PECO STATEMENT NO. 2

Office of
Public Utility Commission

SDT 12-19-85 H09 R-850152

PENNSYLVANIA PUBLIC UTILITY COMMISSION, ET AL.

v.

PHILADELPHIA ELECTRIC COMPANY,

DOCKET NO. R-850152

DOCKETED
DEC 27 1985

UNOFFICIAL FOLDER

TESTIMONY OF JAMES O. LOVE

AND BASIL P. KONONETZ

THEODORE BARRY & ASSOCIATES

INDEPENDENT ASSESSMENT OF THE PRUDENCE
AND REASONABLENESS OF LIMERICK 1 AND
COMMON PLANT PROJECT MANAGEMENT;
PREPARATION OF PECO EXHIBIT 2

September 27, 1985

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TESTIMONY OF JAMES O. LOVE
THEODORE BARRY & ASSOCIATES

I. INTRODUCTION AND SUMMARY OF CONCLUSIONS

Q. PLEASE STATE YOUR NAME, ADDRESS AND OCCUPATION.

A. My name is James O. Love. I am an Executive Vice President and Principal in the management consulting firm of Theodore Barry & Associates ("TB&A"), a California corporation, whose principal business address is 1520 Wilshire Boulevard, Los Angeles, California 90017.

Q. WHAT ARE YOUR PRESENT RESPONSIBILITIES AS AN OFFICER AND A PRINCIPAL IN TB&A?

A. I am a member of TB&A's Office of the President, of the Board of Directors and of the Executive Committee charged with policy formulation for the corporation. In addition, I am a member of TB&A's Management Group charged with the management of TB&A's consulting business. I am also the Director of Engineering and Construction Services for TB&A. I direct the work of consulting teams and perform consulting assignments for clients engaged in major construction projects. For example, I have played an active role in ten of TB&A's thirteen nuclear retrospective reviews and in most of TB&A's prospective project management reviews of more than 50 construction projects.

Q. PLEASE PROVIDE A GENERAL DESCRIPTION OF TB&A?

A. TB&A is one of the leading general management consulting firms in the United States. Founded in 1954, TB&A has performed over 2,000 engagements for more than 700 government and private clients. Within the last ten years, in excess of 60 management and operations reviews on behalf of both public utility commissions and private utilities have been performed, a number of

which have been similar in nature and scope to our review of the Limerick Project. TB&A has provided testimony regarding the prudency of owner actions in rate proceedings involving the Shoreham, Salem, Diablo Canyon and South Texas nuclear projects.

Q. PLEASE GIVE A BRIEF SUMMARY OF THE PURPOSE OF YOUR TESTIMONY?

A. My testimony presents the results of TB&A's investigation into the reasonableness and prudence of the project management of the Limerick Nuclear Generating Station. This investigation, i.e. a retrospective review, covers the entire project from inception to the present.

A retrospective audit, such as that undertaken for Limerick, is an evaluation of management practices actually employed and the steps management took to influence the controllable elements of the project. The evaluation is made in the context of typical industry practices considering then existing circumstances. The audit is focused most heavily on the management process, the controllable aspects of the project, and the key events that had major impacts on the project.

The conclusions drawn are based on documented evidence supplemented by interviews of project personnel and by independent analyses conducted by TB&A.

Q. HOW HAVE YOU ORGANIZED YOUR TESTIMONY?

A. TB&A's findings and conclusions regarding the management process and decisions respecting the Limerick Project have been grouped into five broad discussion areas:

- Pre-project planning and project structure;

- Engineering and procurement management;
- Construction and startup testing management;
- Evaluation of the announcements made regarding the scheduled project completion; and
- Evaluation of the reasons for project cost and schedule growth.

An overall chronology of project events and an overall summary of findings and conclusions are also presented.

A. WITNESS QUALIFICATIONS

Q. PLEASE DESCRIBE YOUR EDUCATIONAL BACKGROUND.

A. I received my Bachelor of Science degree with honors and high distinction in Chemical Engineering from the University of Illinois in 1960. In 1961, I received a Master of Science in Chemical Engineering as a fellow at the University of Southern California. I completed my business school core course work at the University of Chicago in 1968 with honor standing, and in 1970 I received a Masters in Business Administration from Golden Gate University. I have attended many technical and management seminars subsequent to my university training.

Q. PLEASE SUMMARIZE YOUR PROFESSIONAL EXPERIENCE.

A. I have over 24 years of experience in basically three distinct areas: the chemical process industry (including both petrochemical and chemical companies); the regulated utility industry; and the management consulting profession.

For the past 13 years, I have worked predominantly in the utility industry, the last eight as a management consultant. Prior to that, I was employed for ten years in the chemical process industry, performing research

and development and also economic analysis of petrochemical and chemical projects.

Q. WHAT POSITIONS HAVE YOU HELD IN THE UTILITY INDUSTRY?

A. I was Manager of the Economics Division of the El Paso Natural Gas Company, evaluating the economics of major construction projects including the transmission of Alaskan crude oil in large diameter pipelines, El Paso's proposed Alaska Gas Pipeline and Liquid Natural Gas Projects, development of surface and underground coal mines, coal sales to electric utilities, coal gasification and other projects. Prior to that, I was the Manager of Financial Planning for Puget Sound Power & Light Company, where I developed and installed a corporate planning system. My role was to assist the Chairman, President and Chief Financial Officer by devising and evaluating strategic planning alternatives ("what-ifs") with a specific focus on the revenue requirements and financial impacts of power plant construction alternatives.

Since early 1977, I have been employed by TB&A, consulting primarily with electric utilities and public utility commissions. In 1978, I was elected a principal in TB&A and was also voted consultant of the year by my firm, primarily for my contributions in the field of project management of major project engineering design and construction.

Q. ARE YOU A MEMBER OF ANY PROFESSIONAL ORGANIZATIONS?

A. Yes. I am a member of the American Institute of Chemical Engineers and a past member of Planning Executives Institute. I was also a charter participant in the formation of the Society of Rate of Return Analysts in 1976, sponsored by the Federal Power Commission.

I am also a member of the Project Management Institute (PMI) and have been active in its national and local activities. For example, at a Joint Symposium with INTERNET, its international sister organization, PMI sponsored two papers authored by me. In 1982, I served as Vice President of PMI's Washington, D.C. chapter, which was honored as PMI's Chapter of the Year for that year.

Q. HAVE YOU MADE FORMAL PRESENTATIONS OR CONDUCTED PROFESSIONAL DEVELOPMENT SEMINARS RELATING TO PROJECT MANAGEMENT?

A. Yes, I have made presentations on a wide spectrum of corporate planning and project management topics, particularly the cost assurance aspects of major project management.

Q. HAVE YOU PREVIOUSLY PRESENTED TESTIMONY IN UTILITY, REGULATORY OR OTHER PROCEEDINGS?

A. Yes. I have presented testimony before the Texas Public Utility Commission, the California Public Utility Commission, the Commonwealth of Kentucky Public Service Commission (now the Kentucky Energy Regulatory Commission), the New Jersey Board of Public Utility Commissioners, the Pennsylvania Public Utility Commission, the Arkansas Public Utilities Commission, the Kansas State Corporation Commission, the Illinois Commerce Commission, the Alaska Public Utilities Commission and the Federal Energy Regulatory Commission.

Q. WHAT WAS THE SUBJECT OF YOUR PREVIOUS TESTIMONY PRESENTED BEFORE THE PENNSYLVANIA PUBLIC UTILITY COMMISSION?

A. That testimony, presented in 1978, involved a retrospective review of the construction of Salem Unit 1. The Salem Project was constructed by a

consortium headed by Public Service Electric & Gas Company (PSE&G), and was owned equally by Philadelphia Electric Company. TB&A's review, co-sponsored by the New Jersey Public Advocate and the Pennsylvania Consumer Advocate, was from the viewpoint of an "autopsy" to determine PSE&G's prudence in its role as project manager and to evaluate the owner oversight role. The results of our independent review were presented in three separate hearings before the New Jersey Board of Public Utility Commissioners, the Pennsylvania Public Utility Commission, and the Delaware Public Service Commission.

Recently, our firm was retained by the Pennsylvania Commission to perform a broad operations and management audit of Bell Atlantic. In addition, we have performed a general management audit of Pennsylvania Gas and Water Company and reviewed the management and operations of General Public Utilities Company in the aftermath of the TMI-2 incident on behalf of the Pennsylvania Commission.

Q. WHAT IS YOUR PERSONAL EXPERIENCE IN ELECTRIC UTILITY MANAGEMENT AND OPERATIONS AUDITS?

A. With TB&A, I have participated in more than 40 utility projects, including ten of the thirteen retrospective reviews of nuclear power plant construction projects underway or completed by TB&A. My TB&A audit experience encompasses 40 major design and construction projects, including more than 29 nuclear power stations in various stages of construction throughout the United States plus coal and oil-fired power plant construction projects in both the Continental U.S., Alaska and South America. My roles have ranged from consultant to engagement manager and I have managed both company-wide and

functional audits, as well as implementation-oriented improvement projects.

For example, I managed an in-depth management performance review of the Tennessee Valley Authority's ("TVA's") 25,000-person Office of Engineering Design and Construction (OEDC). This review resulted in 115 improvement recommendations in areas throughout OEDC and in other TVA offices interfacing with OEDC. At the time, OEDC was managing the design and construction of 14 nuclear units, including the world's largest nuclear station at Hartsville, Tennessee. I also directed two subsequent follow-up reviews for TVA's Board of Directors to determine the extent of implementation of TB&A's recommendations, and ascertained that implementation had proceeded on 106 of 115 recommendations.

Q. WERE ANY OTHER ASSIGNMENTS IN YOUR PROFESSIONAL CAREER PARTICULARLY PERTINENT TO THE EVALUATION OF NUCLEAR PLANT PROJECT MANAGEMENT AND OWNER OVERSIGHT?

A. Yes, in the early 1970s, I led an investigation of the alternative approaches available at the time for managing the engineering design and construction of nuclear projects. This investigation focused on those approaches that would provide the greatest cost assurance to a utility, commensurate with the utility's skills and resources. As part of this assignment, I participated in a series of tours to six major project construction sites, to vendors of control system software, and to home offices of architect/engineers (A/Es) and construction management and/or project management contractors to inspect their approach to cost assurance. These tours allowed me to see the levels of owner involvement and to understand the implications of alternative management approaches.

B. TB&A QUALIFICATIONS

Q. PLEASE DESCRIBE TB&A.

A. TB&A is one of the leading general management consulting firms in the United States. It provides a broad range of services to industrial enterprises, service businesses, government agencies and health, educational and other nonprofit organizations. A significant portion of TB&A's work is in the electric, gas, water and telephone utility area including engineering and construction related activities. TB&A consultants have also had extensive experience related to natural resource development and availability including coal, oil, natural gas and uranium.

TB&A was founded in 1954 and has performed over 2,000 engagements for more than 700 government and private clients throughout the United States, Canada, Latin America, Europe and Asia. TB&A's professional staff in the U.S. is made up of experienced consultants who are specialists in many fields, including project management, engineering design and procurement for major projects, construction management, licensing, quality programs, startup and testing, nuclear power plant operations, organization planning, financial planning and analysis, operations management, systems and procedures, purchasing, office management, electronic data processing, economics, personnel administration, accounting, management planning, marketing, manufacturing, and distribution.

TB&A is a member of the Association of Consulting Management Engineers and subscribes to the high professional and ethical standards set by that organization. Many members of the firm are Certified Management Consultants (CMC's), which means they have met the strict certification

requirements of the Institute of Management Consultants and have pledged to comply with the Institute's Code of Professional Responsibility.

Q. WHAT EXPERIENCE DOES TB&A HAVE IN CONDUCTING UTILITY MANAGEMENT AUDITS?

A. TB&A has performed more than 60 management and operations reviews of utilities, most of them electric utilities, over the last 10 years. Of these, more than half were of limited scope -- that is, they focused on several of the functional areas of electric utility management and operations. To my knowledge, no other management consulting firm has performed as many regulator-ordered nor as many utility-sponsored audits of electric utilities as TB&A has.

In our many functional audits of electric utilities, TB&A has focused specifically on the project management of more than 50 major projects, including over 30 nuclear power plant construction projects, covering the key project control aspects of organization, owner involvement, contract management, engineering design, procurement management, licensing and regulatory affairs management, construction management and overall project management. Thirteen of TB&A's project management assignments have been retrospective reviews of nuclear power plant construction projects.

Q. HAS TB&A PERFORMED ANY OTHER ASSIGNMENTS THAT WERE SIMILAR IN NATURE AND SCOPE TO THE REVIEW OF THE LIMERICK PROJECT?

A. Yes. TB&A has performed a number of studies similar in nature and scope to our review of the Limerick Project. TB&A has filed prepared direct testimony with the Federal Energy Regulatory Commission (FERC) at Dockets OR 78-1 and P-81-1 concerning the reasonableness of the construction expenditures for

the Trans Alaska Pipeline System (TAPS), on behalf of the State of Alaska. TB&A has also provided testimony regarding the prudency of owner actions in rate proceedings involving the Shoreham, Salem, Diablo Canyon and South Texas nuclear projects, and has provided testimony regarding proper construction management practices in proceedings involving the Clinton Nuclear Project. Also, TB&A is currently performing retrospectives of six additional nuclear projects at the time of this filing.

C. TB&A'S STANDARD OF REASONABLE AND PRUDENT MANAGEMENT PERFORMANCE

Q. WHAT STANDARD DID TB&A APPLY IN THIS RETROSPECTIVE REVIEW TO DETERMINE THE PRESENCE OR ABSENCE OF REASONABLE AND PRUDENT MANAGEMENT PERFORMANCE?

A. TB&A used the same standard in this review that we have utilized in all of our recent major project retrospective reviews. This standard is: Whether PECO, in managing the Limerick Project, made the decisions and took the actions, including implementation of management and control systems, that a reasonable, experienced and competent manager would want and need in order to assure that a project of this size and complexity had a good chance of being completed in a reasonably cost-effective manner. And, where it appeared that such actions were possibly not being taken, and systems not implemented, we looked to see whether PECO top management took reasonable and timely steps to correct the situation.

TB&A focused on those factors that represented the controllable elements of the Project -- given the information and options available when decisions were being made. The question to be answered is: "Did management make a reasonable or appropriate choice from among identifiable alternatives,

given the information and understanding available/knowable at the time of the decision?" In applying this standard to the facts available to TB&A, we drew on well-known and accepted principles of management science that were available and proven in use contemporaneously with PECO's needs for, and choice of, management alternatives to apply to the management of the Limerick Project.

Q. PLEASE DESCRIBE THE ELEMENTS OF THIS STANDARD IN GREATER DETAIL.

A. It bears repeating that TB&A believes that an assessment of management performance must focus on the reasonableness and appropriateness of decisions and actions related to the controllable aspects of a project in the context of information and courses of action contemporaneously available. Evaluation must be made without falling into the trap of hindsight. The outcome resulting from a specific decision, action or sequence of actions, is not the proper indicator of the reasonableness of management's action. An outcome may be adverse through no fault of management, and regardless of entirely appropriate and even superior management practices and actions. In short, the results achieved are not a test of the reasonableness or prudence of management conduct. Nor is it appropriate to rely upon data or management procedures not reasonably available to management in asserting that better or different results could have been achieved.

Also, in conducting a retrospective review of management performance, it is important to be cognizant of a further process limitation. In addition to recreating and basing evaluation only upon contemporaneously available information and alternatives, the performance analyst must also recognize and

factor into his evaluation the priorities demanding management attention during the time period under study. In projects as complex as nuclear power plants, there are, typically, numerous matters requiring management decisions at any point in time. Action on any specific matter is always influenced by the relative impact or importance of that matter at the time compared to other matters requiring management attention. Choices of action are further limited by the time available to assess alternatives, by the resources available to apply to the decision-making process, and by the information reasonably available. The result of this process may be that an individual action may appear to be unreasonable or inappropriate, but when evaluated in context of the total project environment, this same action might be found to be a judicious and proper application of the management process. Failure to recognize this interrelationship of all project activities and processes, and failure to evaluate the reasonableness of the attention devoted to a particular activity in light of the totality of activities then on-going, are improper applications of hindsight.

An additional element of TB&A's standard is the recognition that events upon which management must act or make decisions may be controllable or uncontrollable. Management and the shareholder interests that it represents should not be penalized for events that could not be prevented. As a corallary to this, TB&A believes that while nuclear projects are large and complex, it is through these controllable aspects that management can influence both cost and schedule performance. Similarly, the mere existence of one or more errors on the project, as it relates to either owner or contractor actions, does not in

itself signify unreasonableness or imprudence. The existence of a large number of errors or the unusual nature of a specific error or group of errors, however, would be cause for suspecting unreasonable management action.

D. TB&A'S APPROACH TO THE LIMERICK RETROSPECTIVE AUDIT

Q. PLEASE DEFINE THE SCOPE OF A TYPICAL MAJOR PROJECT MANAGEMENT AUDIT.

A. Project management audits include both "prospective" and "retrospective" audits. Prospective audits are forward looking and focus on current management practices with emphasis on improvements to preferred management practices for the remaining activities of the project. Retrospective or "over-the-shoulder" audits assess the prudency or reasonableness of past management decisions and actions.

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

An element important to a project such as Limerick, which greatly influences cost and schedule, is quality. Quality standards for much of the work associated with nuclear power plant projects are established by outside regulatory agencies. The implementation of these quality requirements, in addition to others deemed necessary by the project participants, become embodied in the overall project cost and schedule.

Quality should be a primary objective of the project, and it is an element which constrains cost and schedule minimization.

Q. WHAT IS THE FACTUAL BASIS FOR TB&A'S CONCLUSIONS REGARDING LIMERICK PROJECT MANAGEMENT IN THIS PROCEEDING?

A. As in most management audits conducted by TB&A, we relied on a sequence of both "top down" and "bottom up" interviews of PECO employees and contractor employees -- including those who had key roles in the design and construction of Limerick -- to acquire a perspective of the project environment. As is our standard methodology, we used a verification process to ensure that the information we were receiving accurately portrayed project circumstances. The verification takes several forms, including:

- Standard, independent source confirmation;
- Feedback to key information sources of conflicting versions of actions or decisions; and
- Presentation of preliminary findings to groups of managers whose interaction can improve the quality and the validity of the reconstruction of contemporaneous project management practices.

Q. WAS TB&A'S FACTUAL BASIS LIMITED TO JUST THE INTERVIEWING AND VERIFICATION PROCESS YOU DESCRIBED?

A. No. Interviews were used to acquire a broad understanding of the project and as a guide for detailed documentation reviews and analyses. The primary bases for our conclusions were documented evidence (i.e. contemporaneous documents relating to project activities, and our independent evaluation of this evidence), supplemented as necessary by information gained from interviews. During the course of our investigation, we reviewed many thousands of

documents and records produced and/or utilized during the period of the Limerick Project, including the project formation period. We also relied upon our extensive experience and knowledge of nuclear project construction practices developed from study and reviews of other projects, in reaching our determination of the reasonableness with which the project was managed.

Q. HOW DID TB&A MAKE ITS DETERMINATION REGARDING THE PRUDENCE OF LIMERICK PROJECT MANAGEMENT?

A. First, we classified the checklist of elements we typically assess in evaluating management performance into six areas:

- Pre-Project Planning and Project Structure;
- Engineering Management;
- Procurement Management;
- Construction and Site Management, including Quality Assurance;
- Startup Testing Management;
- Licensing and Regulatory Relations Management.

These are the same areas we have used in evaluating the management performance in all our prior retrospective reviews where we have presented testimony on prudence.

Second, a team of consultants, headed by me and working under my immediate direction and supervision, was assigned to conduct the interviews and the verification process described above. As part of this team, I designated Basil P. Kononetz as Project Manager. The Project Manager, who overviewed the entire process and promoted interaction among the TB&A team, served as an internal verification and analytical aid in helping to formulate conclusions and synthesize findings.

The TB&A team has had extensive experience in all areas of nuclear power plant construction and engineering management, both before and during their association with TB&A. The experience of this team includes more than 60 man years in the power industry and over 40 man years specifically involved with nuclear projects. The overall review and writing process consumed more than 18 months of calendar time and approximately 1500 consultant-days of effort, during which time extensive findings and conclusions were developed by the team. These findings and conclusions were then reviewed and documented in the form of this testimony. Finally, this testimony underwent a detailed and comprehensive review by TB&A Officers and Principals not on the Limerick team as an additional verification measure.

Q. ARE ANY SPECIAL CHARACTERISTICS ESSENTIAL TO TB&A'S CONDUCT OF RETROSPECTIVE REVIEWS?

A. Yes. TB&A has found that it is absolutely imperative that a consulting firm maintain its independence -- independence in the sense of:

1. Avoiding conflicts of interest, or even the appearance of a conflict.

2. Demanding the freedom to develop objective conclusions regardless of the interests or bias of the client.

3. Developing the balance that comes from viewing problems from more than one perspective -- e.g. working for commissions, consumer and public advocates, and other regulators as well as utilities.

Q. HAS TB&A EVER HAD ANY INVOLVEMENT WITH THE LIMERICK PROJECT PRIOR TO THIS ASSIGNMENT OR WORKED FOR PECO ON ANY OTHER ASSIGNMENT?

A. No.

Q. DO YOU BELIEVE THAT THE TB&A TEAM HAD ALL THE NECESSARY INDEPENDENCE TO CONDUCT AN OBJECTIVE THIRD PARTY RETROSPECTIVE REVIEW OF THE LIMERICK PROJECT?

A. Yes. The TB&A team had unrestricted access to all the necessary PECO documents and files as well as to PECO and Bechtel personnel. TB&A's conclusions are based on the facts obtained from these documents and the individuals interviewed. The approach used by TB&A and the data available were similar to those used in our other nuclear project retrospective reviews, including those performed with regulators or public advocates as sponsors.

Q. HAS TB&A BEEN ABLE TO MAKE A VALID ASSESSMENT OF THE REASONABLENESS OF PECO'S MANAGEMENT OF THE LIMERICK PROJECT?

A. Yes, we have been able to make such an assessment based on our knowledge of the evolution of management practices and techniques in the nuclear industry at the time of PECO's decisions and actions. It is TB&A's conclusion that throughout the 20-year history of the Limerick Project, PECO made reasonable and appropriate decisions and employed reasonable management practices. In sum, we have found, based upon our extensive investigation, that PECO's decisions and actions throughout the project satisfy our standard of reasonable and prudent management conduct as I have described it above. Our detailed assessments and conclusions regarding PECO's management practices and decisions are fully described in each section of testimony that follows.

Q. MR. LOVE, PLEASE DESCRIBE YOUR AND MR. KONONETZ'S ROLE IN THE PREPARATION AND PRESENTATION OF THIS TESTIMONY?

A. This testimony has been prepared in its entirety under my direction and

supervision and it reflects conclusions which I have reached as TB&A's Engagement Director, who is ultimately responsible for the quality of this project. Mr. Kononetz, as Project Manager, has assisted me in the testimony's preparation. We have chosen to present the testimony jointly because of the breadth of the subjects covered and the magnitude of the factual detail which supports the conclusions presented. Mr. Kononetz has been principally responsible for the organization of that detail. A summary of Mr. Kononetz's professional background and experience is set forth in Appendix A.

E. CHRONOLOGY OF MAJOR PROJECT EVENTS

Q. WOULD YOU PLEASE PROVIDE A CHRONOLOGY OF MAJOR LIMERICK PROJECT EVENTS?

A. The following project history summarizes the significant events, activities and decisions that occurred on the Limerick Project. The history is divided into the pre-project planning (1967-1969), pre-construction permit (1969-1974), post construction permit (1974-1978) and post-TMI construction and startup (1979-1985) phases. Schedules 1 through 3 summarize and illustrate significant project events and data as discussed in the ensuing history and employed in our evaluation of Project Management.

Schedule 1, a Major Event Time-Line, shows the significant events that occurred during the engineering, construction and startup phases of the Limerick Project. Also shown are the PECO bond downgradings, the timing of the publicly announced completion deferrals, and construction reported percentage complete at various points in time.

Schedule 2 illustrates the reported Bechtel engineering percent complete from 1973 through 1984 for Units 1 and 2.

