standards Steering Com. - Member

ANSI N-45 Ad Hoc Com. on Packaging, Rec. Handling & Storage - Member

Association of Edison Illuminating Companies - Member
  Committee on Electric Power Apparatus - Member; Chairman

Atomic Industrial Forum
  Ad Hoc Review Group on 10 CFR Parts 2-50 - Member
  Nuclear Materials Safeguards Com. - Member
  Reactor Safety Steering Com. - Member

Concord Township Planning Commission - Member; Vice Chairman; Chairman

EEI-AEIC-NEMA Triple Joint Com. on Power Circuit Breakers - Member

EEI US/USSR Jt. Working Group on Electric Power Generation and Transmission - Member

Electric Power Research Institute - Member
  Nuclear Power Divisional Committee - Member

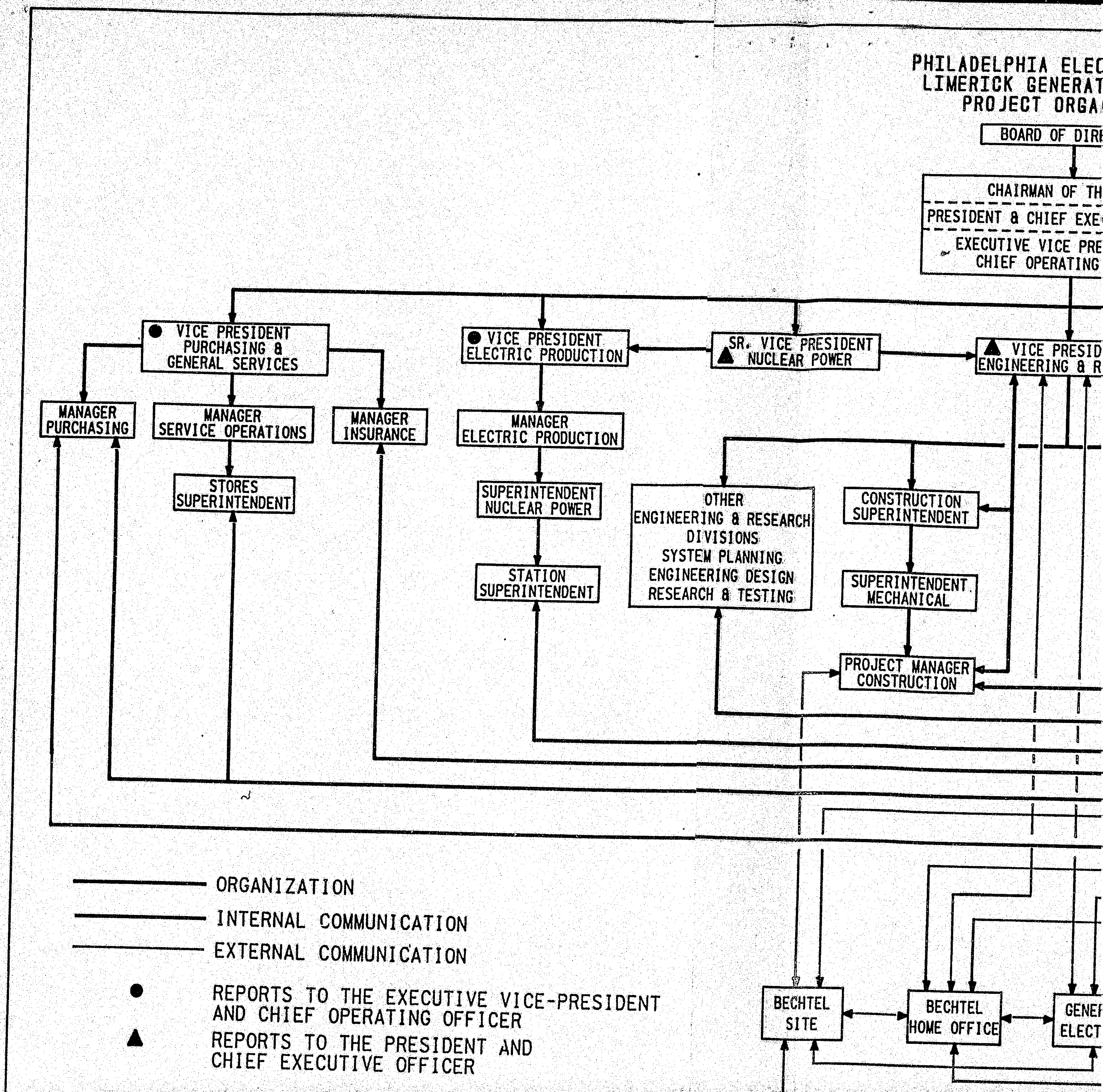
Engineers' Club of Philadelphia - Member