MAJOR EVENT TIME-LINE

1967
- PECo requests proposals to be submitted for a two unit nuclear power station

- GE awarded contract to supply two Mark I Boiling Water Reactors

1968

1969
- Limerick site selected

- Proposals for design and construction solicited and received
- Bechtel selected as Architect/Engineer and Constructor for Limerick

- Start of Limerick engineering activities by Bechtel

1970
- Construction permit application

- First Order-of-Magnitude Estimate
- Second Order-of-Magnitude Estimate

- Original Capital Authorization $716M (Units 1 & 2)

1971

1972
- Preliminary Budget Estimate - Unit 1 Fuel Load February 1978

1973

1974
- Consolidated Edison Dividend Omission

- Construction Permit Received

- Deferral Announcement
  - Unit 1 Fuel Load October 1980 (Public Schedule)
  - $600 M Reduction in Capital Expenditures over 5 years

- PECo Bond Downgrading AA to A

1975
- Forecast 1 - Unit 1 Fuel Load August 1980 (Construction Target Schedule)

1976
- PECo Bond Downgrading A to A-

- Deferral Announcement
  - Unit 2 Fuel Load October 1982 (Public Schedule)
  - $750M Reduction in Capital Expenditures over 5 years

MAJOR EVENT TIME-LINE

•Forecast 2 - Unit 1 Fuel Load October 1981 (Construction Target Schedule)
- Construction of Unit 1 & Common 27% complete

1977

•Capital Authorization Supplement 1 - $2.575B (Units 1 & 2)

•Forecast 3 - Unit 1 Fuel Load October 1981 (Construction Target Schedule)
- Construction of Unit 1 & Common 38% complete

1978

•Deferral Announcement
- Unit 1 Fuel Load October 1984 (Public Schedule)
- $270 M Reduction in Capital Expenditures over 4 years

1979

•Three Mile Island Unit 2 Incident

•Forecast 4 - Unit 1 Fuel Load October 1982 (Construction Target Schedule)
- Construction of Unit 1 & Common 52% complete

1980

•PECo Bond Downgrading A- to BBB+

•Forecast 5 - Unit 1 Fuel Load October 1984 (Construction Target Schedule)
- Construction of Unit 1 & Common 57% complete

1981

•Capital Authorization Supplement 2 - $4.121B (Units 1 & 2)

•PECo Bond Downgrading BBB+ to BBB

1982

•PECo Bond Downgrading BBB to BBB-

•Forecast 6 - Unit 1 Fuel Load October 1984 (Construction Target Schedule)
- Construction of Unit 1 & Common 81% complete

1983

1984

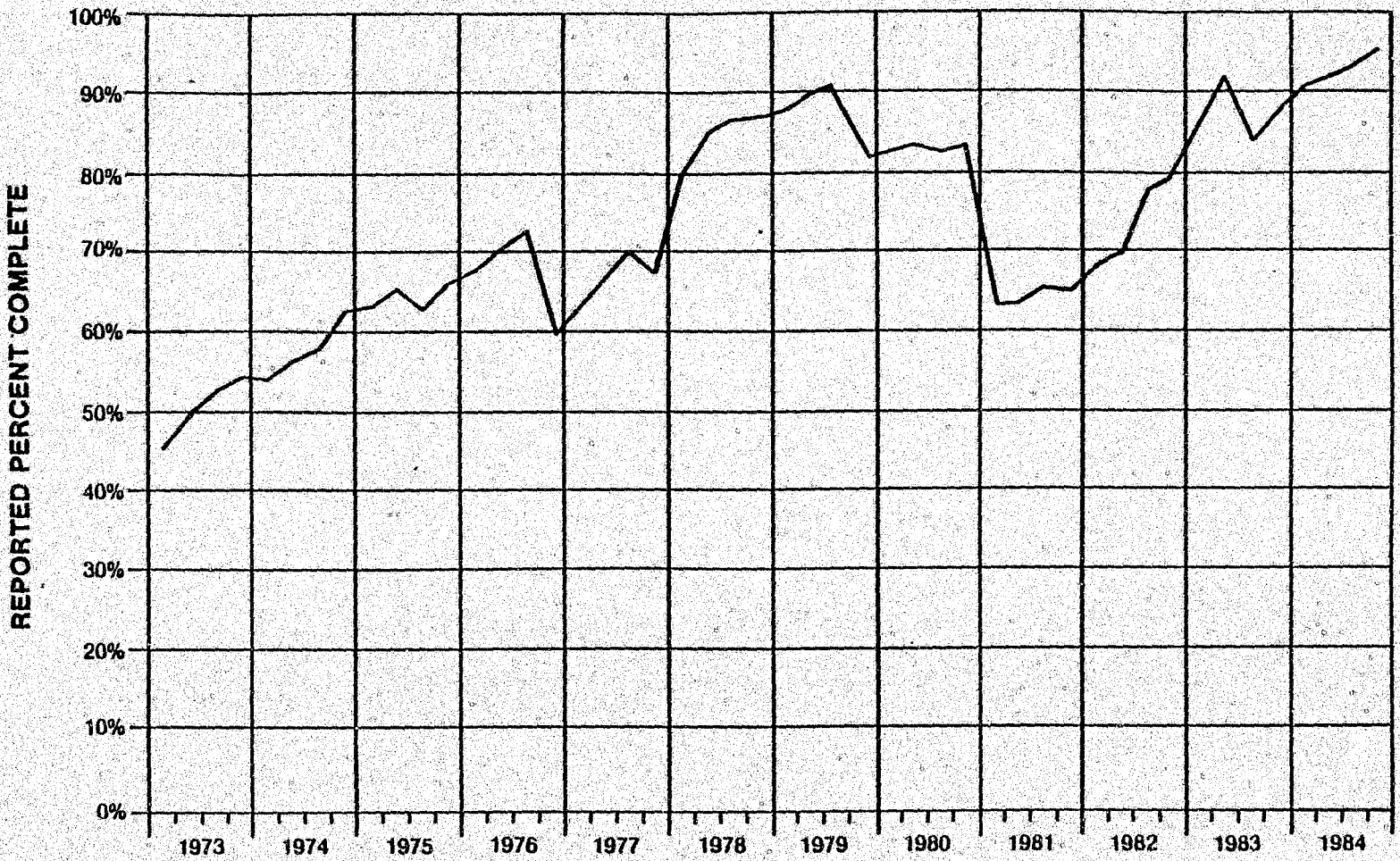
•Forecast 7 - Unit 1 Fuel Load October 1984 (construction Target Schedule)

•Capital Authorization Supplement 3 - $3.706B (Unit 1 & Common)

•Fuel Load (October 26)

PHILADELPHIA ELECTRIC COMPANY

REPORTED ENGINEERING PERCENT COMPLETE BY QUARTER — LIMERICK 1 & 2



SOURCE: BECHTEL RECORDS

SCHEDULE 2

Schedule 3 illustrates the reported construction percent complete from 1976 through 1984 for Unit 1 and Common.

Pre-Project Planning

In the mid 1960s, PECO and PSE&G (along with Atlantic City Electric and Delmarva Power and Light) entered into an agreement to construct Peach Bottom Units 2 and 3 and Salem Units 1 and 2. Ownership of the stations would be shared with PECO retaining construction and operating responsibility for Peach Bottom and PSE&G retaining similar responsibilities at Salem. Construction of PECO's Peach Bottom Units began in 1967 and was completed in 1974 with Bechtel performing duties as both the architect/engineer and constructor and GE supplying the nuclear steam supply system. PECO's work on Peach Bottom Units 2 and 3 was aided by the knowledge gained on the design and construction of Peach Bottom Unit 1, an industry pilot plant, which went into operation in 1967 and was retired in 1975.

In June 1967, PECO requested the four major domestic nuclear steam supply system vendors to submit proposals for a prospective two unit nuclear power station. Following a bid evaluation review process conducted by PECO, General Electric was awarded the contract, in December 1967, to supply two boiling water reactors (BWRs).

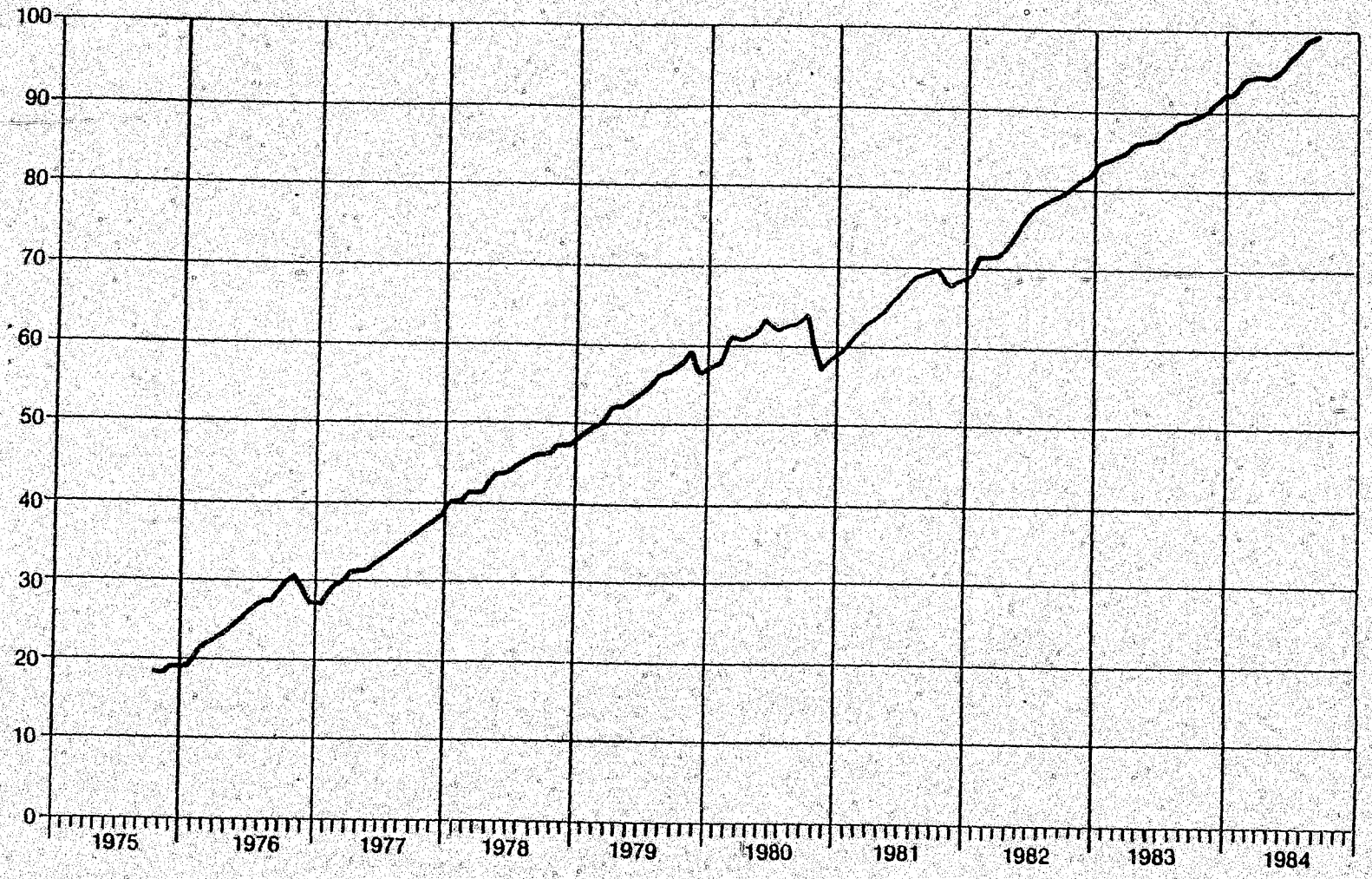
In early 1969, PECO retained a consultant, Gilbert Associates, to evaluate prospective sites for the plant. After a detailed review, PECO chose Sanatoga Crossing (Limerick) as its prospective site.

Two proposals were solicited and received in May 1969, for the design and construction of Limerick. These were from Bechtel Corporation and United Engineers & Constructors, Inc. Following an in-house bid analysis, the

PHILADELPHIA ELECTRIC COMPANY

REPORTED CONSTRUCTION PERCENT COMPLETE

UNIT 1 & COMMON



SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

SCHEDULE 3

design and construction of Limerick was awarded to Bechtel Corporation.

In late 1969, the National Environmental Policy Act (NEPA) was passed, becoming effective January 6, 1970. NEPA requires federal agencies to prepare a detailed statement on specific environmental considerations in connection with all major agency actions that significantly affect the quality of the human environment. The subsequent implementation of this act had a major impact on the construction permit application review process for Limerick.

Pre-Construction Permit Activities (1969-1974)

Bechtel commenced engineering activities in August 1969. The original intent was to pattern Limerick as closely as possible after Peach Bottom Units 2 and 3, which were then under construction. In February 1970, PECO submitted its application (including the Preliminary Safety Analysis Report) for a construction permit to the Atomic Energy Commission (AEC). The construction permit issuance date was anticipated to be May 1971 (15 months after submittal of the application) and a Unit 1 fuel load of October 1974 was expected.

During the subsequent four years, the project was plagued by industry-wide licensing delays, significant public intervention and a very lengthy hearing process. In October 1970, the Limerick Environmental Report was submitted to the AEC. In July 1971, the U.S. Circuit Court for the District of Columbia issued a ruling in a suit brought against the AEC for its failure to enforce the National Environmental Policy Act (NEPA) in licensing the construction of the Calvert Cliffs nuclear plant. The court directed the AEC to require compliance with NEPA in all applications for nuclear construction permits.

This decision required that Environmental Impact Statements be prepared by the AEC, evaluating environmental reports prepared by applicants. PECO was required to submit a revised Environmental Report which it did in May 1972. No construction permits for nuclear plants were issued between July 1971 and August 1972.

PECO's December 1970 Capital Authorization for Limerick estimated the Project to cost $716 million with scheduled commercial operation dates of 1975 and 1977. In September 1971, the commercial operation dates for Limerick were rescheduled to May 1976 and May 1977. In May 1972, PECO recognized another delay in scheduled commercial operation dates. The deferral realized then was one year, with new service dates being May 1977 and May 1978. Bechtel's Preliminary Budget Estimate, issued in July 1972, estimated commercial operation for Units 1 and 2 in August 1978 and January 1980, respectively. It was anticipated, at this time, that the construction permit would be received by January 1973. Continued delays in the construction permit review process due to extended public hearings contributed to further schedule revisions such that PECO was again forced, in August 1973, to reschedule the service dates for Units 1 and 2 to July 1979 and December 1980, respectively.

Preliminary site construction activities, which had been underway since mid-1970, were suspended in January 1972 due to the licensing delays. Site construction forces began remobilization in May 1973. Engineering, however, continued throughout this period.

Subsequent to the issuance of the Safety Evaluation Report by the AEC in November 1971, hearings were held on radiological health and safety issues.

Including the pre-hearing conference, there were 17 days of hearings spread over 23 months (January 1972 to December 1973). The extended and detailed nature of the hearings was due largely to vigorous intervention by concerned groups. The environmental hearings were similarly contested and lasted from December 1973 to March 1974 (15 days over 4 months). The Limerick construction permit was issued on June 19, 1974.

Post-Construction Permit Phase

1974

When the construction permit was received, Bechtel immediately began work on permanent plant structures. Engineering at this point was reported to be approximately 57% complete with over 90% of the then anticipated purchase orders for engineered equipment having been issued. The project was working towards an April 1979 fuel load date for Unit 1.

Bechtel immediately began to work on critical path activities. Major efforts were directed at completion of concrete basemats (the Unit 1 containment basemat was completed in September 1974), pouring of structural concrete, and preparation for installation of structural steel.

In April 1974, Consolidated Edison of New York, due to severe financial constraints, omitted a dividend payment on their common stock. The impact was widespread. PECO's financial condition, which had been weakening prior to Con Ed's action, deteriorated further.

As a result, PECO management concluded that the projected five year capital requirements for the Company of $3.3 billion would have to be reduced. In September 1974, PECO publicly announced that commercial operation of the Limerick Units was being rescheduled to April 1981 (Unit 1),

and April 1982 (Unit 2).

PECO experienced a bond downgrading in October 1974, going from AA to A, thereby incurring commensurately greater costs of capital. In addition, the market to book ratio for their common stock remained well below 1.0, making it undesirable to issue additional common stock.

1975

Engineering was being reported at approximately 63% complete by the end of 1974. Engineering, however, was to be affected by two events. The first was the identification, in early 1975, of design problems with the Mark II containment. Previously unidentified forces (known as hydrodynamic loads) would be generated in the reactor containment structure as a result of both a loss-of-coolant accident ("LOCA") where air and steam would be rapidly forced into a water-filled suppression pool located in containment, and the lifting of the safety relief valves which would cause a similar phenomenon since the relief valves discharge into the suppression pool. The formation of the Mark II Owners Group in 1975, involving all eight owners of Mark II projects including PECO, underscored the seriousness of the problem.

The second event was the fire that occurred at TVA's Browns Ferry nuclear plant in early 1975. The fire was caused by cables that ignited during testing while the plant was operating and resulted in widespread cable damage due to flame propagation that jeopardized safe plant shut-down. This incident resulted in significant fire protection design changes that the industry was required to adopt.

Forecast 1, issued in August 1975 by Bechtel, showed the fuel load dates for Limerick Unit 1 and Unit 2 scheduled for August 1980 and January 1982,

respectively. In October 1975, PECO established the Resident Project Manager position in Bechtel's San Francisco engineering office. By the end of 1975, construction was reporting completion for Unit 1 and common of almost 20%. Work in 1975 was directed principally to installation of civil and structural commodities. By the end of the year, 60,000 cu. yds. of structural concrete, 8,000 tons of structural steel and 500,000 sq. ft. of structural forms had been installed and construction progress was ahead of schedule.

From a licensing standpoint, several important events occurred during 1975. First, the Delaware River Basin Commission (DRBC) gave final approval for PECO to construct the Schuylkill and Perkiomen intake structures. The Limerick Project was also added to the DRBC Comprehensive Plan which meant that the water requirements for the plant were included in the DRBC's overall water allocation plan. Second, the Third Circuit Court of Appeals rejected a suit by intervenors and found that the Final Environmental Statements of both the Nuclear Regulatory Commission (NRC) and the DRBC satisfied NEPA. Finally, in November 1975, the kickoff meeting for preparation of the Final Safety Analysis Report (FSAR), a requirement in obtaining an Operating License, was held.

1976

In May 1976, PECO announced a schedule extension of the Limerick Project. New commercial operation dates were publicly announced to be April 1983 for Unit 1 and April 1985 for Unit 2. However, PECO's construction target schedule still reflected earlier commercial operation dates of April 1982 and April 1984. The decision to defer the Limerick units along with other major cancellations reduced PECO's projected five-year capital expenditures by

$750 million, while Limerick's five-year budget was reduced $181.4 million. PECO also experienced a further downgrading of its bond rating in February 1976, going from A to A-.

By mid-1976, engineering reported completion had reached 73%. Construction progress continued with the installation of civil commodities such as concrete and structural steel. Significant construction milestones in 1976 included completion of Unit 1 Drywell concrete and Unit 1 Turbine Building concrete and the setting in place of the Unit 1 Reactor Pressure Vessel in December.

1977

PECO's May 1977 Capital Authorization Supplement 1 increased the total project cost estimate to $2.578 billion. Licensing activities in 1977 were proceeding as scheduled with the FSAR projected to be submitted to the NRC in September 1978, just over 3 years prior to construction's scheduled fuel load of October 1981, for Unit 1. This was a year of continuing engineering progress, reaching the 80% point by year end. Also, 1977 was the first year in which a significant amount of pipe installation work was accomplished. Meanwhile, the civil commodities such as structural concrete (63% installed of a total 223,000 cu. yds. estimated) remained on schedule.

By late 1977, the Mark II containment problem was still being reviewed through owners' group studies and analyses -- with total resolution forecast for the fourth quarter of 1979. PECO and Bechtel made the decision to begin the Limerick unique design efforts for resolution beginning January 1978 in order to support the construction schedule.

1978

As the result of a study conducted in early 1978, PECO determined that the available cash flow would not support the October 1981 Unit 1 fuel load of Forecast 3. The result was the extension of construction's target schedule fuel load date five months to March 1982. In the spring of 1978, PECO's load forecasting group reduced its peak load forecasts from an estimated compound growth rate of 5% per year to 3% per year.

PECO announced in May that the commercial operation dates for the Limerick Units were being deferred an additional two years to April 1985 and April 1987, respectively. In June 1978, the target construction schedule for Limerick was again adjusted. The new fuel load date for Unit 1 was set at October 1982 and for Unit 2 at October 1984. This represented a seven month increase from the prior working target schedule and the resulting critical path showed an 87 week positive float. By the end of 1978, engineering for Units 1 and 2 was reported to be approximately 88% complete while construction completion for Unit 1 and common was reported at about 47%.

Significant site work on all mechanical and electrical commodities began in 1978. Large pipe, small pipe, heating, ventilating and air conditioning, conduit and cable tray were all being installed.

Post-TMI Construction and Startup

1979

On March 28, 1979, the incident at Three Mile Island Unit 2 occurred. Although recognized as serious at the time, the full ramifications and impact of TMI were not to be realized for several years as the NRC and the industry grappled with the problems it presented. By the third quarter of 1979, the

increased engineering scope due largely to TMI requirements caused the reported engineering percent complete to drop about 6% from that reported at the end of 1978 to 82% complete. This, of course, understates even this short-term TMI effect as engineering work had continued during the intervening nine months. Construction was reported to be 56% complete which represented an increase of about 9% from the end of 1978.

Commodity installation continued, utilizing a revised scheduling method that Bechtel and PECO developed termed the Intermediate Construction Schedule (ICS). Decreasing production rates and difficulty in securing qualified pipefitters, pipe welders and sheetmetal welders led to less than anticipated construction progress.

The factors that were impacting the project schedule were reflected in Forecast 4, issued in December 1979. TMI, Mark II, fire protection and decreasing construction production rates, all generic industry concerns, were causing the work scope and manhour projections to increase significantly.

1980

Significant scope changes occurred during the 1979-1980 timeframe as a result of changing regulations (fire protection, Mark II, TMI, and other factors) that increased required amounts and decreased installation rates of most commodities. Despite efforts at improvement, production rates could not be sustained at the rates required in order to meet a construction target for Unit 1 fuel load in October 1982. PECO's financial condition was aggravated further by another bond downgrading (A- to BBB+) in April 1980.

In August 1980, PECO established the position of Limerick Startup Director at the jobsite, who was responsible for the overall coordination of the

startup effort. By the time Forecast 5 was issued in September 1980, PECO had recognized that the attainment of early completion of Limerick was not achievable and had further adjusted their construction target schedules. Forecast 5 showed Unit 1 to be in service in April 1985 and Unit 2 to be in service in October 1987. The Project reported a decrease of 19% in engineering completion (82% to 63%) and construction percent complete remained essentially the same when comparing Forecast 4 with Forecast 5.

1981

Conditions during 1980 had changed so drastically that PECO Management took the extraordinary step in January 1981 of flying its Board of Directors to the west coast to meet with GE and Bechtel senior managements. Total project cost was reevaluated in March 1981 with the development of CA Supplement 2 which estimated total station costs to be $4.12 billion.

In early 1981, the final design criteria for the Mark II containment problem resolution effort was issued by the NRC and PECO proceeded to implement the necessary design changes. In February 1981, PECO and the Neshaminy Water Resource Authority (NWRA), who are each responsible for a portion of the water supply system for Limerick, received final permission from the DRBC to construct the Point Pleasant Water Supply System. In March, PECO submitted to the NRC, its application for an Operating License. Accompanying the application was the FSAR. In addition to the FSAR, the NRC also required PECO to perform a Probablistic Risk Assessment (PRA) for Limerick, which was submitted in March 1981. By the end of 1981, reported engineering complete for Units 1 and 2 was approaching 70%. Construction on Unit 1 and common was accelerated and construction reported completion was

approximately 68%.

1982

By early 1982, the project had entered into the startup phase of the schedule. Unit 1 and Common commodity installation neared completion and preparation for system completion and turnover began. In mid 1982, components and systems started to be "turned over" from construction to the startup organization for initial operation, flushing, and testing. Revision 6 of the startup schedule, issued in May 1982, reflected PECO's desire to take advantage of early turbine building and systems construction completion. PECO moved up energization of the electrical system, the first major startup milestone, from February 1983 to July 1982 in order to begin the startup program as soon as possible.

PECO achieved the start of energization on July 4, 1982 five days ahead of the revised schedule. PECO startup management was utilizing a more aggressive fuel load schedule of July 1984, three months earlier than the Forecast 5 fuel load date of October 1984. In September 1982, a Test Review Board (TRB) was formed. The Board, which was headed by PECO, and included representation by Bechtel and General Electric, was instituted to review and approve preoperational procedures prior to testing and, later on, to review and approve test results.

On August 27, 1982, an Opinion and Order was issued by the Pennsylvania Public Utility Commission (PUC) in the matter of the 1980 Limerick Investigation. The Commission found that either the cancellation or suspension of construction at Limerick Unit 2 would be in the public interest. PECO, after an appeal process, elected to suspend construction. Construction

on Unit 2 was halted at about the 30% physical completion point.

In December 1982, Bechtel issued Forecast 6. Commercial operation for Unit 1 was still shown to be April 1985. However, Unit 2's service date had slipped to October 1989, reflecting the Commission's recently issued Order. Overall reported construction progress through 1982 for Unit 1 and Common advanced to approximately 81% while reported engineering (for Units 1 and 2) completion reached about 87%. Forecast 6 estimated Unit 1 and Common engineering and other home office manhours as 10.994 million, a 38% increase over the Forecast 5 estimate. The impact of regulatory changes including equipment qualification, fire protection, ATWS, and pipe break analyses and definitive identification of the analyses and modifications required to resolve the Mark II containment problem, were the primary causes of the increased engineering manhour estimate.

1983

Construction on the Point Pleasant Pumping Station, located in Bucks County, began in early 1983 but was curtailed soon thereafter due to intense intervention efforts. Construction (for Unit 1 and Common) and engineering (for Units 1 and 2) completion were both above 90% by the end of 1983. During 1983, site management efforts relative to construction concentrated on completing punch list work on pipe, hangers, conduit, cable and terminations.

Startup activities intensified during 1983. The Integrated Condensate Flush was completed in February and two major milestones, Turbine on Turning Gear and RPV Code Hydro, were attained in July and August, respectively.

1984

Bechtel issued Forecast 7 in June 1984 when commercial operation for

Unit 1 was still projected at April 1985. Additionally, CA Supplement 3 was issued in July 1984, which estimated Limerick Unit 1 and Common Plant to be $3.706 billion.

Punch list work, system turnover and preoperational testing were the predominant activities during 1984. Construction activities consisted of assisting startup crews and final clean up of the plant and surrounding site prior to fuel load.

The startup schedule was revised in May 1984 to reflect a September 15, 1984 fuel load. Startup attained both its Cold Functional and Loss of AC Power major milestones on August 10, 1984 while still on the critical path for a September 15 fuel load. Fuel loading did not actually commence until October 26, 1984, upon Limerick's receipt of the license from the NRC. Initial criticality occurred on December 22, 1984.

1985

Following extensive public hearings on safety and environmental issues, PECO was granted a full power license for Limerick Unit 1 on August 8, 1985.

II. PRE-PROJECT PLANNING AND PROJECT STRUCTURE

A. PRE-PROJECT PLANNING

Q. PLEASE DESCRIBE WHAT TB&A DEFINES AS PRE-PROJECT PLANNING.

A. Pre-project planning includes principally those decisions or actions by a utility prior to or at the initiation of a project. Normally, this encompasses three matters: 1) determination of the need for additional capacity; 2) determination of that capacity's type and fuel source; and 3) determination of the site at which to place the capacity. In evaluating the pre-project planning activities for Limerick, TB&A was concerned with developing answers to three specific

questions:

1. Did PECO have reasonable expectations that its load growth would warrant the addition of Limerick capacity in the time frame it was expected to take to put it in operation?
2. Did PECO adequately assess generation alternatives in its determination to meet this load growth with nuclear power versus other options available?
3. Did PECO assure that site alternatives were adequately evaluated prior to the selection of the Sanatoga Crossing site (Limerick)?

1. PECO's ASSESSMENT OF ITS GENERATING CAPACITY NEEDS

Q. WHAT IS THE TYPICAL PROCESS BY WHICH A UTILITY ASSESSES ITS GENERATION NEEDS AND THEN PLANS TO MEET ITS ANTICIPATED REQUIREMENTS?

A. First, a utility develops projections of future annual sales and peak load demands. Typically, these forecasts are produced on a yearly basis, and project ten to twenty years into the future. These forecasts are then compared with the utility's existing generation capacity, along with its required reserve margin and current plans for additions and retirements. Generating capacity is then added or deleted from the plan as required. If additional generation is needed, an analysis is performed to determine the type (base, intermediate, peaking), source (nuclear, fossil, hydroelectric, etc.) and finally, the location of the plant.

The planning process, however, may be subject to a myriad of restraining conditions. The need date for the new capacity will have an effect on the type of plant built due to the various lead times required to construct different generating facilities. Additionally, financial, technical, regulatory, environmental and societal factors must be considered when undertaking new power plant construction. The important point, though, is that planning for new generating capacity additions, especially base plants, is a highly technical,

complex process involving timely and detailed planning by utility management.

Q. AS BACKGROUND FOR YOUR EVALUATION OF PECO'S GENERATION CAPACITY NEED DETERMINATION, PLEASE DESCRIBE THE STATE OF THE UTILITY INDUSTRY IN THE MID TO LATE 1960s WITH RESPECT TO LOAD GROWTH.

A. The load growth experienced by the entire U.S. electric utility industry during the 1950s and 1960s was dramatic. As shown in Schedule 4, the compound annual rate of increase for energy growth during this period was over 8%/year. Growth of this magnitude was producing a doubling of load approximately every 10 years. Some of the main causes for this rise in electricity consumption were related to the Korean and Vietnam wars which kept unemployment relatively low and GNP increases high. The economy expanded almost continuously, especially during the period of the late 1960s.

It was during the period of the late 1960s and early 1970s that utility load forecasts chronically understated the level of energy demand that was actually experienced. This led to over utilization of existing capacity with consequent dire results, as epitomized by the blackout in the Northeast region of the country on November 9, 1965. The PJM interchange also experienced a blackout, which lasted up to 10 hours in some areas, on June 5, 1967.

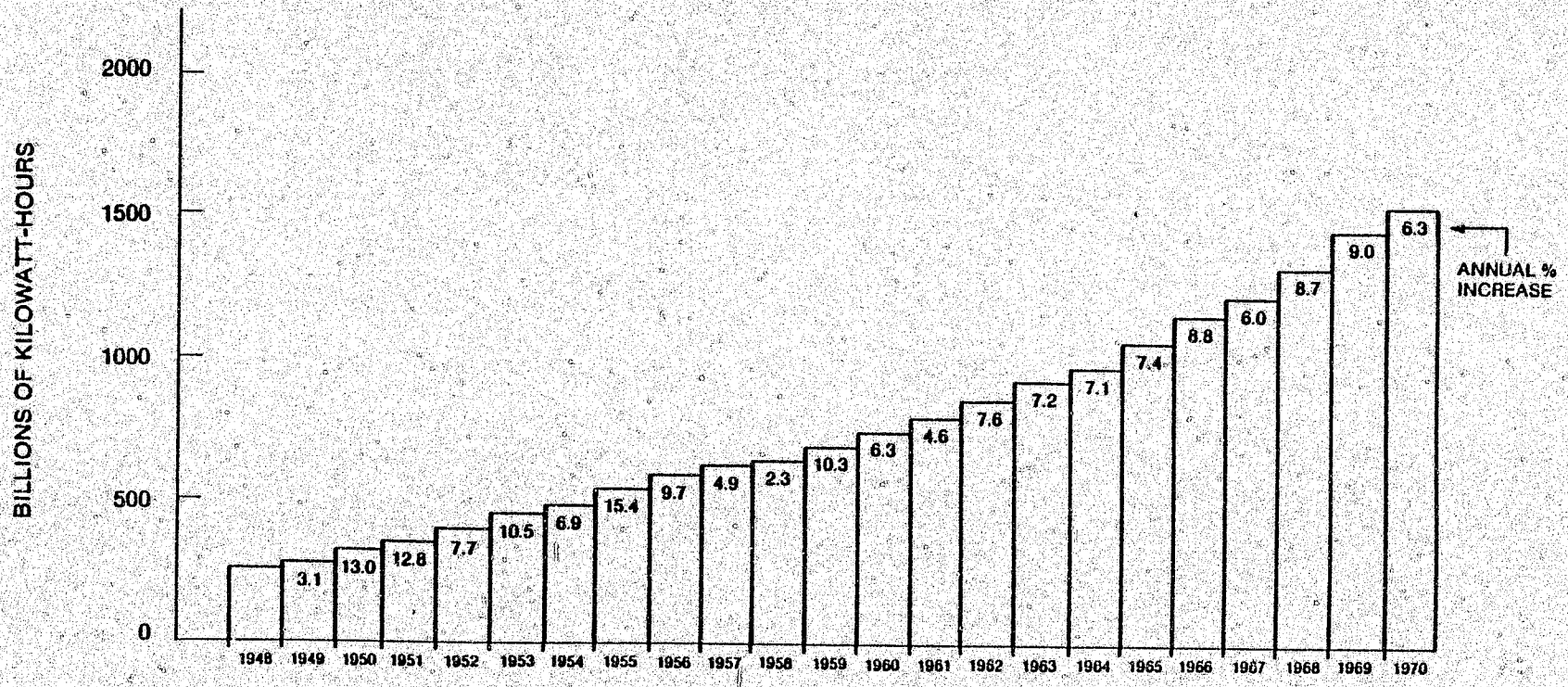
On a state level, Pennsylvania was experiencing similar conditions. Between 1960 and 1965 and between 1965 and 1970, Pennsylvania experienced electricity consumption growth rates of 5.6% per year and 7.4% per year, respectively. Reserve levels in the late 1960s and early 1970s fell significantly below planning and reliability goals, to as low as approximately 12%.

The ability of the utilities in Pennsylvania to meet anticipated demand

PHILADELPHIA ELECTRIC COMPANY

TOTAL ELECTRIC UTILITY ANNUAL ENERGY OUTPUT

CONTIGUOUS U.S.A.



SOURCE: EEI ELECTRIC POWER SURVEY, 1976

SCHEDULE 4

was given high priority by the Pennsylvania Public Utility Commission. A March 13, 1972 Order, concerning a Commission Investigation to determine the need for additional electric generating and transmission facilities for the coming decade, supplied a concise summary of utility and Commission meetings during the mid to late 1960s to address this problem. Some highlights extracted from the Order are as follows:

> "... In view of the influence of power pools, a joint meeting was held on March 31, 1966 in Philadelphia with the commissions of Delaware, District of Columbia, Maryland and New Jersey to analyze the purpose and operation of the PJM interconnection. Efforts to reassure commission representatives that capacity was capable of meeting expected loads and still maintain adequate reserves was not accepted with confidence. The companies and public were warned by the Commissions that according to our predictions a desperate situation was developing that within the near future could result in possible blackouts and customer load curtailment. The companies were told that immediate preparations should be made to increase installed capacity until a reliable reserve of 20% above forecasted loads was reached..."
>
> "...On June 19, 1967 another meeting was held in Philadelphia...The companies were told that excuses were unacceptable..." (referring to the blackout of June 5, 1967)
>
> "...On September 16, 1969 Commonwealth Associates presented to the Commission and PJM member companies an analysis of the interconnection system with recommendations to avert the expected capacity deficiency. The picture presented was more dire than expected..."
>
> "...The Commission is now concerned about whether current plans are satisfactory to meet projected future needs for electric power..."

It is obvious that the situation in Pennsylvania, as elsewhere in the country, during the 1960s, was precarious and reflected an almost universal underestimation of demand and the consequent ability to supply electricity to meet that demand.

Q. WOULD YOU NOW DISCUSS PECO'S SPECIFIC ENVIRONMENT PRIOR TO THEIR COMMITMENT TO BUILD LIMERICK?

A. The situation for PECO was the same as for most other utilities during the 1960s. Demand for electricity on the PECO system was increasing faster than the Company was adding capacity to meet it. This situation, coupled with similar ones at other PJM member companies, necessitated voltage reductions every year from 1965 through 1971, except 1966. In an attempt to meet these needs, PECO had added 260 megawatts of peaking capacity at Conowingo and was constructing an additional 880 megawatts at Muddy Run in 1969 along with 550 megawatts of combustion turbine capacity also under construction. This latter capacity was added in response to a specific request from the Pennsylvania Commission. Also, PECO was planning increases to its base load capacity in the form of the Peach Bottom and Salem Units.

Q. PRIOR TO PECO'S COMMITMENT TO CONSTRUCT LIMERICK, WHAT WAS THE ACCURACY OF PECO'S LOAD FORECASTS?

A. As was discussed previously, PECO's situation was similar when compared with the rest of the utility industry. It is important, though, to understand the historical context of the Company-specific forecasts. Schedule 5 compares actual sales with forecasts made 5 years previously for the years 1952 to 1969. Also shown is the percentage difference between the actual and forecasted levels. For the years 1964 thru 1969, the PECO forecast prepared 5 years earlier was consistently under the actual level of sales achieved. The position of achieving sales above forecasted levels, however, is not necessarily equivalent to that of sales below forecasted levels. As a Vice-President of the National Economic Research Associates (NERA) testified in proceedings before

PHILADELPHIA ELECTRIC COMPANY

COMPARISON OF ACTUAL AND FORECASTED ELECTRIC SALES
PHILADELPHIA ELECTRIC COMPANY SYSTEM

Million kWh

Year	Actual	Forecast (made 5 yrs. previous)	% Variance From Actual
1952	8,643	7,325	(15.2)
1953	9,198	7,606	(17.3)
1954	9,356	8,744	(6.5)
1955	10,273	9,854	(4.1)
1956	10,836	11,419	5.4
1957	11,259	11,176	(0.7)
1958	11,266	11,595	2.9
1959	12,264	12,092	(1.4)
1960	12,666	12,503	(1.3)
1961	13,332	13,441	0.8
1962	13,902	14,528	4.5
1963	14,647	14,916	1.8
1964	15,595	15,422	(1.1)
1965	16,738	16,102	(3.8)
1966	17,924	16,647	(7.1)
1967	18,703	17,257	(7.7)
1968	20,622	19,328	(6.3)
1969	21,873	20,105	(8.1)

SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

the Pennsylvania Public Utility Commission in 1972:

> "...to the extent that there would be surplus capacity following the completion of the facility, that surplus would reside not in the new capacity, but in the older capacity on the system. The savings in fuel and operating cost resulting from the displacement of this older capacity could go far toward offsetting the cost of carrying the surplus capacity. Equally important, the displacement of the older capacity would have a favorable environmental impact. In considering the need for new capacity in light of the load projections, therefore, it would appear to be better to risk having surplus capacity than to risk a capacity deficiency."

PECO's planning decisions in the late 1960s reflected these external demands of the PUC and the awareness that prior years' load forecasts had missed the mark.

Q. HOW ACCURATE WERE PECO'S LOAD FORECASTS WHEN COMPARED WITH OTHER UTILITIES?

A. PECO's forecasts were in fact better than most other utilities. The Franklin Institute Research Labs reported in a 1972 study that:

> "...In its annual advance projection of system peak demand for the decade of the 1960s the Philadelphia Electric Company's 5 year forecasts were very accurate up through the middle 1960s. Thereafter, largely as a result of a not uncommon inability to project the extreme economic expansion of the late 1960s, their projection error rate began to increase. Five year forecast errors rose from 1-2% for the early 1960s to 5-6% in the latter half of the decade.
>
> The Philadelphia Electric Company's projection accuracy in relation to that of other electric utilities has been somewhat above average. Compared with the other six PJM (Pennsylvania - New Jersey - Maryland) Interchange companies, the Company's mean forecast error for projections made 5 years in advance ranked third in accuracy. Furthermore, in the Edison Electric Institute's 1969/1970 survey of load forecasting, PECO's three year average forecast error ranked tenth in accuracy out of forty eight companies responding to the survey."

Q. WHAT IS TB&A'S CONCLUSION REGARDING PECO'S LOAD FORECASTING EFFORTS DURING THE LATE 1960s?

A. When the project was announced in 1968, the service dates for Limerick Units 1 and 2 were anticipated to be 1975 and 1977. If Limerick or another plant of equal capacity had not been planned, anticipated reserve margins would have been 11.5% in 1975, 6.0% in 1976 and 0.9% in 1977. (See Schedule 6). This would have been, of course, intolerable. The load forecasts that produced these projections were compiled in the dire atmosphere of the late 1960s following brownouts and blackouts, and reflected the Company's best judgment of its future needs. They were also, to a degree, reflective of demands of the PUC for higher energy forecasts. As already discussed, the Company's projections were, historically, more accurate than most other utilities and therefore provided as sound a basis for capacity planning as one could expect. TB&A concludes that PECO's load forecasting efforts and results formed a reasonable basis for projecting the need for Limerick's generating capacity.

2. SELECTION OF A NUCLEAR FUELED GENERATION ALTERNATIVE

Q. DID TB&A REVIEW THE PROCESS BY WHICH PECO EVALUATED THE VARIOUS ALTERNATIVES AVAILABLE TO MEET ITS CAPACITY REQUIREMENTS?

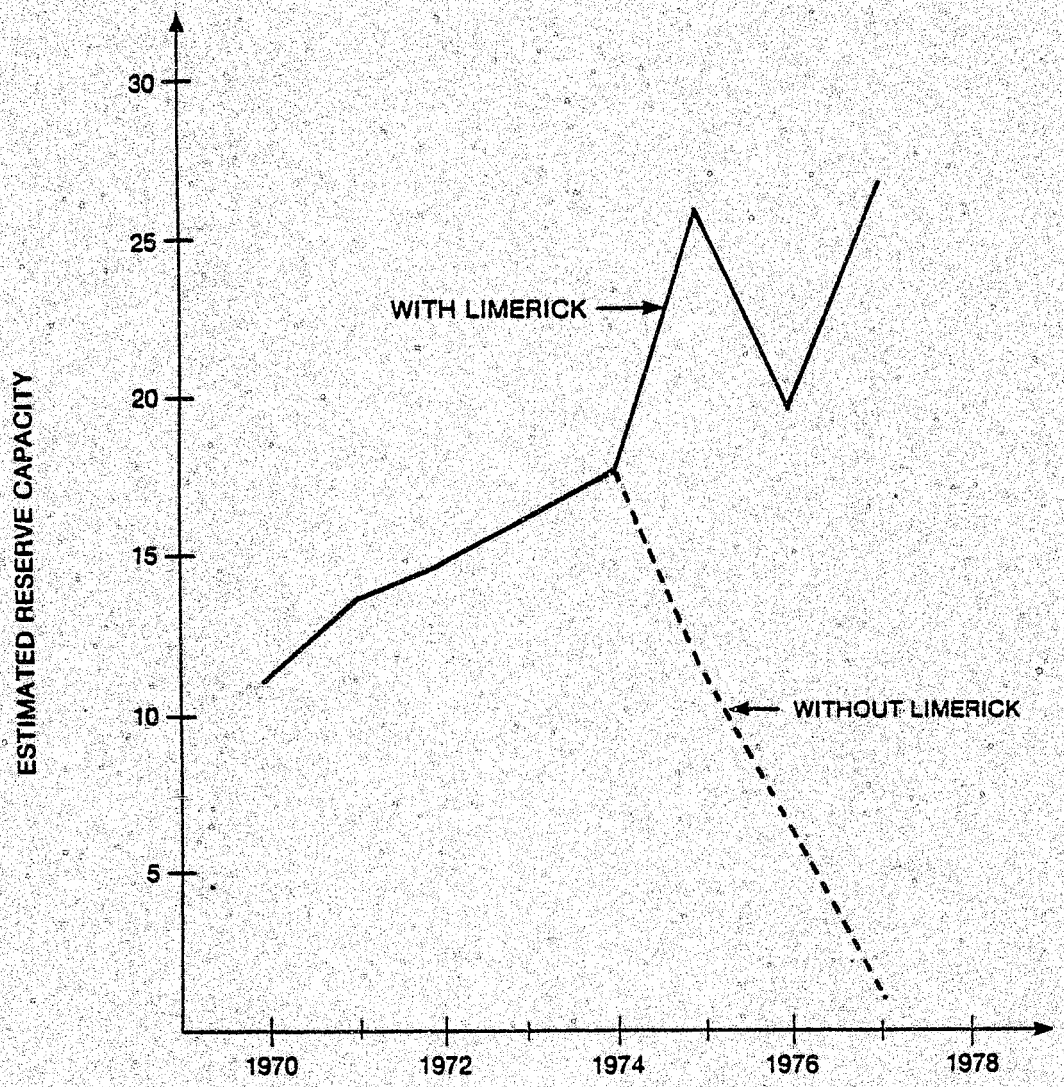
A. Yes. PECO had decided that to meet the projected energy demands on its system it would require additional base-load generating capacity, since they felt there was already sufficient cycling and peak load capacities.

Once the need for base-load capacity was identified, the next step for PECO was to determine the type of fuel source, i.e. nuclear, coal, oil, hydroelectric, gas, cogeneration, etc. TB&A interviews with PECO

PHILADELPHIA ELECTRIC COMPANY

PHILADELPHIA ELECTRIC COMPANY ESTIMATED RESERVE CAPACITY

MAY 1968



SOURCE: PHILADELPHIA ELECTRIC COMPANY SYSTEM PLANNING DEPARTMENT RECORDS

management identified that they: 1) quickly eliminated hydroelectric generation from contention due to the fact that prospective sites had been or were being developed; 2) considered the possibility of utilizing gas but uncertainty regarding future supplies made this untenable; and 3) also assessed the relative benefits of oil and coal fired plants. Coal was preferred because it was slightly less expensive and the Company anticipated that this situation would prevail in the future. Mine-mouth coal sites were then considered but transmission costs, due to the fact that the plant would be outside the Company's service territory, made this alternative prohibitively expensive.

The remaining choices were for a nuclear powered plant or a coal fueled plant within PECO's service territory. The analysis of these two alternatives for Limerick was based mainly on the "Joint Generation Study Report" prepared by PECO and PSE&G in September 1965. Some highlights of the study were that:

> "... The levelized annual revenue requirements of an 1800 mw nuclear station will be approximately $6,500,000 less than a fossil plant. An 1800 mw nuclear plant will provide energy at a total cost excluding transmission of 3.63 mills per kilowatthour levelized over the 1971-90 period. An alternate fossil fuel plant would provide energy at 4.71 mills per kilowatt hour..."

It was recognized that the capital costs of a nuclear plant would be greater than a fossil plant, but anticipated reduced operating expenses from lower fuel costs for a nuclear plant gave it an important overall economic advantage.

PECO updated the earlier study before it committed to build Limerick to determine whether the nuclear option was still the most economical. In late 1968 and early 1969, PECO performed an additional nuclear vs. fossil economic comparison using oil as the preferred alternative. The Company considered the

emerging pollution control requirements for sulphur-dioxide removal to have eliminated coal's economic advantage over oil-fired generation. The results of this study, which examined production, transmission and operating costs, confirmed the Company's earlier evaluations in that the fossil alternative was anticipated to cost over $4 million more on an annual basis than a comparably sized nuclear plant.

Q. WERE OTHER UTILITIES MAKING COMMITMENTS TO NUCLEAR POWER WHEN PECO DECIDED TO PROCEED WITH LIMERICK?

A. Yes. Schedule 7 shows that of the total 185,307 MW planned to be added by all electric utilities in the period 1968-1975, 32.1% (59,564 MW) was slated for nuclear generation. This compared with only 1.0% of total utility capacity being nuclear based as of the end of 1967. PECO was certainly not alone in its determination that nuclear power was an effective, economic solution to its power needs.

Q. DID PECO PERFORM ANY ADDITIONAL EVALUATIONS WITH REGARD TO THE ECONOMICS OF NUCLEAR POWER AFTER IT HAD COMMITTED TO BUILD LIMERICK BUT PRIOR TO ITS RECEIPT OF A CONSTRUCTION PERMIT?