Institute of Electrical and Electronics Engineers - Member

Union League of Philadelphia - Member

University of Pennsylvania
  Mechanical Engineering and Applied Mechanics Advisory Council - Chairman
  Wharton Center for Risk and Decision Processes - Member

Widener University School of Engineering Board of Advisors



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MANAGER ELECTRIC PRODUCTION
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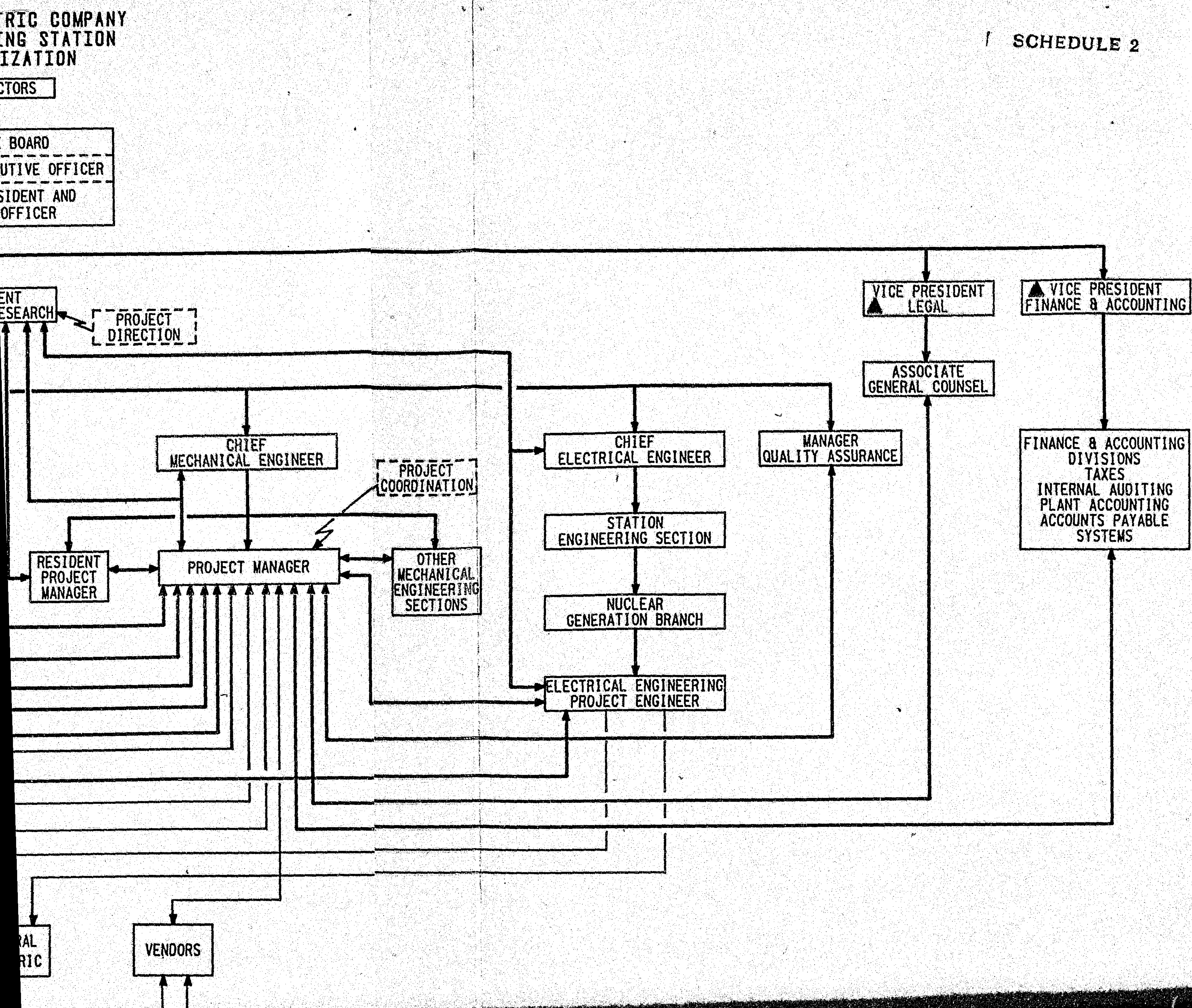
STATION SUPERINTENDENT
OTHER ENGINEERING & RESEARCH DIVISIONS
SYSTEM PLANNING
ENGINEERING DESIGN
RESEARCH & TESTING
CONSTRUCTION SUPERINTENDENT
SUPERINTENDENT MECHANICAL
PROJECT MANAGER CONSTRUCTION
BECHTEL SITE
BECHTEL HOME OFFICE
GENEF
ELECT
ORGANIZATION
INTERNAL COMMUNICATION
EXTERNAL COMMUNICATION
REPORTS TO THE EXECUTIVE VICE-PRESIDENT AND CHIEF OPERATING OFFICER
REPORTS TO THE PRESIDENT AND CHIEF EXECUTIVE OFFICER