A. Yes. In 1971, PECO prepared a generation study for the years 1978-1980 and found that nuclear fueled generation should be installed to meet the 1978-1980 power requirements. Specifically, PECO's Environmental Report (Revised) submitted to the AEC in May 1972 identified the economic benefit of Limerick compared with an oil-fired alternative (coal was not considered to be viable then because of stringent environmental standards). Nuclear power was anticipated to have a 2.48 mills per kilowatthour cost advantage over a

SCHEDULE 7

PHILADELPHIA ELECTRIC COMPANY

ELECTRIC POWER INDUSTRY CAPACITY TO 1975

Fuel Type	Total Capacity Dec. 31, 1967		Capacity Additions 1968-1975		Total Scheduled Capacity 1975	
	Mw	%	Mw	%	Mw	%
Hydro.....	47,350	17.7	11,981	6.5	59,331	13.1
Fossil*.....	217,288	81.3	113,762	61.4	331,050	73.2
Nuclear.....	2,437	1.0	59,564	32.1	62,001	13.7
TOTAL INDUSTRY.....	267,075	100.0	185,307	100.0	452,382	100.0

*Includes internal combustion and gas turbines

SOURCE: ELECTRICAL WORLD, SEPTEMBER 16, 1968

comparable oil-fired plant.

Q. WHAT ARE TB&A'S CONCLUSIONS REGARDING PECO'S EFFORTS, DURING THE PRE-PROJECT PLANNING STAGE, TO EVALUATE THE VARIOUS GENERATION ALTERNATIVES THAT WERE AVAILABLE TO MEET THE COMPANY'S ANTICIPATED FUTURE DEMAND FOR ELECTRICITY?

A. TB&A concludes: 1) that PECO's evaluation efforts properly considered probable generation alternatives; 2) that, based on documented studies and senior management interviews, a reasonable number of detailed comparable cost studies were performed; and 3) that the selection of a nuclear fueled plant to meet anticipated energy demand resulted from a reasonable and appropriate management process.

3. SELECTION OF THE LIMERICK SITE

Q. WHAT DOES THE SITE SELECTION PROCESS FOR A NUCLEAR GENERATING STATION TYPICALLY ENCOMPASS?

A. The site selection process for a nuclear generating station typically includes a number of steps. First, the utility identifies the major selection criteria to be used in evaluating and comparing the prospective sites. These criteria may include system balance, geology, demography, seismicity, water supply, transmission factors and fuel transportation costs, as well as other cost and safety considerations.

Second, the utility ensures that a reasonable range of alternative sites are considered for comparative evaluation purposes. Third, after an initial screening process, detailed evaluations of prospective sites are performed so that the significant advantages and disadvantages of the potential locations are fully explored and documented. This step may and usually does entail the use

of consultants with particular expertise in this area to screen the total population of available sites. Fourth, the utility applies its selection criteria in more detail to the sites that, after being analyzed and evaluated, survived the screening process. Finally, the site is selected based on reasonable consideration of all relevant criteria. The overall analysis should result in an economical, environmentally compatible and licensable location.

Q. WOULD YOU PLEASE DESCRIBE HOW PECO PROCEEDED IN ITS SELECTION OF THE LIMERICK SITE?

A. PECO's initial major site selection criteria were predicated on the need for system balance and customer requirements, as well as transmission considerations. With a preponderance of base generating capacity in the southern end of its service territory, PECO felt the need to more adequately balance this distribution by proposing a new generating station in its northern reaches. Also, then recent environmental difficulties with the construction of its Whitpain-Branchburg transmission line had sensitized PECO to the need for careful consideration regarding the location of any new transmission corridor.

In February 1969, PECO retained Gilbert Associates, Inc. (GAI) to perform site evaluation studies for the prospective plant. The purpose of the study, as stated therein, was to:

> "...establish bases for comparison between sites and alternatives in order to evaluate relative costs and realistic methods for the development of each site, considering the conditions imposed by: topography, location, access to road and rail facilities, availability of water supply, land procurement costs, general geology and seismology, population density and proximity, meteorology and transmission."

Of the nineteen sites originally considered, PECO requested that GAI perform a detailed evaluation of the five which survived the initial screening process.

The five sites, along with an alternative for each, were evaluated in detail and summarized in GAI's report of April 1969.

The site characteristics analyzed by GAI included:

- Plant Placement on Site
- Site Preparation
- Reliable Water Supply
  - Primary Water Source
  - Utilization of Primary Water Source
- Land Cost
- Capitalized Pumping Costs
- Also: Radiology, Meteorology, Population, Stack Characteristics, Hydrology, Seismology

PECO quantified the transmission and substation costs for the evaluated sites, while GAI enumerated the major advantages and disadvantages of each site and also provided estimated costs for site development work.

After receiving the GAI report with the estimated site development costs, PECO then included transmission costs for the prospective locations. Transmission line characteristics were one of the main features that differentiated the various alternatives on a cost basis. Some sites would have required acquiring extensive right-of-way approvals and would have incurred commensurately greater costs. PECO's evaluation indicated that when considering all probable charges, including transmission costs, the Sanatoga Crossing (Limerick) site, with its close proximity to an existing 500KV transmission line, was the most economical. Further, not only were the transmission costs at Limerick the lowest, but, from an environmental standpoint, utilization of the existing line would eliminate any major adverse environmental impacts of new transmission line construction.

Thus, PECO's choice of Limerick satisfied its desire to locate the plant in the northern end of its service territory, minimized costs and environmental impacts from transmission considerations, and presented a licensable location from a regulatory perspective.

Q. WAS PECO AWARE WHEN THEY SELECTED THE LIMERICK SITE THAT WATER SUPPLY AT THAT LOCATION WAS A CONCERN?

A. Yes. PECO had expressed early on to GAI the necessity of careful evaluation of prospective sites as they related to cooling water. A letter from GAI to PECO, prior to GAI's commencing work, underscored this concern when it stated in part:

> "... It is my understanding, as a result of our conversations, that the area in which you desire maximum participation by Gilbert is with respect to site evaluations as they relate to cooling water, with all the peripheral questions of thermal enrichment, reservoirs, cooling towers and associated areas of concern..."

Consequently, as a result of PECO's early expression of concern, GAI included in its report a detailed evaluation of the water supply aspects of each particular site. They noted that an adequate cooling water supply for Limerick depended on "future development of dams upstream on the Schuylkill River by the Government for a reliable primary water service."

Thus, PECO was aware at the time it selected Limerick as a site for the proposed nuclear generating facility that sufficient cooling water would be dependent on construction of supplementary facilities.

Q. PLEASE BRIEFLY DESCRIBE THE SUPPLEMENTAL WATER SUPPLY SYSTEM FOR LIMERICK.

A. PECO currently anticipates obtaining supplemental cooling water for Limerick as part of the Neshaminy Water Supply System (NWSS). Different aspects of

the system are to be constructed by either PECO or the Neshaminy Water Resources Authority (NWRA). Water from the Delaware River will be pumped, via the Point Pleasant Pumping Station, through a combined transmission main to the Bradshaw Reservoir, where it will then be pumped through the Perkiomen transmission main to the East Branch of the Perkiomen Creek. From there it will flow by gravity to another pumping station on the Perkiomen Creek, where it will be diverted and pumped through another transmission main to Limerick.

Q. WHAT WAS THE EVOLUTION OF PECO'S PARTICIPATION IN THE NESHAMINY WATER SUPPLY SYSTEM?

A. PECO had an initial series of meetings with the Delaware River Basin Commission (DRBC) staff to discuss water availability in the Delaware River Basin in early 1969. The Company knew, from site investigations, that due to periodic low flows and previous water allocations, they could not rely solely on the Schuylkill river for year round cooling water and would have to develop some form of supplemental water supply for the recently selected Limerick site. PECO was subsequently directed by the DRBC to Bucks County, which was then in the process of conducting studies to augment their own water supplies. The Bucks County plan was based on diversion of Delaware River water to the North Branch of the Neshaminy Creek, via a pumping station at Point Pleasant. The possibility of joint usage of these facilities was investigated and reported on in a study conducted for the DRBC. This study, the "Point Pleasant Pumping Facilities - Feasibility Study" was released in March 1970, and recommended selection of the Delaware River, augmented by upstream storage as the source of additional water for the needs of Bucks

County and PECO, along with construction of joint usage diversion facilities at Point Pleasant.

Following inclusion into the DRBC's Comprehensive Plan in November 1975, PECO began negotiations on a water supply agreement with the NWRA. However, continued re-estimation of water supply needs by the surrounding counties made this a protracted process. In February 1980, PECO entered into an agreement with the NWRA that would have allowed the construction of the water supply facilities to be completed well in advance of the construction target schedule for the commercial operation of Unit 1 in April 1983. However, concerted intervention efforts and continued lengthy court proceedings have prevented PECO from achieving this goal.

Q. HAS PECO MANAGEMENT BEEN ACTIVELY INVOLVED IN ATTEMPTS TO RESOLVE THIS ISSUE?

A. Yes. TB&A's examination of this area has found that PECO senior management has been actively involved in attempts to expeditiously resolve all outstanding issues in this area. For example, PECO's Senior Vice President - Nuclear Power has been heavily involved in negotiating and coordinating activities related to this issue and has led PECO efforts to address, in a timely fashion, legal and environmental concerns related to the supplemental cooling water system. Further, the Senior Vice President - Nuclear Power had weekly meetings with the President of the Company to keep top management fully informed and apprised of all developments in this area.

Q. WHAT ARE TB&A'S CONCLUSIONS REGARDING PECO'S PROCESS FOR SELECTING THE LIMERICK SITE AS ITS PREFERRED LOCATION FOR A NUCLEAR GENERATING STATION?

A. TB&A's examination of the process by which PECO selected the Limerick site has led TB&A to conclude that: 1) PECO utilized reasonable selection criteria in its initial determination of prospective sites; 2) the total number of sites considered by PECO (nineteen) for possible location of its generating facility was a reasonable sample from which to initiate the screening process; 3) the detailed evaluation of the five sites surviving the initial screening by an outside consultant was comprehensive and reflected reasonable consideration of the relevant site characteristics; 4) PECO's choice of Limerick was based on appropriate consideration of the evaluated criteria; 5) concerns regarding the supplemental water supply for Limerick have resulted from events beyond the control of PECO management; and 6) that PECO senior management has been actively involved in intensive efforts to resolve the water supply issue.

In summary, TB&A finds the choice of the Limerick site to have been the product of an effective management process and to be reflective of reasonable management actions.

B. PROJECT STRUCTURE

Q. PLEASE DESCRIBE WHAT TB&A DEFINES AS PROJECT STRUCTURE?

A. Construction of a nuclear generating facility involves numerous separate organizations. These include the project's owner/utility, who may or may not directly perform project activities; an architect/engineer responsible for design; a construction manager or constructor, whose firm may also serve as architect/engineer, responsible for construction; and various subcontractors and/or technical consultants. The number and type of organizations participating in a specific nuclear project depends upon the organizational strategy of the owner/utility and its need for technical expertise in project

functional areas.

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

To summarize, Project Structure consists of a review of the entirety of the Project Management structure and organizations, and their interrelationships. It is, however, only an overview; evaluations of detailed management actions, decisions and implementation in specific project functional areas are discussed in subsequent sections of this testimony.

Q. HAS TB&A DIVIDED "PROJECT STRUCTURE" INTO FURTHER SUB-CATEGORIES FOR EVALUATION PURPOSES?

A. Yes. These sub-categories and the specific questions addressed by TB&A in each category are as follows:

1. Project Organizational Strategy and Relationships

   - Did PECO develop an appropriate organizational strategy and establish organizational relationships based upon its previous power

plant construction experience, the nature of the Limerick Project and the resources available to the Company such that there was a good prospect of successful project completion from a cost, schedule and quality vantage point?

- Were PECO's resources organized in an appropriate manner to execute its owner oversight responsibilities?
- Were major contractor resources organized in an appropriate manner to execute their responsibilities?

2. Contractor Selection

- Were the selection of Bechtel as architect/engineer and constructor and General Electric as the nuclear steam supply system vendor (GE also supplied the turbine-generators, reactor feedpumps and initial fuel fabrication services) made pursuant to a reasonable and appropriate decision-making process given the information and alternatives available at the time?
- Did PECO have a clearly defined and appropriate strategy with regard to subcontractor utilization and selection?
- Did PECO formulate its contracts with Bechtel and GE to clearly define responsibilities and minimize cost and schedule?

3. Project Controls

- Was PECO appropriately involved in the development and institution of the initial project controls, procedures and systems for Limerick?
- Did PECO evidence a reasonable level of participation in the evolution of the project controls systems?

- Were the project controls systems utilized on the Limerick Project sufficient to effectively plan, monitor and report cost and schedule progress on the job and did they assist in:
  - Identifying problems;
  - Determining the primary causes of those problems; and
  - Assessing the validity/effectiveness of corrective actions and methods improvements.

4. Project Oversight

- Was the information available to PECO Senior Management timely, detailed and sufficient to allow reasonable, informed decision making to take place?
- Was PECO management appropriately involved in problem resolution as needed throughout the course of the project?
- Overall, were the project oversight activities of PECO sufficient to provide a good prospect of successful project completion from a cost, schedule and quality vantage point?

1. PROJECT ORGANIZATIONAL STRATEGY AND RELATIONSHIPS

Q. PLEASE DESCRIBE THE EVOLUTION OF UTILITY STRATEGIES FOR ORGANIZING NUCLEAR POWER PLANT CONSTRUCTION PROJECTS DURING THE PERIOD OF THE 1970s?

A. Organizational strategies adopted by utilities in the 1970s reflected the evolution occurring in contractual relationships with major vendors and construction managers. In the mid-1960s, the major NSSS vendors discontinued the practice of offering full scope, turnkey nuclear plants and instead began to offer utilities a more limited scope of services as designers and manufacturers

of only the reactor and steam generation equipment. This made it necessary for utilities to contract separately for engineering and construction services for the balance of the plant.

NSSS vendors and architect/engineering firms also at this time ceased offering "fixed price" contracts to utilities due to the financial risk of nuclear construction projects. Similarly, firm price, full service, construction contracts, i.e. general contractor or construction management, were no longer available. Instead, nuclear projects were bid on the basis of "cost reimbursable" contracts with various fee arrangements, which essentially shifted the economic risks for uncontrollable circumstances from the contractor to the utility/client. These additional contractual risks forced greater utility involvement in their nuclear generating projects and served as an impetus toward the evolution of new organizational strategies for power plant construction.

Q. PLEASE DESCRIBE THE ORGANIZATIONAL STRATEGIES THAT EVOLVED AND WERE USED IN THE EARLY TO MID 1970s?

A. A TB&A study of the electric utility industry, conducted in 1979, revealed that the following five basic organizational strategies were used during the 1970s to construct major utility generation projects:

Design and Build - a single architect/engineer/constructor is responsible for the project design and construction.

Project Manager - an independent firm serves as the prime contractor to the utility. The project manager is responsible for major subcontracts with separate or combined engineering and construction firms.

General Contractors - the utility assumes the project management role by contracting directly with an engineering firm, and separately, with a general contractor who serves as construction manager.

Prime Specialty Contractor - the utility assumes the major role of project management and construction manager through contracts directly let by the utility to specialty contractors. Engineering may be done either in house or through a separate contract with an outside architect/engineer.

In-house Design/Construction - the utility uses its own "force account" personnel for construction; engineering may be performed either internally or by an outside architect/engineer.

The aforementioned TB&A study surveyed the organizational and contractual relationships utilized by utilities on 39 fossil and nuclear power plant construction projects. The frequency of occurrence of the previously outlined strategies as well as their major characteristics were defined. The Design and Build, General Contractor and Prime Specialty Contractor approaches accounted for over 90% of the strategies used, with 27%, 43% and 21% frequencies of occurrence, respectively.

Q. OF THE ORGANIZATIONAL STRATEGIES OUTLINED, DID THE TB&A STUDY IDENTIFY WHICH OF THEM WAS THE BEST OR MOST EFFECTIVE?

A. No. The TB&A study found that no one organizational structure was best, but rather, that the "best" organization for a project depends on the utility's resources, capabilities, experience and the type of project being undertaken. The existence of prior successful experience and working relationships with a

particular organizational approach is also an important factor.

Q. WHAT TYPE OF ORGANIZATIONAL STRATEGY DID PECO EMPLOY IN CONSTRUCTING THE LIMERICK NUCLEAR GENERATING STATION?

A. PECO's approach was closest in concept to the Design and Build strategy outlined previously, though PECO's involvement in the project was significantly more extensive than selection of this approach would normally suggest. Although PECO had performed engineering and design activities in-house for most of its previously constructed non-nuclear power plants, senior management felt that the Company would be better served by allowing an experienced outside design firm handle this function for the nuclear units. Additionally, from its experience on Peach Bottom Units 1, 2 and 3, PECO had extensive exposure to the concept of a single firm performing both design and construction activities on major generation projects. This arrangement, PECO felt, allowed better control and monitoring capabilities and also lessened interface problems between the owner and the design/construction firm. Further, PECO management has stated that the Keystone and Conemaugh projects (in which PECO was a participant) completed in the late 1960s, which were constructed by Ebasco but engineered by Gilbert Associates, had experienced communication interface problems during their design and construction. Thus, recent PECO experience on fossil units, as well as experience being gained from the ongoing construction at Peach Bottom, led PECO to conclude that the best strategy for Limerick was to let both the A/E and construction management contracts to a single firm.

Q. HOW WAS PECO INTERNALLY ORGANIZED TO MANAGE THE CONSTRUCTION OF THE LIMERICK PROJECT?

A. PECO's internal approach to managing the construction of Limerick was structured along the lines of both matrix and functional organizations. The matrix organization, consisting of those people dedicated solely to Limerick but administratively reporting to a functional group, included the construction field forces, electrical field engineering, instrumentation and control field engineers, field Quality Assurance/Quality Control forces as well as a contingent of auditors from the Internal Auditing Department.

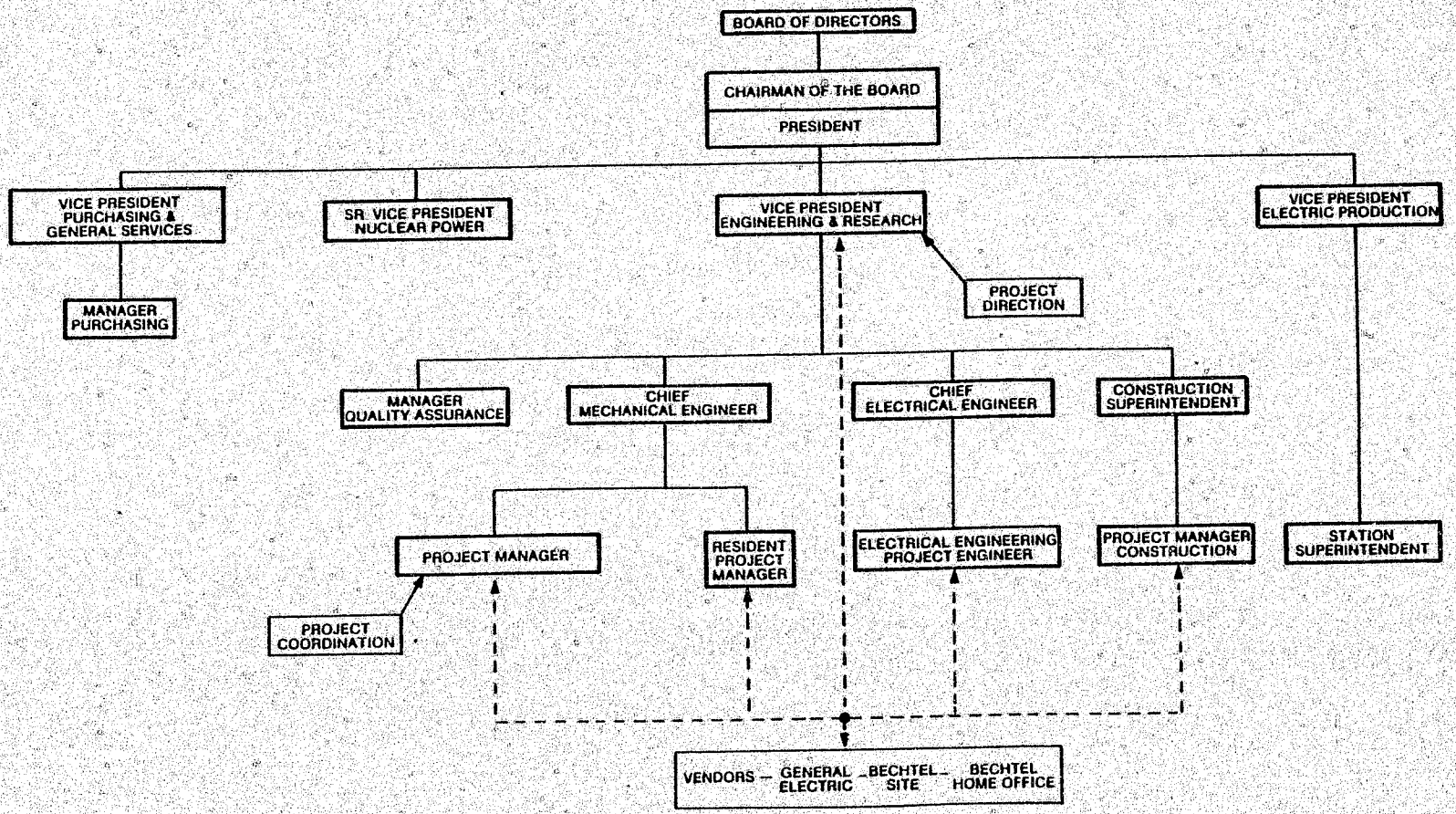
The functional organization comprised the mechanical and electrical engineering divisions who were responsible for independently monitoring and supporting Limerick activities on an 'as needed' basis. Schedule 8 shows the general reporting relationships of the various members/groups of the Limerick Project. As shown, effective day-to-day control was exercised by the Vice-President - Engineering and Research. The various subordinate groups reported directly or indirectly to him, through the position of PECO Project Manager.

An additional key facet of PECO's project organization was the Senior Vice-President - Nuclear Power who supplemented and supported the overall duties and activities of the Vice-President - Engineering and Research. His involvement encompassed interface roles with numerous external agencies and organizations, such as the NRC for regulatory matters and the DRBC and Bucks County on issues related to Limerick's need for supplementary cooling water. The effect of the Senior Vice President's role was to allow greater emphasis on the internal activities of the project by the Vice-President - Engineering and Research, while transferring some duties and responsibilities related to external matters to another member of senior management. This arrangement allowed for a more effective concentration of efforts in dealing with the issues

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PHILADELPHIA ELECTRIC COMPANY ORGANIZATION—LIMERICK PROJECT

1984



----- EXTERNAL LINES OF COMMUNICATION

SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

SCHEDULE 8

and concerns of the project.

Q. HOW WAS BECHTEL INTERNALLY ORGANIZED TO MANAGE THE CONSTRUCTION OF THE LIMERICK PROJECT?

A. Bechtel's approach to managing the Limerick Project was structured along the lines of a matrix organization. Bechtel project team members maintained a dual working relationship in which they received technical and administrative direction from their department manager and overall project direction from the project manager, as head of the project. This form of organization was common for firms designing or building large generating facilities during the 1970s and early 1980s. A detailed examination and evaluation of the Bechtel engineering and construction organizations and their effectiveness in monitoring and controlling project activities is presented in sections III and IV, respectively, of this testimony.

Q. HOW DID PECO MANAGE THE INTERFACE AND COMMUNICATION ROLE BETWEEN THE COMPANY AND BECHTEL?

A. PECO's principal method of delineating the roles and responsibilities of project organizations and of defining the methods for communication and interface was the Project Procedures Manual. This manual, originally issued in 1971, was intended to serve,

> "... as a guide for the organization and conduct of the services and will establish the interface responsibilities of each party in the conduct of the project..."

The document outlined in detail the major responsibilities of the Bechtel project team members and described the engineering and construction procedural interfaces between Bechtel and PECO and other project groups. The manual also provided procedures for interfaces between Bechtel's

procurement, division services and project administration groups and the PECO organization. Interface procedures for the Quality Assurance and Startup groups were addressed in separate manuals.

The Project Procedures Manual was intended to be a dynamic document so as to reflect the changing needs and scope of the project and, in fact, went through seven revisions.

Q. DID PECO'S ORGANIZATIONAL STRATEGY ALLOW FOR SUFFICIENT MANAGEMENT INVOLVEMENT IN THE LIMERICK PROJECT?

A. Yes. TB&A has concluded that PECO's involvement in the project was more extensive than was typical for nuclear project owners during this time period. For example, PECO established at an early stage (1975) in the project, a continuing presence, in the form of a Resident Project Manager, at the San Francisco headquarters of Bechtel to monitor and report to PECO management on Bechtel home office engineering design activities and progress. PECO's establishment of such a position so early in the project was unusually proactive when compared to other utilities' actions in this regard. PECO also instituted and chaired a monthly progress meeting with Bechtel personnel which served as a forum for addressing in detail the ongoing needs and status of the entire project, and which was useful in implementing and monitoring actions necessary to control any problems that arose. Additionally, as mentioned previously, the project was effectively managed by the Vice-President - Engineering and Research who was supported extensively by the Senior Vice-President - Nuclear Power. Thus, PECO's internal organizational structure for managing the Limerick Project allowed for near full-time involvement of two senior Company officers. Further, PECO's functional organization in the Mechanical

and Electrical Engineering Divisions allowed them to capitalize on expertise developed by PECO personnel serving on the many industry committees and organizations addressing various facets of nuclear generation. For instance, PECO employees are, or were:

- Chairman and Vice-Chairman of the BWR Owners Group.
- Chairmen of 10 BWR Owners Group subcommittees and members on 14 others.
- Chairman of the American Society of Mechanical Engineers (ASME) Nuclear Engineering Division and Code Committee on Nuclear Air and Gas Treatment.
- Chairman of the Edison Electric Institute's (EEI) Nuclear Power Executive Advisory Committee.
- Members of numerous other industry groups, e.g. Atomic Industrial Forum (AIF), American Nuclear Society (ANS), Institute of Electrical and Electronic Engineers, and committees.

PECO's high level of involvement (numerous other examples are cited throughout this testimony) in the Limerick Project was a direct result of their previous nuclear experience on Peach Bottom and reflected greater involvement than was typical in the industry at the time.

Q. WHY IS PRIOR EXPERIENCE IMPORTANT IN CONSTRUCTING NUCLEAR GENERATING STATIONS?

A. Prior experience of company personnel, especially senior management, while not a prerequisite for successful completion of nuclear projects, has certainly proven to be beneficial. As the 1970s progressed and the nuclear industry began to be buffetted by external forces such as rampant inflation, increased

regulatory intervention and technical and design evolution, the ability to deal effectively with these issues hinged on management's early recognition and prospective evaluation capabilities, followed by timely, decisive action to mitigate the impact of these concerns. The ability of management to draw on past experience in resolving such concerns as contractual problems, quality assurance and licensing issues, as well as both internal and external organizational conflicts, was of great benefit. It allowed management the use of an extra "measuring stick" and provided a basis for sound judgment when confronted with major decisions. TB&A's review has indicated that PECO had extensive relevant nuclear experience prior to the start of construction at Limerick.

Q. WHAT OTHER ASPECTS OF PECO'S ORGANIZATIONAL STRATEGY WERE IMPORTANT TO AN EFFECTIVE OWNER OVERSIGHT ROLE AT LIMERICK?

A. With some nuclear projects extending for as long as twenty years from inception to commercial operation, the ability of utility and A/E managements to ensure a semblance of personnel continuity on their projects becomes of prime importance. This continuity is especially critical as the nature and scope of project requirements and the external environments in which projects are constructed change dramatically over time. Consequently, first-hand knowledge of important project decisions, related environmental factors, design philosophy, and past and present management practices became very important to successful project completion.

Q. WHAT DID TB&A FIND REGARDING THE CONTINUITY OF KEY PROJECT PERSONNEL ON LIMERICK?

A. As Schedule 9 demonstrates, PECO retained many of the key managers who had

been associated with Limerick. For example, John Kemper, first as Manager and then as Vice President of the Engineering and Research Department, exercised day-to-day control of the project from its inception. He was supported by the same PECO Construction Manager and only two different Project Managers (the first of whom filled the position until late 1984) over the entire life of the project. Further, there were only three PECO Resident Project Managers. This continuity also extended to Bechtel's Project Manager, who served in that position for the entire duration of the project, which TB&A has found to be highly unusual in the nuclear construction industry.

Such stability in key management positions allowed PECO and Bechtel to utilize, over time, the extensive Limerick-specific experience of its managers when addressing critical project issues.

Q. WHAT ARE TB&A'S CONCLUSIONS REGARDING THE ORGANIZATIONAL STRATEGY EMPLOYED AT THE LIMERICK PROJECT?

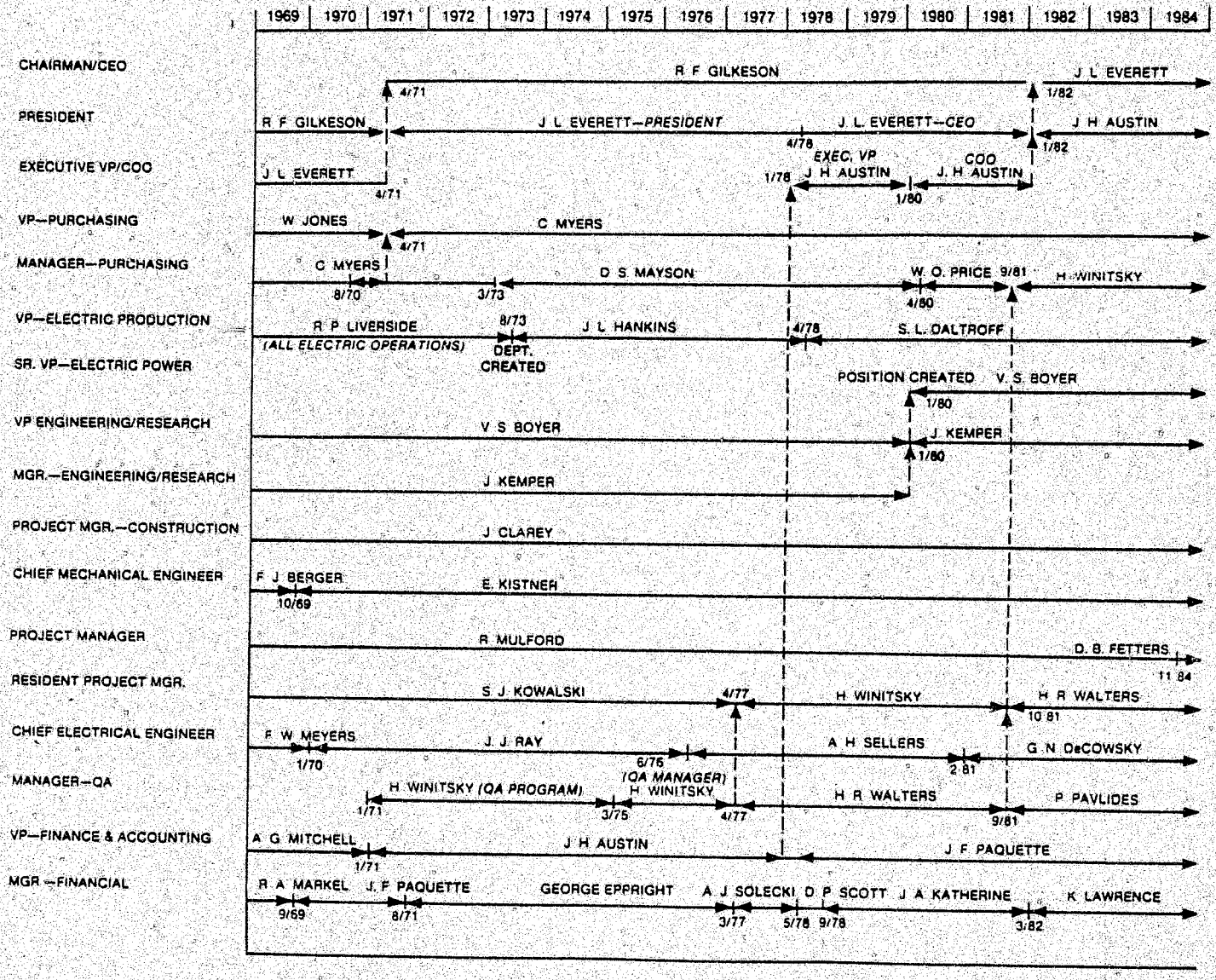
A. TB&A's examination of PECO's organizational strategy and approach to constructing the Limerick Project has led to the following conclusions:

(1) PECO's organizational strategy of utilizing a single, experienced firm for both architectural/engineering and construction management services, as well as its own existing internal organizational structure developed at Peach Bottom, was a reasonable, effective approach to performing its owner oversight duties. This approach was especially appropriate in light of PECO's decision to duplicate Peach Bottom at Limerick (discussed later in this section) and its successful experience with that approach at Peach Bottom. The selection of Bechtel and GE as major contractors, for the reasons described below, further supports the use of this approach and thereby the continuation of Peach Bottom working relationships.

(2) PECO approached the Limerick Project with a great deal of relevant nuclear background and experience, and subsequently assigned knowledgeable key personnel to the project. This assisted and permitted effective PECO participation in project decisions at all levels throughout the completion period.

PHILADELPHIA ELECTRIC COMPANY

PHILADELPHIA ELECTRIC COMPANY LIMERICK PROJECT MANAGEMENT TIMELINE



SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

(3) PECO and Bechtel maintained excellent continuity among key top management and project personnel over the life of the Limerick Project.

In summary, TB&A concludes that PECO's organizational approach, supplemented by its exceptionally high level of involvement and relevant nuclear experience, allowed PECO to fulfill its owner oversight responsibilities, as more fully described below, in a reasonable and appropriate manner. PECO's organizational strategy and the organizational relationships it established provided a good prospect of successful project completion from a cost, schedule and quality vantage point and faciliated PECO and its major contractors in the execution of their responsibilities.

2. CONTRACTOR SELECTION

Q. WHAT IS THE PURPOSE OF THIS SECTION OF TB&A'S TESTIMONY?

A. TB&A examined the specific process by which Bechtel was selected as architect/engineer and constructor and General Electric was selected as the nuclear steam supply system vendor. TB&A's examination included a review of: 1) PECO's selection process and evaluation criteria; 2) type of contract awarded; and 3) the terms and conditions of the contracts, i.e. whether PECO's interests were adequately addressed. Additionally, TB&A reviewed PECO's utilization strategy and selection procedure with respect to subcontracts.

The purpose of this review was to determine whether PECO management's selection of Bechtel and GE and its award of subcontracts, as well as the structure and terms of the contracts between PECO and the respective contractor organizations, were appropriate given the information and alternatives available at the time.

Q. HOW DOES TB&A EVALUATE A UTILITY'S MAJOR CONTRACTOR

SELECTION PROCESS?

A. In reviewing a utility's major contractor selection process, TB&A looks for a utility to first identify the major selection criteria by which it will evaluate prospective bidders. Second, the utility should solicit an appropriate number of bids from competent vendors to provide reasonable assurance that it is obtaining cost competitive services. Third, a detailed bid analysis should be performed on all vendor proposals. Finally, the selection should be based on the application of the identified major selection criteria followed by a reasonable evaluation and interpretation of the results.

Q. WOULD YOU PLEASE DESCRIBE THE TYPES OF CONTRACTS THAT HAVE BEEN UTILIZED FOR MAJOR UTILITY CONSTRUCTION PROJECTS?

A. Major utility construction projects have, over the years, exercised basically three types of contractual agreements for equipment and services. These are:

- Firm or Fixed-Price Contracts
- Incentive Contracts
- Cost-Plus Contracts

Firm or fixed-price contracts establish a fixed cost, including contractor fees and profit, for the defined project scope. Cost overruns are absorbed by the contractor and underruns are to the benefit of the contractor. Changes that expand project scope usually result in a renegotiated firm-price level. Fixed-price contracts are beneficial to the utility in that total costs are reasonably well-defined before committing to the project. However, A/E's and constructors are normally unwilling to enter into a fixed-price contract unless project specifications and design are developed in detail ahead of time and there is a reasonable expectation that the specifications and design will prevail.

Fixed-price contracts, which are vulnerable to frequent and large change orders, are sometimes available on vendor-supplied items and are frequently used between prime and subcontractors. However, these contracts often include an escalation clause indexed to wage rates or other cost indices which dilutes the fixed nature of the contract. Generally, longer-term fixed price contracts will contain such clauses.

Incentive contracts may include a variety of arrangements, but normally they specify target criteria and provisions whereby the contractor can earn a premium on his fee if the project is completed at better than the target criteria, or be penalized if the target criteria are not met. Target criteria may be based on time, costs, manhours, or some other measurable indicator. However, changes in project scope or conditions may alter the target criteria so the ability to define project scope is important, but presents a difficult impediment to the effective administration of an incentive type contract.

Incentive contracts can be equitable for both the utility and the contractor. They provide some protection for the utility in that the contractor has a financial motivation for completing the project within target levels, thus helping to ensure that the work is carried out efficiently and effectively. However, incentive contracts do not commit the contractor to a fixed price, thus the contractor does not incur undue risks associated with project uncertainties. Because scope changes do arise, "targets" are often difficult to define and are troublesome to administer for a nuclear power project.

The cost-plus contract is an agreement where the utility pays essentially all project costs plus a fee for contractor services. The contractor's fee may be calculated on a variety of bases. For example, specific services such as

engineering or purchasing may be charged at a fixed rate (i.e. a multiple of salaries for the assigned personnel). Management fees may be established at a fixed dollar amount or as a percentage of project costs. Although fee schedules sometimes include "not to exceed" clauses for hard-dollar items, the cost-plus contract provides the least risk for the contractor and the least protection for the utility, and it is common for projects with great scope uncertainty, e.g. nuclear generating stations, where conditions and project requirements may change. The cost-plus contract requires the greatest project management and contract administration effort by the utility.

Q. WHAT CHANGES AFFECTED THE TYPE OF CONTRACT UTILITIES COULD ENTER INTO TO CONSTRUCT A NUCLEAR GENERATING STATION DURING THE 1960s AND 1970s?

A. Major changes within the nuclear project construction process during the mid to late 1960s and early 1970s directly affected the contract types available to utilities. Due to the costs and schedule overruns being experienced on large scale projects, fixed-price prime contracts were virtually eliminated for new work since A/E's were typically unwilling to enter into fixed-price contracts, and those projects that were already in progress with fixed-price contracts frequently were renegotiated to some form of cost-plus arrangement.

The result of this change in contract type was to effectively shift most of the risk associated both with actual construction and other external uncertainties (such as inflation, regulation, etc.) from the contractor to the utility/owner. Thus, as a consequence of these contractual changes, utilities were required to develop, out of necessity, stronger project control and contract administration groups to maximize their control over a project.

a. Selection Of Bechtel

Q. WOULD YOU PLEASE DESCRIBE THE PROCESS BY WHICH BECHTEL WAS SELECTED AS ARCHITECT/ENGINEER AND CONSTRUCTOR FOR LIMERICK.

A. Subsequent to the identification, in the late 1960s, of the need for additional generating capacity, PECO solicited proposals for the design and construction of Limerick from Bechtel Corporation and United Engineers and Constructors (UE&C), Inc. The proposals were received in early 1969, and were subjected to an in-house bid evaluation. PECO's analysis compared such proposal items as home-office overhead, field non-manual overhead, fee, on-time bonus and late penalties.

Q. WHY WERE ONLY TWO BID PROPOSALS SOLICITED?

A. Interviews with PECO senior management personnel have indicated that PECO's main concern at this point was that the prospective bidders had the technical competence and experience to design and construct Limerick and, preferably, specific experience with the design and construction of boiling water reactors. The firm with the greatest nuclear experience at that time was Bechtel, which was then designing and building the Peach Bottom Units. UE&C was constructing Salem Units 1 and 2 at the time and had constructed every generating facility, except for Barbados, in the PECO system since World War II. With proposals from two major, nuclear-experienced architect/engineers who had PECO-specific experience, PECO was confident of receiving competitive terms and conditions from proven contractors.

Q. WAS THE BECHTEL PROPOSAL LOWER IN COST THAN UE&C's?

A. Each proposal contained some form of incentive clause whereby contract cost

would depend on the number of payroll hours the contractor was above or below a specified target. Therefore, under certain hypothetical conditions, Bechtel would have the lower cost contract, while under others, UE&C could be more cost-effective. Direct comparisons, however, were difficult because the base target value that each contractor cited was composed of different elements. However, PECO was able to identify probable maximum and minimum values for fee and overhead charges based on the then anticipated project scope. These maximum and minimum values were comparable for the two proposals.

Q. GIVEN THE DIFFICULTY IN DIRECTLY COMPARING BID PROPOSALS, WHAT OTHER CRITERIA INFLUENCED PECO'S DECISION TO SELECT BECHTEL AS A/E AND CONSTRUCTOR FOR LIMERICK?

A. A number of key factors weighed heavily in Bechtel's favor during the selection process. These were:

- PECO/Bechtel Relationship. A close working relationship between PECO and Bechtel had developed through the design and construction of the Peach Bottom Station. Because of this close association, Bechtel was able to develop a better understanding of PECO's operating concerns. Further, PECO engineering and operations personnel had become familiar with Bechtel's design and construction system, methodology and control procedures. These two factors would result in a more efficient and expeditious working relationship between PECO and its major contractor on Limerick.

- Design. The original Limerick design was to be a duplication of the Peach Bottom design. Hence, the opportunity for design efficiencies, construction productivity improvements due to system

and component standardization, as well as favorable learning curve effects, was enhanced by selecting the same A/E for each project. Further, selection of Bechtel permitted a close liason between the Peach Bottom 2 and 3 startup group and the engineering design group for the two new Limerick units. Any solutions to problems discovered in the startup of Peach Bottom could be effectively incorporated early on into the Limerick design, thereby minimizing last minute operations improvement changes.

- Personnel. Bechtel committed to supplying key management personnel, many directly from the Peach Bottom staff. The familiarity of these experienced personnel with the general type of equipment and systems required by PECO would result in savings in decision-making and engineering time. Moreover, PECO could be assured that these personnel were properly experienced in nuclear plant construction and familiar with PECO personnel.

- Reputation of Bechtel. Bechtel had considerable experience in the design and construction of BWR nuclear generating stations and, in fact, was considered by most people in the industry to be the preeminent nuclear contractor.

Q. WHAT DID TB&A CONCLUDE REGARDING THE SELECTION OF BECHTEL AS A/E AND CONSTRUCTOR FOR LIMERICK?

A. TB&A concludes that, although PECO's selection process was not as structured and documented as TB&A deems generally appropriate, the reasoning presented by PECO for the choice of Bechtel is compelling. Thus, Bechtel's selection reflects reasonable and appropriate management action. This conclusion is

based on PECO's then extensive nuclear experience, its ongoing relationship with Bechtel at Peach Bottom, Bechtel's reputation and experience, as well as PECO's reasonable intent (as described further below) to have Limerick duplicate the Peach Bottom design.

Q. DID TB&A REVIEW THE TERMS AND CONDITIONS OF THE CONTRACT THAT PECO SIGNED WITH BECHTEL?

A. Yes. TB&A reviewed the contract to determine whether the interests of PECO were given adequate consideration in the formulation of the contract between the two organizations.

Q. WHAT DID YOUR REVIEW OF THE CONTRACT INDICATE?

A. The Bechtel contract was a cost-plus fixed fee agreement containing time related incentive clauses, subject to approval by PECO. TB&A's examination of the contract indicated that it defined the responsibilities of Bechtel in terms of work to be performed and schedule to be attained. TB&A's review of the contract indicated that it was comparable to similar contractual arrangements made between utilities and major A/E's during this time frame and afforded PECO adequate opportunity for monitoring and oversight control.

Q. WHAT DOES TB&A CONCLUDE FROM ITS ANALYSIS OF THE TYPE AND TERMS OF THE CONTRACT BETWEEN PECO AND BECHTEL?

A. TB&A finds that the contract adequately addressed, from a contemporaneous standpoint, major issues, such as schedule, liabilities, performance, fee and responsibilities, pertaining to the project. TB&A concludes that the type and terms of the contract gave sufficient consideration to the interests of the Company.

b. Selection Of General Electric

Q. WOULD YOU PLEASE REVIEW THE PROCESS BY WHICH GENERAL ELECTRIC WAS SELECTED AS THE NUCLEAR STEAM SUPPLY SYSTEM VENDOR FOR LIMERICK?

A. In June 1967, PECO requested that all four major nuclear steam supply system vendors (General Electric, Combustion Engineering, Babcock & Wilcox and Westinghouse) submit proposals for the Limerick Station. The NSSS systems offered by these firms included both boiling water reactors (GE) and pressurized water reactors (Combustion Engineering, Babcock & Wilcox, and Westinghouse). As was common industry practice, due to the amount of money involved and specific design preferences, PECO elected to award and administer the NSSS contract directly.

A detailed in-house bid review was conducted by PECO in August 1967. PECO evaluated the submitted proposals (Combustion Engineering had declined to bid) against a significant list of criteria, including technical preferences, total capital costs, capital cost based on a net $/kw, and operating and maintenance costs. Additionally, PECO contracted with NUS Corporation to perform an analysis of fuel cycle costs for GE, Babcock & Wilcox and Westinghouse, who had included nuclear fuel offerings in their proposals.

Q. WHICH PROPOSAL WAS LOWEST IN COST?

A. The three proposals were essentially equivalent in cost. Based on anticipated total capital costs, GE's proposal was the lowest. Babcock & Wilcox's (B&W) proposal, however, was evaluated to be the least expensive based on total energy costs. This was possible because although B&W's proposal had higher estimated capital costs, the design rating of their reactor was also higher,

which tended to reduce the cost when evaluated on a net $/kw basis. Additionally, NUS Corporation evaluated B&W's fuel costs, on a mills/kwh basis, to be slightly less than GE's. Overall, B&W's, GE's and Westinghouse's total energy costs were estimated to be 3.74, 3.84 and 4.07 mills/kwh, respectively.

Q. WHY DID PECO SELECT GE AS THE NSSS VENDOR IF B&W's PROPOSAL PROJECTED SLIGHTLY LOWER ESTIMATED COSTS?

A. First, the GE proposal, although higher on a net basis, projected total energy costs that were estimated to be not significantly above B&W's. Second, GE's proposal called for a duplication of the Peach Bottom facility which was anticipated to eventually produce economies of operation for both Peach Bottom and Limerick. Third, PECO preferred, from a technical standpoint, boiling water reactors (BWR's), which were manufactured by GE, to pressurized water reactors (PWR's), produced by Babcock & Wilcox. Finally, PECO had familiarity (through Peach Bottom) with the GE design as well as GE's management personnel and procedures, which would facilitate communication and effective interaction between them.

In summary, PECO performed a detailed and comprehensive bid evaluation which compared the direct costs of the various NSSS proposals and also considered the indirect impacts. Based on this evaluation, PECO chose GE.

Q. WHAT ARE TB&A's CONCLUSIONS REGARDING THE PROCESS BY WHICH PECO SELECTED GE AS THE NSSS VENDOR FOR LIMERICK?

A. TB&A finds that PECO presented sound reasoning for GE's selection. TB&A concludes that PECO's choice of General Electric as the NSSS vendor for

Limerick resulted from reasonable management actions and was appropriate. GE's selection, it should be noted, was consistent with PECO's reasonable intention that Limerick duplicate Peach Bottom. The potential benefits from such a strategy included minimizing the Limerick cost and schedule. PECo's familiarity and established working relationships with GE and also Bechtel, were also important elements in PECO's overall decision-making process to duplicate Peach Bottom, and to re-engage GE for Limerick. Indeed, the benefits of duplication have been recognized by the NRC. In a 1978 policy statement, the NRC stated that ". . . the duplicate plant concept has been demonstrated to be an effective means of reducing staff and applicant resources required for licensing reviews. The concept has been favorably commented on by all parties. . . ."

Q. DID TB&A REVIEW THE TERMS OF THE CONTRACT BETWEEN GE AND PECO?

A. Yes. TB&A performed a review of the terms and conditions of the contract between GE and PECO to determine whether PECO interests were properly addressed.

Q. WHAT WERE THE RESULTS OF YOUR REVIEW?

A. The GE-originated contract was a firm-price type of contract, subject to certain escalation clauses. Specifically, General Electric was responsible for supplying boiling water reactors for Limerick Units 1 and 2 as well as, via separate contracts, the turbine generators, reactor feed pumps and initial fuel fabrication services, while PECO was responsible for the equipment installation at the station. The Technical Description outlined in the contract provided the basis for the preparation of the design, drawings, specifications, and other

technical documents required in GE's scope of supply.