SCHEDULE 2



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...OFFICER
...ENT
...ESEARCH
PROJECT DIRECTION
VICE PRESIDENT LEGAL
VICE PRESIDENT FINANCE & ACCOUNTING
ASSOCIATE GENERAL COUNSEL
CHIEF MECHANICAL ENGINEER
PROJECT COORDINATION
CHIEF ELECTRICAL ENGINEER
MANAGER QUALITY ASSURANCE
FINANCE & ACCOUNTING DIVISIONS
TAXES
INTERNAL AUDITING
PLANT ACCOUNTING
ACCOUNTS PAYABLE
SYSTEMS
RESIDENT PROJECT MANAGER
PROJECT MANAGER
OTHER MECHANICAL ENGINEERING SECTIONS
STATION ENGINEERING SECTION
NUCLEAR GENERATION BRANCH
ELECTRICAL ENGINEERING PROJECT ENGINEER
...RAL
...RIC
VENDORS

Bechtel Documents Reviewed By PECO Engineering Personnel Under Design Review Program

1. Basic Design Drawings (But Not Construction)
2. Specifications
3. Procedures
4. Material Requirements
5. Selection of Subcontractors and Vendors
6. On-Site Administrative Controls
7. Material Controls
8. Examination Procedures
9. Inspection Plans
10. Design Calculations

Major Equipment Procurement
Administered Directly By PECO

I. Electrical Equipment

A. Transformers, Main Unit, 22-500 kV and 22-230 kV and associated lightning arresters

B. Transformers, Start-up, and associated lightning arresters

C. Transformers, Unit Auxiliary

D. Transformers, Safeguard and Plant Services

E. Switchgear, 4kV and above

F. Cable, 600 volt and above

G. Generator Isolated Phase Bus

H. Generator Surge Protection Equipment

I. Disconnect Switches, 230 and 500 kV

II. Mechanical Equipment

A. Air Compressors

B. Auxiliary Boilers

C. Condensers and Air Ejectors

D. Condenser Tubes

E. Diesel-Generators

F. Feedwater Heaters

G. Nuclear Steam Supply System and Auxiliaries

H. Pumps - Circulating Water, Condensate, Reactor Feed and Service Water.

I. Traveling Screens

J. Turbine-Generator and Auxiliaries

K. Turbine, Reactor Feed Pumps

L. Water Treatment - Make-up and Condensate Polishing

Schedule 5

Increases In Quality Assurance/Quality Control Field Staffing Levels

Year	PECO QA	BECHTEL QA	BECHTEL QC
1975	5	5	
1976	5	5	66
1977	5	5	66
1989	6	6	67
1980	6	6	72
1981	7	8	117
1982	11	8	150
1983	16	9	210
1984	26 peak	15	265 peak

NRC Site Inspections of Limerick Generating Station

Year	No. of Inspections
1970	2
1971	3
1972	0
1973	5
1974	8
1975	13
1976	13
1977	15
1978	12
1979	15
1980	21
1981	17
1982	16
1983	23
1984	74
1985 (As of 7/15/85)	27
	264

Limerick Generating Station
Unit 1 & Common
Cost Reconciliation Summary

		($1,000s)
Original PECO Capital Authorization Value (Unit 1 & Common)		$344,100
Regulatory and Other Externally - Imposed Changes		
- TMI-2	$ 57,500	
- Plant Staffing, Startup and Training	181,600	
- Seismicity	119,600	
- Mark II	136,100	
- Fire Protection & Electrical Separation	65,800	
- Equipment Qualification	38,600	
- Anticipated Transients Without Scram	20,900	
- ALARA & OSHA	39,600	
- ASME Code Requirements	20,900	
- Security Requirements	43,500	
- IGSCC	10,200	
- Licensing Costs	62,900	
- Miscellaneous Other NRC Regulations	116,300	
- Non-NRC Requirements	63,800	
- Schedule Delays Due to Licensing Delays and Other Factors	385,100	
		1,362,400
Design Changes to Facilitate Operability and Reliability		111,900
Estimate Refinements and Other Causes		208,600
Unanticipated Escalation		322,100
Subtotal		$2,349,100
AFUDC		1,426,200
Overheads		5,800
Taxes (PURTA)		30,500
Contingency		7,500
RECONCILIATION TOTAL		$3,819,100