Our review of the GE/PECO contract indicated that the NSSS contract was comparable to other contemporaneous NSSS contracts. It was comprehensive in that it addressed, among other factors, scope-of-services, party responsibilities, project control procedures, design reviews, quality control, and project progress reporting methods.

Q. WHAT ARE TB&A's CONCLUSIONS REGARDING THE TYPE AND TERMS OF THE CONTRACT BETWEEN PECO AND GE?

A. TB&A finds that the contract was reasonable, from a contemporaneous standpoint, in addressing major issues germane to the successful fulfillment of a contract to supply a nuclear steam supply system for Limerick. TB&A concludes that the type and terms of the contract gave sufficient consideration to the interests of the Company.

c. Subcontractor Utilization And Selection Strategy

Q. WHAT ARE THE BENEFITS TO BE GAINED FROM A WELL-DESIGNED SUBCONTRACTOR UTILIZATION STRATEGY?

A. There are a number of benefits to be gained from a well thought out subcontractor utilization strategy. First, proper utilization of qualified, competent subcontractors will effectively support the cost and schedule goals of the project. Second, a proper strategy will promote labor harmony on the project by including as many qualified local contractors as possible. This policy also promotes, from a public relations standpoint, broad based public support of the project. Third, by letting subcontracts for a reasonable amount of the total project scope of work, the construction manager's force account work level is reduced, and control of the project becomes a matter of coordination between

the subcontractors, construction manager and owner. This increases the level of management and supervisory resources available to the project, and also incorporates additional technical expertise into the project organization. Finally, a project benefits because a proper strategy will effectively utilize the skills of a number of the specialty contractors whose talents are typically required in the construction of a nuclear generating facility. Although not essential to successful project management, existence of such a strategy demonstrates a greater degree of utility involvement than TB&A typically finds on nuclear construction projects.

Q. DID PECO DEVELOP A SUBCONTRACTOR UTILIZATION STRATEGY FOR LIMERICK?

A. Yes. PECO's experience in the construction of fossil units, as well as the lessons being learned from the ongoing activities at Peach Bottom, convinced management that a proper subcontractor utilization plan would go far towards meeting the cost and schedule goals set for Limerick. Toward this end, management commissioned Bechtel to examine the use of local contractors at Limerick.

Bechtel's response to this was to prepare a report, entitled, "Analysis of Field Work for Optimum Use of Local Contractors." The purpose of this report, issued in September 1971, was to:

> "...determine the best use of subcontractors to achieve optimum labor productivity in the construction of the Limerick Generating Station..."

Q. WHAT WERE THE RESULTS OF THIS STUDY?

A. Bechtel developed two plans for consideration by PECO management. The first plan, Work Plan 1, entailed breaking the project into 31 separate packages and

effectively subcontracting the entire job. The second plan, Work Plan 2, proposed that Bechtel retain the four key control packages, i.e. Civil/Structural/Architectural, Mechanical, Piping and Associated Mechanical, and Electrical. Bechtel felt that control of the project, if the key control packages were split, would be especially difficult considering the regulatory and environmental aspects of nuclear power plants. Subcontracting under Plan 2 would amount to approximately 37% of the total work effort. This compared with roughly 15% of the work that had been subcontracted on Peach Bottom at the time.

All of the subcontracts, with the exception of the four major packages, would be awarded on a competitive firm price bid basis. Bechtel's recommendation to PECO regarding the selection of Work Plan 1 or 2 stated:

> "After careful consideration of the various factors of project control such as job administration, cost, schedule, labor practices, labor recruiting, and in the ambient conditions surrounding the Limerick Project, we conclude that there should be a greater amount of subcontracting on Limerick than on the Peach Bottom Project, but that direct control of the key critical path and major work packages should be under a single Manager.
>
> Therefore, we recommend that the project proceed with Work Plan #2."

Q. WHAT WAS PECO'S RESPONSE TO BECHTEL'S RECOMMENDATION?

A. PECO agreed with Bechtel that it would be detrimental to the cost and schedule control aspects of the project to subcontract the entire scope of work for Limerick. Therefore, PECO opted to proceed with Work Plan 2, which allowed for 37% of the anticipated work to be subcontracted, while having Bechtel retain responsibility for the four major work packages. TB&A considers PECO's choice to have resulted from a reasonable consideration of

the possible alternatives, i.e. Work Plan 1, 2 or no subcontracting, and to be based upon reasonable factors and to be appropriate.

Q. HOW MUCH WORK WAS EVENTUALLY SUBCONTRACTED AT LIMERICK?

A. Subcontracted work at Limerick (Units 1 and 2) through the issuance of Forecast 6 in December 1982 amounted to over 17% of the total direct, non-manual and distributable manhours. Through Forecast 6, subcontracted activities (including material and labor) amounted to over $450 million. One of the more significant reasons for the inability to meet the initial targeted percentage was the dramatic increases in scope that occurred over the life of the project. These scope increases had a more significant effect on the four major control packages, i.e. Civil/Structural/Architectural, Mechanical, Piping and Associated Mechanical, and Electrical, which Bechtel was responsible for, and consequently increased their percentage of work, on both a dollar and manhour basis, for the entire project. Further, Bechtel occasionally performed work that was originally intended to be subcontracted.

Q. PLEASE DESCRIBE THE PROCESS BY WHICH SUBCONTRACTORS WERE SELECTED?

A. Subcontracts between the Bechtel organization and subcontractors were formed and issued from either Bechtel's San Francisco home office or the Bechtel jobsite office. Generally, Bechtel home office procurement formed and issued subcontracts and Bechtel construction administered them. (Subcontract administration is described in detail in Section IV of this testimony.)

Bechtel's home office prepared recommended bidder's lists for all engineered permanent plant equipment and incorporated input from PECO on a time-to-time basis if PECO had prior experience or knowledge of particular

subcontractors. Subcontractor bidder's lists were approved, in writing, by PECO prior to soliciting proposals for subcontracts.

A bid analysis summarizing the pertinent details of each bidder's proposal was prepared by Bechtel. Bechtel then recommended the bidder who best met the technical and quality assurance requirements of the specifications and offered satisfactory delivery at a favorable price. The letter of recommendation together with the bid analysis was sent to PECO for approval for each Bechtel subcontract with a value in excess of $100,000. This letter of recommendation noted differences in commercial terms, exceptions to specifications, and provisions for price adjustments for all subcontracts. If differences in price adjustment proposals existed, the effects were, procedurally, included in the bid analysis.

Q. HOW DID PECO ASSURE BECHTEL'S COMPLIANCE WITH THE SUBCONTRACTOR SELECTION PROCESS JUST DESCRIBED?

A. PECO assured Bechtel's compliance by incorporating the process into the project procedures manual, which as previously mentioned, served to "... establish the interface responsibilities of each party in the conduct of the project". PECO also monitored Bechtel activity and requested corrective action when necessary. Also, at important points in the process, PECO approval was required prior to further action.

Q. WHAT DOES TB&A CONCLUDE REGARDING PECO'S SUBCONTRACTOR UTILIZATION AND SELECTION STRATEGY FOR THE LIMERICK PROJECT?

A. TB&A found that PECO addressed in detail, at an early stage in the project, the need for an effective, coordinated subcontractor utilization strategy that would allow for the best use of available local contractors in the hope of achieving

optimal efficiency at Limerick. TB&A concludes that PECO's heavy involvement in this aspect of project management represented an unusually proactive stance when compared to actions of other utilities in this regard. TB&A also found that PECO's position of awarding subcontracts on a firm-price, competitive bid basis was reasonable based on the anticipated long lead of design engineering over construction activities. Further, TB&A concludes that PECO's strategy allowed for a reasonable and proper level of involvement in the selection of major subcontracts, and produced a reasonable and appropriate selection process.

3. PROJECT CONTROLS

Q. WHAT IS THE PURPOSE OF PROJECT CONTROLS ON A CONSTRUCTION PROJECT SUCH AS LIMERICK?

A. The main objective of project controls are to provide the information required to identify problems and initiate corrective action on a systematic and timely basis in order to meet project cost, schedule and quality goals. In the broadest sense, owners "control" major construction projects through an interrelated combination of: 1) organizational relationships; 2) contractual provisions; and 3) judicious use of project controls. Previous sections of this testimony have affirmed the reasonableness of the organizational and contractual relationships implemented by PECO on the Limerick Project. This section reviews the reasonableness of PECO's performance with regard to the project control systems utilized on the Project.

Q. PLEASE DESCRIBE THE USE OF THE TERM "PROJECT CONTROL"?

A. TB&A has found that project control, as exercised on nuclear construction projects, consists of the following broad areas of management activity:

- Planning - Defining project scope and developing plans, estimates, budgets, and schedules consistent with this scope and with overall project requirements.
- Reporting - Communicating status against the plan to appropriate levels of management.
- Monitoring - Evaluating progress and performance and analyzing variances with respect to the plan.
- Control - Taking corrective action to alleviate or minimize variations in progress or performance.
- Plan Modification - Updating the plan to keep it current and achievable.

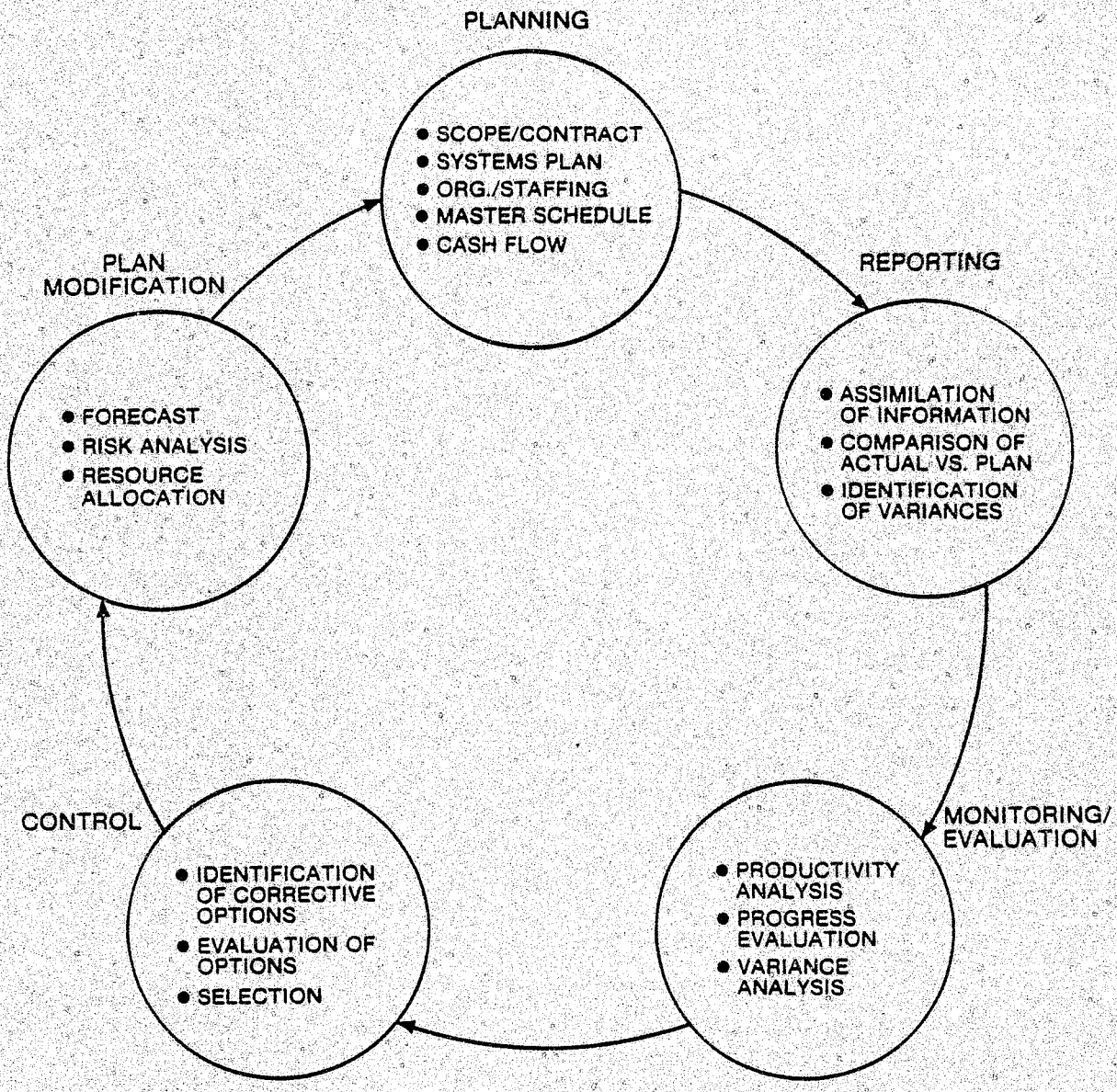
The cyclical relationship of these five elements of project control is shown as Schedule 10. That is, the process of planning, reporting, monitoring, controlling, and updating is systematic and repetitive, thus providing greater and greater control as the project progresses. The project controls section will describe the planning, reporting and monitoring processes that PECO used on Limerick; control and plan modification are discussed in the Project Oversight section.

Q. ARE YOU FAMILIAR WITH THE EVOLUTION OF PROJECT CONTROL TOOLS IN THE UTILITY INDUSTRY AS APPLIED TO NUCLEAR POWER PLANT PROJECTS?

A. Yes. Most of the techniques for planning, scheduling, estimating, and cost control were derived from aerospace and military application of the Project Evaluation and Review Technique (PERT) program and related programs. PERT, one of the first Critical Path Method (CPM) approaches, was a system

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ELEMENTS OF PROJECT CONTROL



SOURCE: TB&A ANALYSIS

originally developed to assist the Navy in controlling its Polaris missile and nuclear submarine development project. An example of the aerospace/ military to power plant contractor/utility evolution is McDonnell Douglas Automation's (McAuto) Management Schedule and Control System (MSCS), which was a PERT spin-off used by Bechtel in its engineering design and construction of nuclear power plants.

All cost codes in the utility industry have their origin in the Federal Energy Regulatory Commission (FERC) and its predecessor, the Federal Power Commission (FPC) code of accounts--a system that is not conducive to controlling engineering design and construction costs. The evolution in the last eight to ten years has focused on the Work Breakdown Structure (WBS), i.e. the appropriate unit, level, package or breakdown for describing the work or tasks to be planned and performed.

Development of scheduling methods such as MSCS and programs to better define the work packages through the work breakdown structure have provided projects with better methods for controlling the project work. Bechtel incorporated these improved methods and, for example, in conjunction with PECO established the MSCS program on the Limerick Project to control both engineering and construction schedules.

Today, almost two decades after the initial transfer of formal techniques for planning, scheduling, estimating, and cost control from the aerospace/military to power plant contractor/utility applications, the integration of cost and schedule is still evolving. This evolution includes the development of new scheduling programs, better definition of work packages, and a better understanding of the information needed for project control. On

Limerick, the project control program evolved with this improved industry knowledge and in response to the changing needs of the Project.

Q. PLEASE DESCRIBE HOW PROJECT PLANNING, REPORTING AND MONITORING WAS ACHIEVED ON LIMERICK?

A. These project control functions on Limerick were achieved by combining the organizational and management capabilities of PECO, Bechtel and other contractors into a project controls program. The program incorporated planning, reporting and monitoring, the activities that furnish the information required for the oversight roles of control and plan modification.

PECO effected the planning, reporting and monitoring functions by assigning to its own personnel the task of overseeing the performance of these functions and the development of the tools required for their performance. Bechtel was assigned responsibility for generating and operating these data gathering and reporting tools. The PECO construction and startup organizations, located at the Limerick site, were assigned responsibility for reviewing the Bechtel construction and startup plans to ensure they reflected PECO's requirements. The construction organization assigned, to its schedule and progress review and cost analysis groups, the specific responsibility for preparing an overall project analysis.

The PECO/Bechtel contract called for project control tool development and implementation to fall within the scope of services to be provided by Bechtel, subject to PECO review, monitoring and acceptance. To support this contractual arrangement, Bechtel organized and staffed a large project control organization with people assigned to project control groups in San Francisco and at the construction site.

In San Francisco, each engineering group was responsible for developing detailed plans for their work. The planning responsibility was assigned to engineering group supervisors and support was provided by assigning planning personnel to the group. The overall engineering plan was coordinated into the project plan by the Bechtel Engineering Planner.

Bechtel's construction plans were developed by the Bechtel construction personnel in conjunction with project controls personnel. The construction supervisors defined the work sequences and communicated that information to the project planners, allowing the planners to develop the formal plans. Startup planning was accomplished by the startup engineers working with the planners.

A detailed description of the PECO and Bechtel organizations engaged in project control and the operation of this process in each of the functional areas of the project is described in Sections III and IV below.

Q. WHAT PROJECT CONTROLS SYSTEMS DID PECO AND BECHTEL IMPLEMENT ON THE PROJECT?

A. The project controls program implemented by PECO and Bechtel consisted of cost control programs and schedule control programs. The original programs were derived from Bechtel systems that had been used on Peach Bottom, as well as other projects.

For project cost control, a cost estimate, collection, and control program was implemented by Bechtel and centered around the Bechtel forecasting program. The Project Forecasts established the plan for the project, i.e. defining the activities required, the sequence of their occurrence (i.e. schedule) and their cost. A Trend program was established to identify significant, required changes in the plan, and a Forecast Control and Updating

System (FOCUS) system was established to collect costs, provide detailed cost reports, and permit monitoring of progress against the plan.

A multilevel scheduling program that addressed all aspects of the project, including engineering, procurement, construction and startup was implemented. The multiple levels provided in the program, i.e. consisting of schedules of different lengths and different amounts of detail, permitted different groups interested in the project, i.e. from PECO senior management down to the craft supervisor level, to obtain information that served that group's needs. The cost and schedule programs used throughout the project are shown on Schedules 11 and 12.

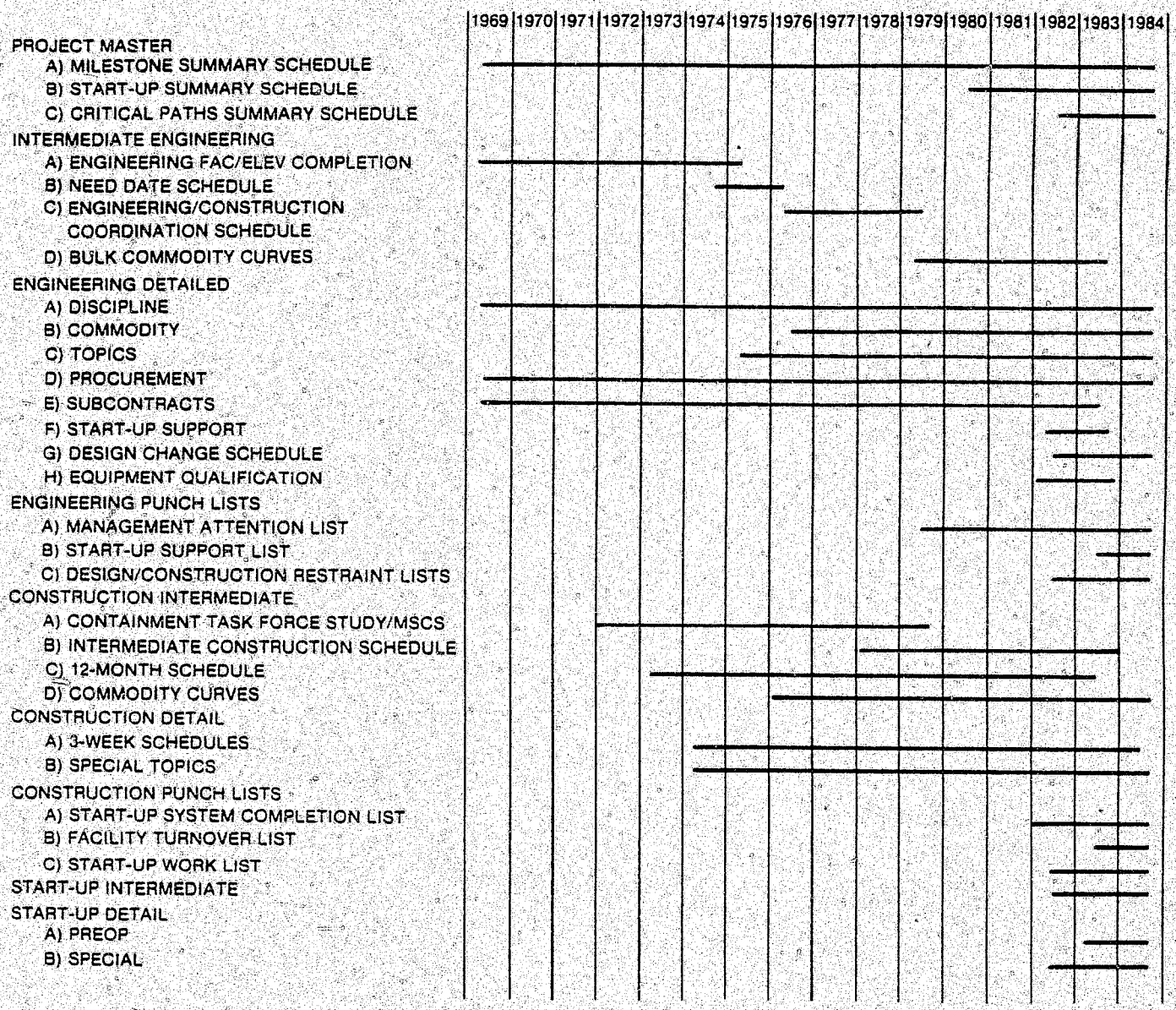
An important aspect of the project control program was the detailed interchange of information in the regular project engineering and construction meetings. Regular project meetings were held to report progress and to resolve concerns between engineering, construction and startup. The meetings used the reports produced by the project controls programs as a source of information. Various meetings were held on a regular basis involving different levels of management personnel. The Monthly Project Status Review or "Kemper" meeting provided management with much of the detailed information required for their oversight of the total project.

Q. PLEASE DESCRIBE THE PLANNING PROCESS IN MORE DETAIL?

A. The Limerick planning process was an iterative process and involved both PECO and Bechtel. PECO management defined the overall project objective, that of completing the unit at reasonable cost to support the need for power. The Limerick Project organizations -- both PECO's and Bechtel's -- defined a plan that consisted of a schedule, the overall cost, and the resultant required and

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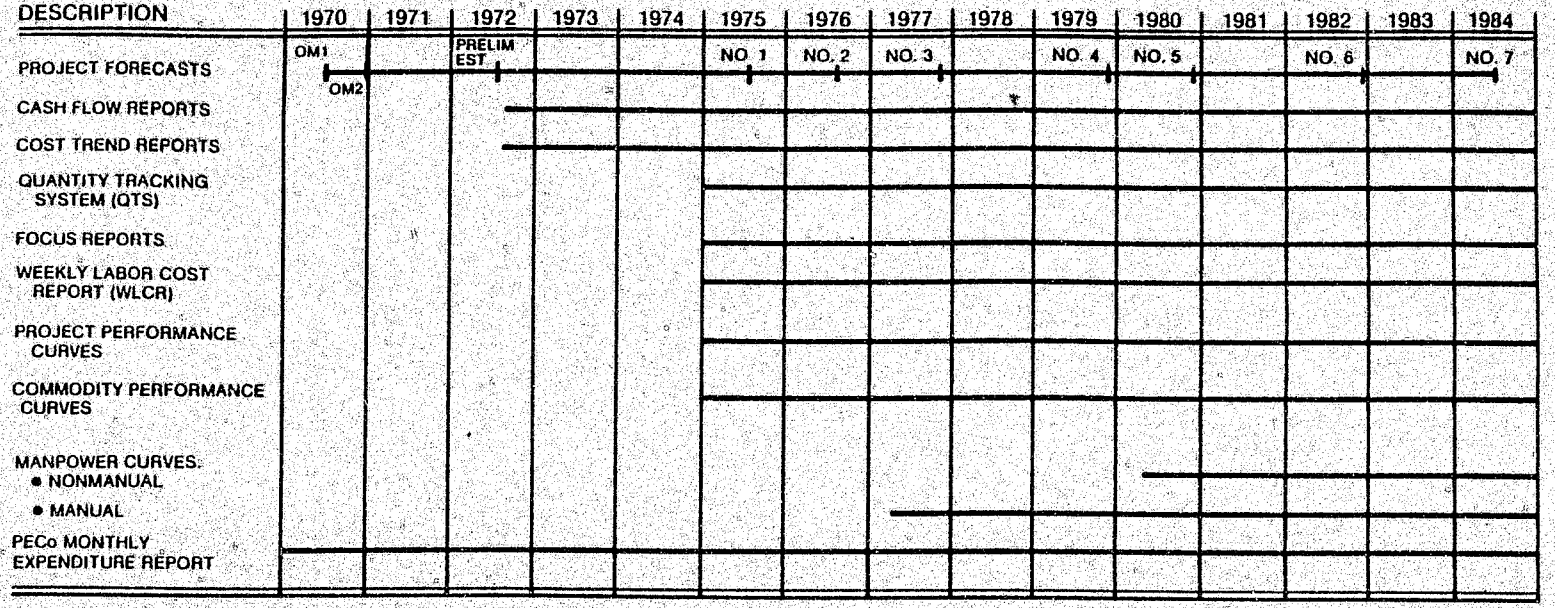
LIMERICK PROJECT SCHEDULES TIMELINE



SOURCE: PHILADELPHIA ELECTRIC COMPANY AND BECHTEL RECORDS

PHILADELPHIA ELECTRIC COMPANY

LIMERICK PROJECT COST REPORT TIMELINE



SOURCE: PHILADELPHIA ELECTRIC COMPANY AND BECHTEL RECORDS

SCHEDULE 12

available cash flows. The development of the overall plan involved reviews and approvals by both Bechtel and PECO with the final approval to the plan given by PECO management. The approved plan was issued as the project Forecast.

The project plan defined in the Forecasts provided engineering, construction and startup with the milestones required to monitor their activities in support of completing the project. The project organizations then developed detailed plans -- for both schedule and costs to support the overall project requirements. The plans varied in level of detail but highlighted the activities that were required to complete the project.

Engineering planning, for example, defined the requirements for design completion, purchase of equipment, special studies and analyses, and the completion of bulk commodity design. Construction plans defined the sequence of construction in the various buildings, identified the required installation rates for various commodities and identified when areas of the plant were required to be ready for startup. Startup schedules detailed the sequence of the preoperational testing and startup program and its associated activities.

Q. PLEASE DESCRIBE IN GREATER DETAIL THE PROJECT COST AND SCHEDULE REPORTING PROGRAM THAT WAS IMPLEMENTED ON THE LIMERICK PROJECT?

A. Project cost and schedule reporting provided management with information required to make project decisions. The reporting program involved formal reports developed through the project control systems, information received in meetings, and management summaries developed by Bechtel and PECO.

Formal reports were prepared by the Bechtel cost and planning departments using the project control programs. The reports identified trends

and defined specific items required to complete the project.

The various project meetings described earlier were also an integral part of the project reporting system. Project status was discussed and problems were identified.

PECO, from the start of the project, also prepared management summaries that addressed project performance. The summaries were developed from reviews of Bechtel reports, participation in project review meetings, and direct observation of project engineering and construction progress. Management summaries were prepared for PECO project management by the PECO engineering and construction departments.

Q. PLEASE SUMMARIZE TB&A'S FINDINGS REGARDING PECO'S PROJECT PLANNING, REPORTING AND MONITORING PERFORMANCE ON THE LIMERICK PROJECT.

A. PECO demonstrated sound project control management practices by establishing, at the outset of the project, cost and schedule goals and programs to approximately monitor and control the project toward the attainment of those goals.

The various project reports and the monthly project status review meetings, chaired by the PECO Vice-President - Engineering and Research Department and involving PECO and Bechtel management personnel, during which progress, problems and resolutions were addressed, served to keep management appropriately informed. The monthly report issued for and used in these meetings was very comprehensive and indicative of the detail provided to management in the reporting process.

TB&A concludes that PECO instituted and employed throughout the

project an appropriate project controls program to properly achieve the functions of project planning, reporting and monitoring. Further details of this program and its functioning throughout the project are provided in Sections III and IV.

4. PROJECT OVERSIGHT

Q. WHAT WERE PECO'S OWNER OVERSIGHT ROLES AND RESPONSIBILITIES ON THE LIMERICK PROJECT?

A. PECO's role consisted of monitoring Bechtel and other major contractors' compliance with contract provisions along with performing as an overseer, monitor and reviewer of project activities. PECO, as owner, was further charged with providing direction on the project with regard to overall cost and schedule goals and, when required, had to recognize the need for and take appropriate actions to overcome project difficulties. In summary, PECO was responsible for providing reasonable assurance that the project could be completed satisfactorily from a cost, schedule, quality and safety standpoint. This role comprises the functions of control and plan modification as described above.

Q. HOW DID TB&A DETERMINE WHETHER PECO PROPERLY FULFILLED ITS OWNER OVERSIGHT ROLE AND RESPONSIBILITIES ON THE PROJECT?

A. TB&A's process for determining whether PECO properly fulfilled its owner oversight roles and responsibilities for Limerick included: 1) a review of information flow to management to ensure that they received timely, detailed and sufficient data to allow for reasonable, informed decision-making; and 2) an analysis to determine whether the information received was utilized in a manner that permitted reasonable control of project activities.

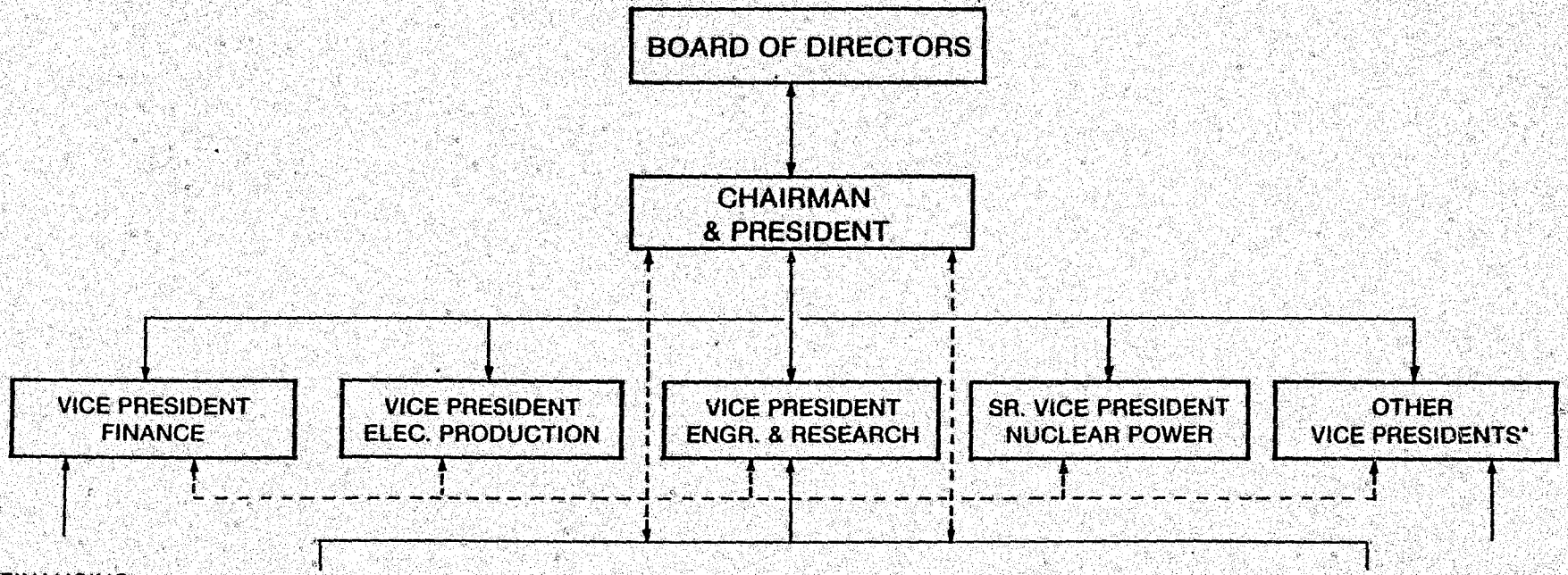
Q. WHAT WERE THE RESULTS OF TB&A'S EXAMINATION OF THE INFORMATION FLOW TO PECO MANAGEMENT ON THE LIMERICK PROJECT?

A. TB&A's examination of the information flow to PECO management indicated that they had adequate access to both detailed information regarding project-specific items as well as summary data on overall project status. Schedule 13 displays this generic information flow to PECO. With regard to specific data sources, Schedule 14 catalogues the major reports, meetings and studies that were regularly submitted to senior management. Additionally, Schedule 15 outlines the major reports received by the Vice-President - Engineering and Research (the defacto Project Manager). Schedules 14 and 15 vividly demonstrate the large quantity and broad range of information that was supplied to PECO management over the course of Limerick's construction. This information ranged from detailed and frequently issued documents, such as the weekly Quality Assurance and Startup Activities reports sent to project management personnel, to the less frequently issued and limited distribution documents, such as the Quarterly Audit reports compiled for the Board of Directors.

Q. DID PECO MANAGEMENT UTILIZE THE INFORMATION THEY RECEIVED TO EFFECT ADEQUATE CONTROL OVER MAJOR PROJECT ACTIVITIES?

A. Yes. TB&A's review has indicated that PECO management was actively involved in monitoring and controlling major activities on the Limerick Project. A detailed discussion of the high level of PECO's day-to-day involvement in the engineering and construction aspects of the project is presented in Sections III and IV of this testimony. TB&A also found PECO

PHILADELPHIA ELECTRIC COMPANY — LIMERICK PROJECT MAJOR INFORMATION CHANNELS



- FINANCING
  - —REQUIREMENTS
  - —SCHEDULING
  - —IMPACT
- CURRENT MARKET ANALYSIS
- FINANCIAL WHAT IFS
  - —MODELING
- BUDGET PREPARATION

VERBAL REPORTS

- PROBLEMS
- PROGRESS
- CONCERNS
- NEED FOR SUPPORT/ ACTION
- DECISION TO INVOLVE EXECUTIVE MANAGEMENT

INTERNAL STUDIES

- LONG TERM FORECASTS
- REVIEW OF LIMERICK ECONOMIES
- GENERATION ALTER-NATIVES
- LIMERICK EFFECT ON REVENUE REQUIREMENTS
- RETIREMENT SCHEDULES

WRITTEN REPORTS

- CONSTRUCTION REPORTS
- PROJECT MANAGERS REPORTS
- RESIDENT PROJECT MANAGER REPORTS
- BECHTEL REPORTS
- AUDIT REPORTS

OTHER REPORTS/ STUDIES

——— FORMAL LINES OF COMMUNICATION

- - - - - - INFORMAL LINES OF COMMUNICATION

*PURCHASING & GENERAL SERVICES; LEGAL; COMMERCIAL OPERATIONS

SOURCE: TB&A ANALYSIS

SCHEDULE 13

PHILADELPHIA ELECTRIC COMPANY

MAJOR MANAGEMENT REPORTS & MEETINGS

REPORT/MEETING	SUBJECT	DISTRIBUTION	ORIGINATOR
Chairman's Staff Meeting	Current Status & Significant Items	Chairman, President & V.P.s	Chairman
Weekly Capital Authorization Approval Meeting	Significant Items	President & V.P.s	
Special Report to Board of Directors	Current Status & Significant Items	Board of Directors	V.P.-Engineering Research
Limerick Related Issues	Water Supply, Emergency Planning	President	Sr. V.P.-Nuclear Power
Internal Auditing Monthly Letter to Chairman	Audit Highlights	Chairman & V.P.s	Manager - Internal Auditing
Audit Report to Board of Directors	Audit Highlights	Board of Directors (Audit Committee)	Manager - Internal Auditing
Informal Meetings Between I.A. Manager & Chairman	Audit Concerns	Chairman	Chairman/ Manager
Project Status Review Meeting	Overall Project Status	President and Project Organization	Bechtel Field
Bechtel Progress Report	Summary of Bechtel Progress	Chairman and Project Organization	Bechtel Project Manager
M.E. Division Meeting Re: Limerick	Engineering Topics	V.P. and Project Organization	PECo Project Manager
E.E. Division Meeting Re: Limerick	Engineering Topics	V.P. and Project Organization	E.E. Division Project Engineer
Engineering Review (San Francisco)	Engineering Topics	V.P. and Project Organization	Chief Mechanical Engineer
Resident Project Manager's Report	Engineering Topics	V.P. and Project Organization	Resident Project Manager

PHILADELPHIA ELECTRIC COMPANY

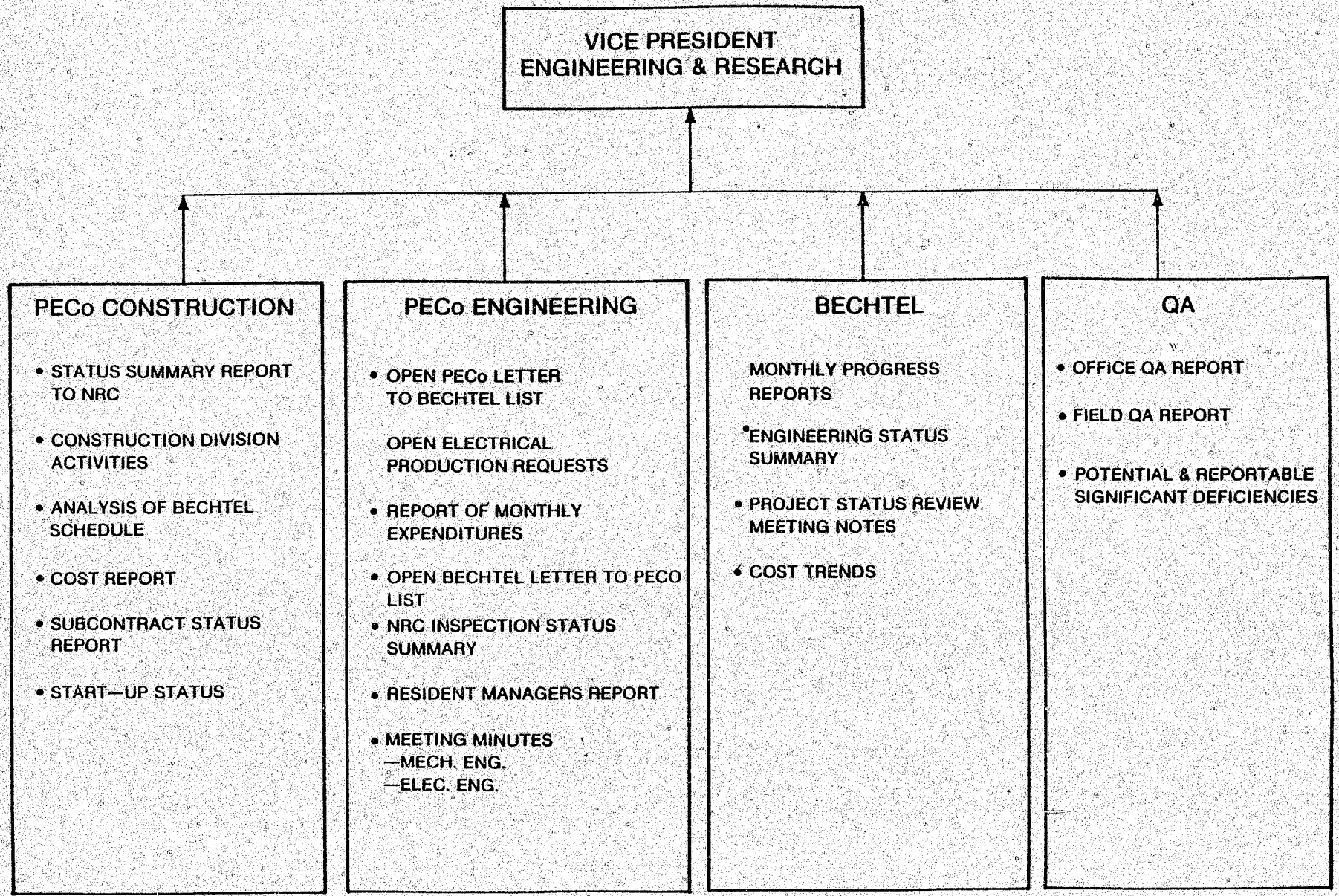
MAJOR MANAGEMENT REPORTS & MEETINGS

REPORT/MEETING	SUBJECT	DISTRIBUTION	ORIGINATOR
Field Engineering Review (Jobsite)	Engineering Topics	V.P. and Project Organization	Chief Mechanical Engineer
Construction Division Activities Report	Construction Topics	V.P. and Project Organization	PECo Construction Manager
Cost Report	Cost Items	V.P., Assistant & General Supt's Construction Division	PECo Construction Manager
Schedule Report	Schedule Items	V.P., Assistant & General Supt's Construction Division	PEco Construction Manager
Startup Activities	Startup Items	V.P. and Project Organization	Start-Up Director
Q.A. Activities	Q.A. Items	V.P. and Project Organization	Field QA Manager
Monthly Q.A. Activities Report	Ongoing Q.A. Activities	V.P. and Project Organization	Office QA Manager
Long Term Forecasts	Electric Energy Use	Board of Directors/and other Company Personnel	Manager Marketing Department
Weather Corrected Output	Weather Corrected Output	President & Chairman/and other Company Personnel	Manager Marketing Department
Sales Comparison Letters	Explain Variance Between Budget & Actual	President & Chairman/and other Company Personnel	Manager Marketing Department
Management Information System Reports	Loads Committed & Connected By Class	V.P.-Commercial Operations	Manager Marketing Department
Budget Forecasts	Company Budget	Board of Directors/and other Company Personnel	Manager Marketing Department
Management Letters	Company Controls	Financial Vice President	Coopers & Lybrand

SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS AND TB&A ANALYSIS

PHILADELPHIA ELECTRIC COMPANY

MAJOR LIMERICK PROJECT REPORTS TO V.P. ENGINEERING & RESEARCH



SOURCE: TB&A ANALYSIS

SCHEDULE 15

senior management to have had a similarly high level of involvement. TB&A's examination of this aspect of project management indicated that major project decisions and actions, especially regarding cost and schedule, have usually been the product of recommendations or studies that have involved most of the key PECO departments.

An example of this form of coordinated management activity was the Strategy Formulation session held in March 1982, at which PECO senior management identified critical issues then facing the Company. Needed actions were identified and assigned to various Vice-Presidents for implementation or monitoring. Some of the Limerick items related to licensing, supplementary water concerns, financing, building local support, quality assurance, competent staffing for operation, and overall cost and schedule goals of the project. Status of the various action items was monitored and reported back to the Strategy Formulation Group, which included all Company Vice-Presidents, as well as the Chairman and President of the Company.

Further examples of PECO oversight and control actions in addressing important project issues included:

- The Monthly Project Status Review Meetings, which were chaired by a PECO Vice President. These meetings served to identify project issues and concerns and also served as a forum for implementing and monitoring action items that were utilized to resolve those concerns.

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

- The physical presence of PECO Vice-President - Engineering and

Research, at the jobsite during the critical preoperational testing period of the startup phase for Limerick.

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

- The PECO Board of Director's meeting with Bechtel and General Electric senior management, in January 1981, for the purpose of demonstrating to Bechtel and GE, the need for their continued upper level management commitment of resources and to review and expedite actions on key problems threatening Limerick's scheduled completion.

The above examples, while certainly not all inclusive, are representative of the mature process and the nature and depth of management involvement and knowledge of Limerick related project activities.

Q. WHAT OTHER METHODS WERE AVAILABLE TO THE BOARD OF DIRECTORS AND SENIOR MANAGEMENT THAT ALLOWED FURTHER OVERSIGHT OF THE PROJECT?

A. A main source of information to the Board and senior management was PECO's Internal Auditing Division.

Q. WHAT WAS THE FUNCTION OF THE INTERNAL AUDITING DIVISION WITH REGARD TO THE LIMERICK PROJECT?

A. The overall function of PECO's Internal Auditing Division is to act as an independent entity dedicated to the objective analysis of Company records and operations. Regarding construction activities, the auditing division is to:

> "... measure and review performance and use of resources...," as well as,
>
> "... [monitor] the costs and activities of the responsible contractor/agent and subcontractor..."

For Limerick, this mandate included audits of the major contractors and

subcontractors to determine compliance with contract financial provisions as well as audits covering compliance with Limerick procedural guidelines and methodologies for all project organizations.

Q. HOW DID THE INTERNAL AUDIT DIVISION MAINTAIN AN ACTIVE ROLE DURING THE PERIOD OF LIMERICK'S CONSTRUCTION?

A. In the early 1970s, PECO's "initial interest in auditing major construction projects came from experiences related by auditors from other utilities and from a strong recommendation by our Construction Division, who specifically requested our presence at the major building sites." PECO, recognizing the importance of this function, retained the accounting firm of Coopers and Lybrand to assist them in setting up their construction auditing program. Following the creation of the program, PECO began auditing the construction activities at the Peach Bottom and Eddystone Projects. Thus, when construction activities began in earnest at Limerick in 1974, PECO had a program in place as well as experienced auditors to monitor the activities there.

Over the course of the Limerick Project, Internal Auditing maintained a constant presence at the Limerick site in the form of four auditors. The Division conducted over 70 audits, and also performed continuous post audit monitoring of compliance with initial audit findings.

Q. HAS INTERNAL AUDITING HAD ADEQUATE ACCESS TO SENIOR MANAGEMENT TO REPORT AND DISCUSS IMPORTANT FINDINGS?

A. Yes. Although the Manager of Internal Auditing reports administratively to the Vice-President - Finance and Accounting, he functionally communicates regularly with the Audit Committee of the Board of Directors, through

quarterly meetings and summary reports of audit activities. Additionally, the Internal Auditing Manager meets personally with the Chairman of the Board at least twice a year and with the President every 2 to 3 months. Moreover, a monthly letter concerning audit highlights is prepared by Internal Auditing and sent to the Chairman and all Vice-Presidents. The Vice-Presidents then have 30 days to respond to any audit findings related to activities under their control. Derelictions by the Vice-Presidents in responding to audit findings within the 30-day period may be submitted to the Chairman for resolution.

Q. WHAT ARE TB&A'S CONCLUSIONS REGARDING PECO'S MANAGEMENT OVERSIGHT ROLE ON THE LIMERICK PROJECT?

A. TB&A has concluded that: 1) the information supplied to PECO management over the life of the project was timely, detailed and sufficient to afford management the opportunity to make reasonable, informed decisions; and 2) PECO management was involved, to an appropriate degree, in the major functions and aspects of the Limerick Project such that there was a reasonable prospect of successful project completion from a cost, schedule and quality perspective. Further details demonstrating this involvement are set forth in Sections III, IV and V of this testimony.

In summary, TB&A finds that PECO appropriately fulfilled their project management oversight duties and responsibilities on the Limerick Project.

III. ENGINEERING AND PROCUREMENT MANAGEMENT

Q. DESCRIBE WHAT TB&A DEFINES AS ENGINEERING AND PROCUREMENT MANAGEMENT.

A. Engineering and procurement management consists of: 1) owner and A/E engineering and procurement organization, staffing and communications; 2)

engineering and procurement schedule and cost control; and 3) engineering and procurement quality management. These particular functional areas are analyzed in this section of testimony. In addition, major engineering activities and events are also evaluated.

Q. PLEASE DESCRIBE IN GREATER DETAIL ENGINEERING AND PROCUREMENT MANAGEMENT AND HOW TB&A EVALUATES THE REASONABLENESS OF SUCH MANAGEMENT.

A. The engineering for a nuclear power plant project provides the technical and analytical basis for the actual plant that is constructed and subsequently put into commercial operation. Management of the engineering and procurement process encompasses the actions of the owner and architect/engineer managers in developing, implementing and monitoring the performance of their organizations, human resources, systems and procedures necessary to expeditiously complete the technical design and the procurement and delivery of engineered equipment required to support the construction of a nuclear power plant project. Effective engineering will ensure that a sound basis has been formulated for the efficient construction, licensing, operation and maintenance of the plant. Effective engineering management will ensure that all available resources are utilized with reasonable efficiency in an effort to complete the project within a reasonable budget and schedule.

Q. WHAT GENERAL TASKS ARE INVOLVED IN FULFILLING THE A/E'S AND OWNER'S MANAGEMENT ROLES?

A. An A/E's management tasks typically include such activities as organizing and staffing the design function of the project, assigning responsibilities and resources for the performance of the technical tasks, planning and scheduling

the technical tasks, and monitoring and controlling the progress of those tasks.

The owner's tasks typically include defining the roles and responsibilities of the A/E, reviewing the organization and staffing of the project, providing specific technical requirements or criteria, reviewing and monitoring actual progress against established schedules, and taking appropriate action to resolve problems.

The actual managerial responsibilities can be divided between the owner and the A/E in various ways. The defined role of the owner can include review, review and approval, or actual task performance responsibilities for individual activities in the engineering and procurement process.

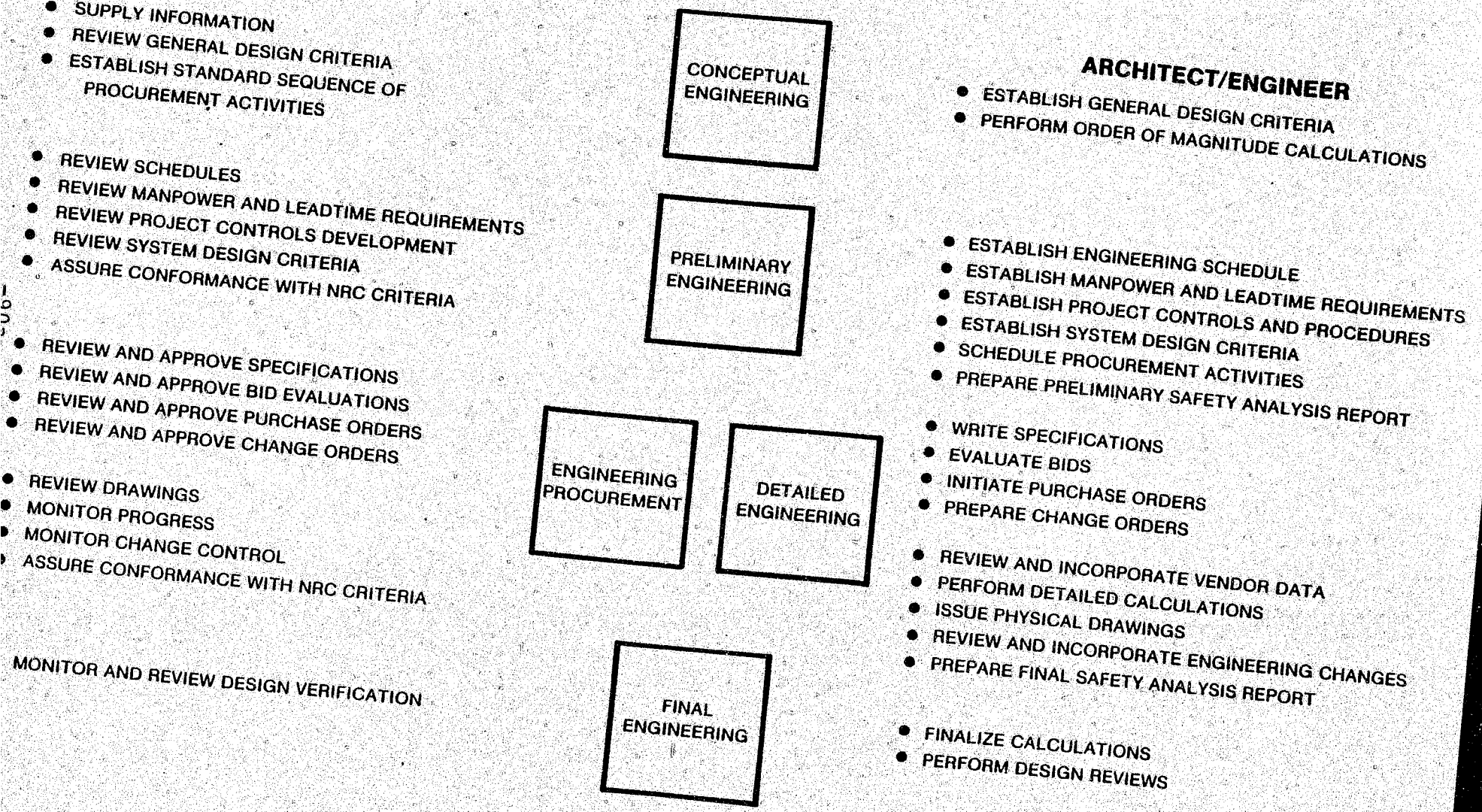
Typical task division-of-responsibility between an owner and its A/E for a major nuclear power plant project is shown in Schedule 16. This exhibit also illustrates the iterative nature of the engineering process as it evolves from conceptual engineering to preliminary engineering, detailed design and procurement through to final engineering.

Q. WOULD YOU PLEASE DESCRIBE FURTHER THE ENGINEERING EVOLUTION THROUGH THESE PHASES?

A. The engineering process begins in the conceptual phase with the establishment of general design criteria. The owner works closely with the A/E, supplying information and ensuring that its needs are met by the conceptual design. The engineering groups at this stage develop the initial engineering drawings and perform some order of magnitude cost calculations.

As the engineering moves into the preliminary phase, the A/E's project organization staffing increases and some detailed engineering begins. The volume of technical tasks likewise increases and more formal controls are

TYPICAL NUCLEAR POWER PLANT PROJECT ENGINEERING OVERSIGHT AND MANAGEMENT ACTIVITIES



SOURCE: TB&A ANALYSIS

implemented through the planning and scheduling of engineering activities.

The owner's oversight responsibilities in this phase typically consist of ensuring that the schedules meet the project requirements, monitoring and reviewing various design criteria, and ensuring that adequate project controls are being developed.

The engineering procurement phase consists of developing the specifications for the equipment required for the project, evaluating the vendors' bids for the equipment, and initiating and issuing the purchase orders. Typically several steps in this sequence will involve the owner so that sufficient quality and budget control is ensured. The owner also monitors the placement of the purchase orders to ensure timeliness and oversees any subsequent administration of changes to the contracts.

Following placement of the purchase orders, information becomes available to develop detailed physical drawings and detailed designs of the various systems. As they are completed, the drawings necessary for construction are then sent to the field. Any changes due to field conditions must also be reviewed by engineering to assure that the original design criteria of the system have not been violated.

As the intensity of the engineering activities increases on the project, the emphasis which must be placed on the planning and scheduling of these activities, and the owner's monitoring of conformance to these plans and schedules, increases significantly. In addition, the design control becomes extremely important as the number of interrelated engineering drawings and documents increases significantly.

The final engineering phase involves the A/E's incorporation of all the

design changes into the engineering drawings/documents for the project. A final design review, including updating of calculations for various structures and systems is performed by the A/E to validate the final design. The owner oversight role in this final engineering phase is primarily concerned with ensuring that the changes have been completed, that all licensing requirements are met, and that the design verification is adequate and complete.

Q. WHAT IMPORTANT POINTS FROM THIS DISCUSSION ARE PERTINENT TO THE REST OF YOUR TESTIMONY?

A. Three major points should be derived from this discussion. The first point is an understanding that the engineering of a nuclear plant is a large, complex undertaking. The magnitude of the engineering process is determined by the number of drawings, calculations, and system designs that must be developed, and by the number of highly trained people needed to complete the project. Secondly, the complexity of the engineering process is a function of its iterative nature. The engineering process is iterative in that one cannot move from the initial design to final design in one step. In addition, the engineering tasks are interrelated -- the results of calculations impact engineering drawings and equipment designs, and vice versa. A significant amount of inter-disciplinary coordination must occur for the design to be consistent. Finally, numerous interfaces, such as input from outside regulatory agencies, must be accommodated.

Q. WHAT CRITERIA CAN BE TYPICALLY APPLIED IN ASSESSING AN OWNER'S PERFORMANCE OF ITS OVERSIGHT ROLE?

A. The assessment of an owner's performance of its oversight role is based on the owner's defined role in the project and the needs of the project as it

progresses. In addition, the owner's role is based on an expected level of performance by the A/E and the other participants in the engineering and procurement process. As the A/E's actual or perceived level of performance varies from the expected, the degree of involvement required of the owner should reflect the needs of the project.

The owner's performance can be assessed based on an analysis of the significant project engineering activities, which include:

- establishing the engineering organization
- implementation of roles and responsibilities
- engineering cost and schedule control
- engineering quality assurance and control
- procurement of equipment, and
- resolution of major technical issues.

The testimony sections which follow assess and evaluate both PECO's and Bechtel's engineering decision-making and management processes against the assessment criteria described above.

A. EVALUATION OF ENGINEERING MANAGEMENT ORGANIZATIONS

Q. WHAT IS THE PURPOSE OF THIS SECTION OF YOUR TESTIMONY?

A. The purpose of this section of testimony is to evaluate whether the Limerick engineering organization and control processes were adequate in structure, quality and numbers of personnel to effectively monitor, control and support the engineering activities associated with the Limerick Project. This section of testimony describes and assesses both PECO's and Bechtel's engineering organization and structure, their staffing levels and evolution, and their roles, responsibilities and interfaces. To provide a perspective in which to make

these evaluations and assessments, the engineering organization structures predominantly in use in the nuclear power industry are also described.

Q. PLEASE DESCRIBE THE PRIMARY ORGANIZATION STRUCTURES UTILIZED FOR THE ENGINEERING OF NUCLEAR POWER PLANT PROJECTS.

A. The two predominant types of organization structures utilized are 1) the functional organization structure; and 2) the project organization structure.

In a functional organization, tasks are accomplished in a departmentalized fashion, wherein specific departments maintain those personnel with the skills required for the completion of tasks associated with its functional responsibilities. Functional departments are organized to respond to the overall needs of the company on a continuous basis. Examples of the types of continuing tasks that an electric utility is involved with include plant operations, accounting and engineering.

In a project organization, personnel are assigned to a project based upon the particular needs of that project. Project-type organization structures are generally utilized in companies that have a number of concurrent projects in which personnel can be moved from one project to another, in response to the changing needs of each project. Prime examples of organizations that utilize the project-type organizational structure are some of the architect/engineers that serve the electric utilities. As the complexities of the nuclear industry have increased along with their associated manpower demands, some utilities have also moved from the functional to project organization structures for oversight of their A/E's activities.

Q. WHAT ARE THE SIGNIFICANT ADVANTAGES AND DISADVANTAGES OF EACH ORGANIZATION STRUCTURE?

A. The functional organization allows a company to efficiently transfer experience gained from one project to another project since the same people are involved. It also enables a company to avoid duplication of staffing skills when a number of projects are on-going simultaneously. The primary disadvantage of a functional structure is the potential difficulty of the personnel working on a project to isolate themselves from the concurrent requirements of other projects or tasks. Those owners, such as PECO, who have multiple nuclear power plants have demonstrated a preference for utilizing the functional structure.

The project organization's principal advantage is that it allows personnel to focus on their particular project needs and schedule without experiencing the conflicts that might otherwise arise from other sources. A disadvantage of the project-type organization is the potential isolation of the project personnel from the knowledge and experiences of other projects and the fact that there may be insufficient or unequally qualified personnel to be assigned to some projects. Project-type organizations typically experience difficulty in transferring information on problems and thus many problems that are experienced on one project within an organization are repeated on other projects.

Q. HOW WAS THE PECO ENGINEERING DEPARTMENT ORGANIZED?

A. The PECO engineering organization is headed by the Vice-President of Engineering and Research. Reporting to the Vice-President are the Mechanical and Electrical Chief Engineers, Manager of Quality Assurance, Construction Superintendent, and other divisions of Engineering and Research (System Planning, Engineering Design and Research & Testing). (See Schedule 8).

PECO utilizes a functional organization within both its Mechanical and Electrical Engineering Divisions. The organization structure for these divisions is depicted in Schedule 17. Within the Mechanical Engineering Division the functional areas are the Nuclear and Environmental, Power Plant Services, Power Plant Design, Industrial and Civil Sections. The PECO Project Manager for Limerick, who is responsible for the coordination of all PECO project activities, and the Resident Project Manager who reports administratively to the Chief Mechanical Engineer. The Electrical Engineering Division consists of the Station Engineering, Field Engineering, Transmission and Distribution Engineering, Computers and Controls sections.

Although these sections within both the Mechanical and Electrical Engineering Divisions have evolved somewhat during the Limerick Project, the overall structure has remained the same. PECO used this same engineering organization on the Peach Bottom Project, continued its use on Limerick, and was thus able to efficiently transfer experience from Peach Bottom to the Limerick Project.

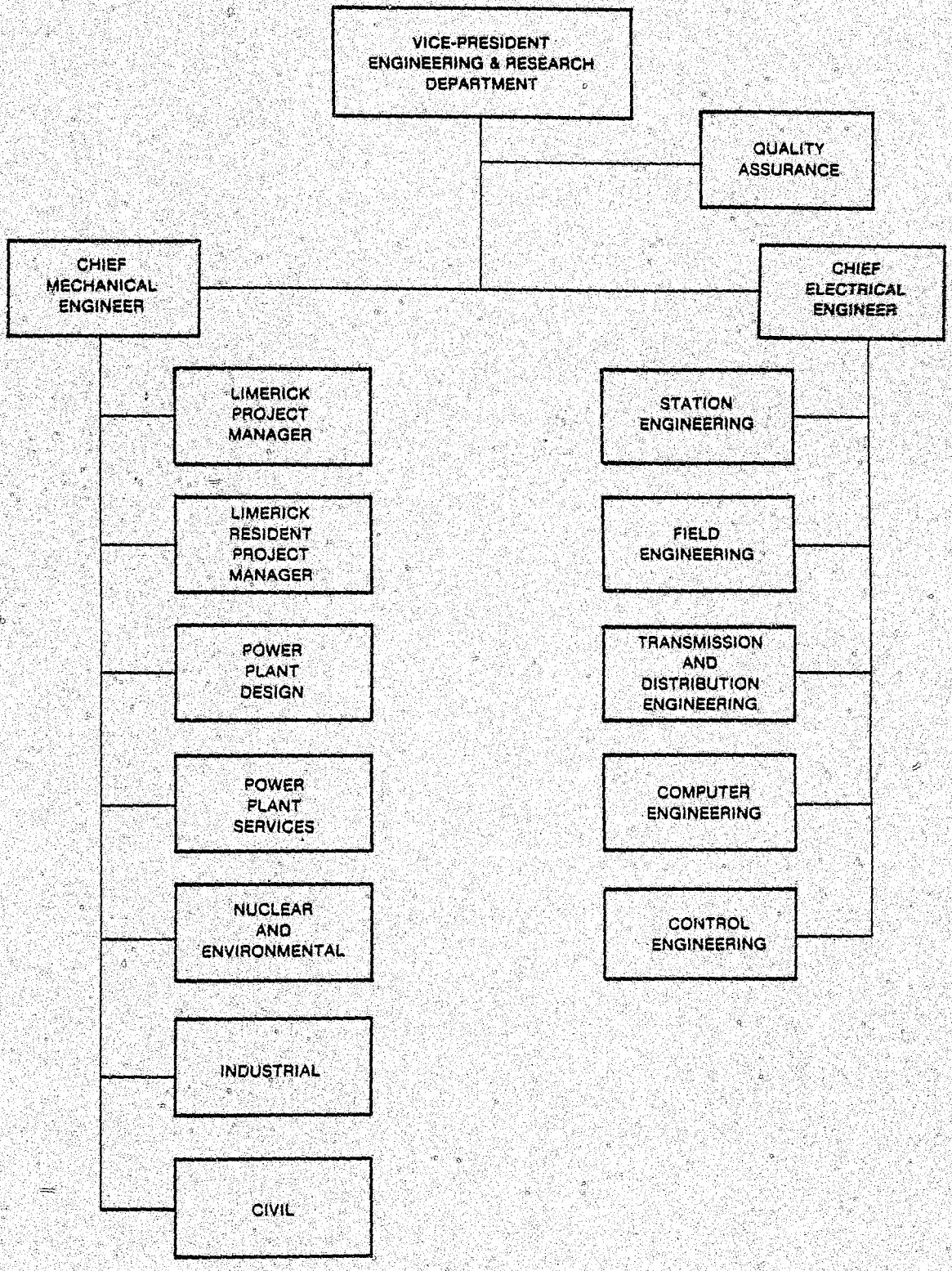
Q. WHAT IS TB&A'S ASSESSMENT OF PECO'S CHOICE TO USE A FUNCTIONAL ORGANIZATION?

A. The use of a functional organization structure for engineering provided PECO with the ability to maximize the transference of Peach Bottom experience both early and throughout the project, and to maintain the functional skills required by the Company for projects other than Limerick. The fact that PECO used the same A/E, constructor and NSSS vendor on both Peach Bottom and Limerick maximized the potential for applying "lessons learned" between these projects and the benefits to be obtained from a functional organization. Based

PHILADELPHIA ELECTRIC COMPANY

PHILADELPHIA ELECTRIC COMPANY ENGINEERING ORGANIZATION

1984



SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

on these specific circumstances, TB&A found PECO's use of a functional organization to be reasonable and appropriate.

Q. DID PECO HAVE SIGNIFICANT EXPERIENCE IN THE ENGINEERING ASPECTS OF NUCLEAR PLANTS AT THE START OF THE LIMERICK PROJECT?

A. Yes. PECO engineering personnel had significant experience in the design, construction and operation of nuclear power plants at the start of the Limerick Project. Moreover, the continuity of certain key PECO engineering personnel (i.e. the Chief Mechanical Engineer and the Project Manager who held their positions for virtually the full duration of the project) was beneficial for the project. PECO management and engineering personnel experience included Peach Bottom Units 2 and 3, and two test reactor plants (Peach Bottom 1 and Fermi 1). PECO was thus able to bring to the Limerick Project an experienced management and engineering staff with knowledge and expertise gained from these previous efforts. TB&A found that PECO aggressively strove to incorporate the Peach Bottom "lessons learned" into the Limerick design, and to improve upon Limerick's design where possible.

Q. WHAT WERE PECO'S RESPONSIBILITIES FOR THE LIMERICK PROJECT IN TERMS OF ENGINEERING MANAGEMENT OVERSIGHT?

A. PECO was responsible for monitoring the management and technical activities of its architect/engineer, Bechtel, to ensure that reasonable engineering management and technical performance was achieved. To achieve this, PECO clearly defined Bechtel's roles and responsibilities in the project procedures manual first issued in 1971. This procedures manual covered all administrative aspects of the project, including review and design change procedures,

correspondence, owner involvement, and the project organization structure. In addition, PECO maintained responsibility for regulatory compliance, including review and submittal of the PSAR and FSAR. PECO engineering personnel were also involved in the Quality Assurance aspects of Bechtel's work on Limerick, performing audits to verify that the quality requirements were being appropriately addressed. PECO also maintained control over Bechtel's key hiring and staffing decisions through review of Bechtel's staffing activities.

Q. HOW DID PECO'S RESPONSIBILITIES EVOLVE OVER TIME?

A. The level of PECO's direct involvement in the engineering of Limerick increased over the course of the project. PECO assumed direct control of engineering in a number of areas, such as fire protection, equipment qualification and TMI-related changes. Throughout the course of the project, PECO maintained approval over changes in the engineering design, specifications, contractor selection and design documents.

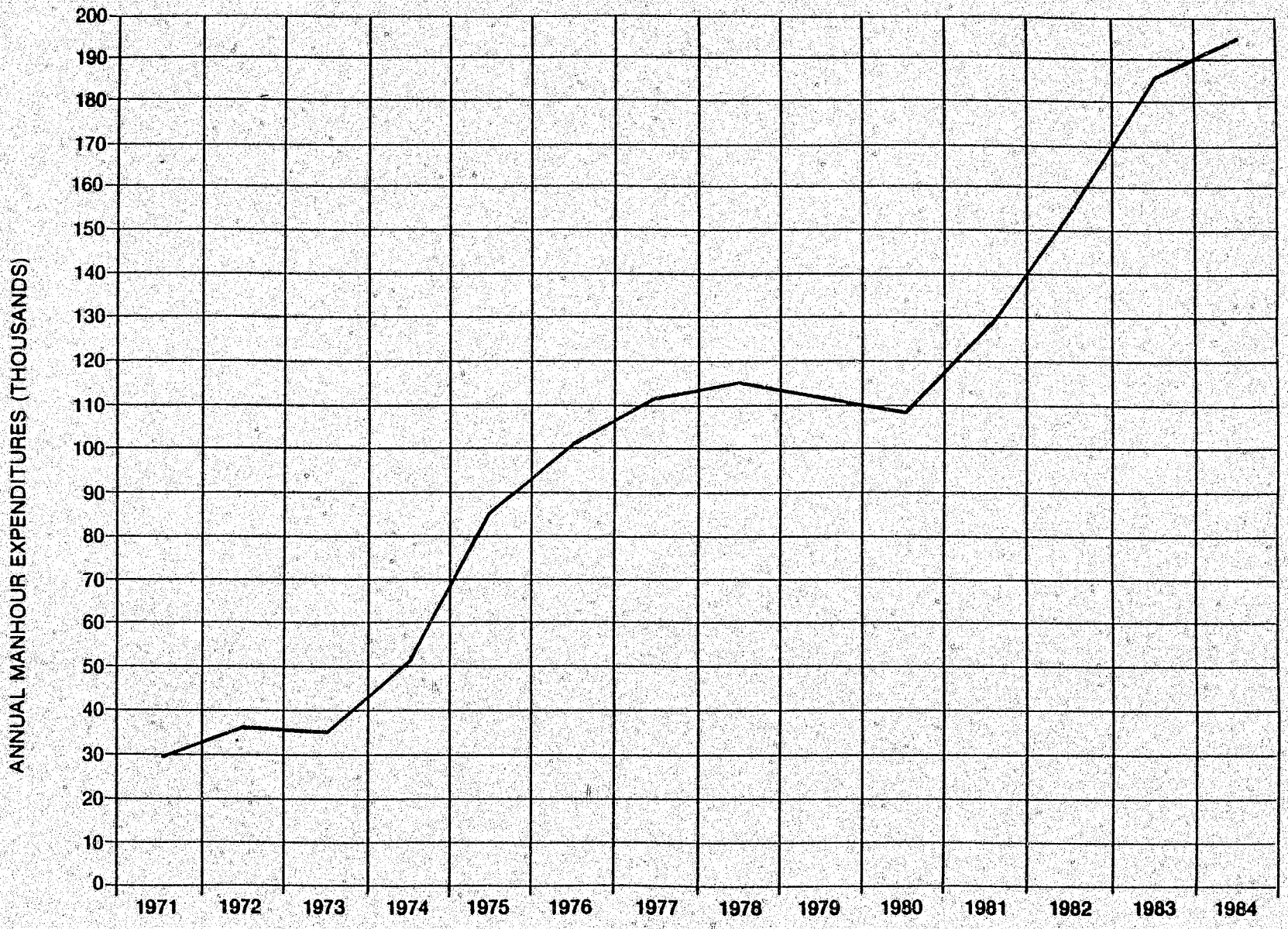
This increase in the level of PECO's direct involvement was appropriate since PECO's management deemed concerns in the above cited areas as potential problems that could jeopardize the schedule of Limerick.

Q. PLEASE DESCRIBE THE GROWTH IN PECO STAFFING DURING THE COURSE OF THE LIMERICK PROJECT.

A. PECO engineering accounted for approximately 10% of total engineering manhours expended on the Limerick Project. Both the Mechanical and Electrical Engineering Divisions of PECO performed detailed design reviews, engineering audits and engineering oversight of Bechtel engineering.

Schedule 18 shows PECO engineering manhour expenditures for the 1971 through 1984 period of the Limerick Project. These expenditures are generally

PHILADELPHIA ELECTRIC COMPANY ENGINEERING MANHOURS — LIMERICK 1 & 2



SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

indicative of a high level of owner involvement.

Q. PLEASE DESCRIBE THE BECHTEL ENGINEERING ORGANIZATION STRUCTURE.

A. Bechtel uses a project organization with each project operating as a somewhat separate entity within the overall company. Personnel are specifically assigned to each project for a specific function on that project.

Q. HOW WAS THE LIMERICK PROJECT STRUCTURED WITHIN THE BECHTEL ORGANIZATION?

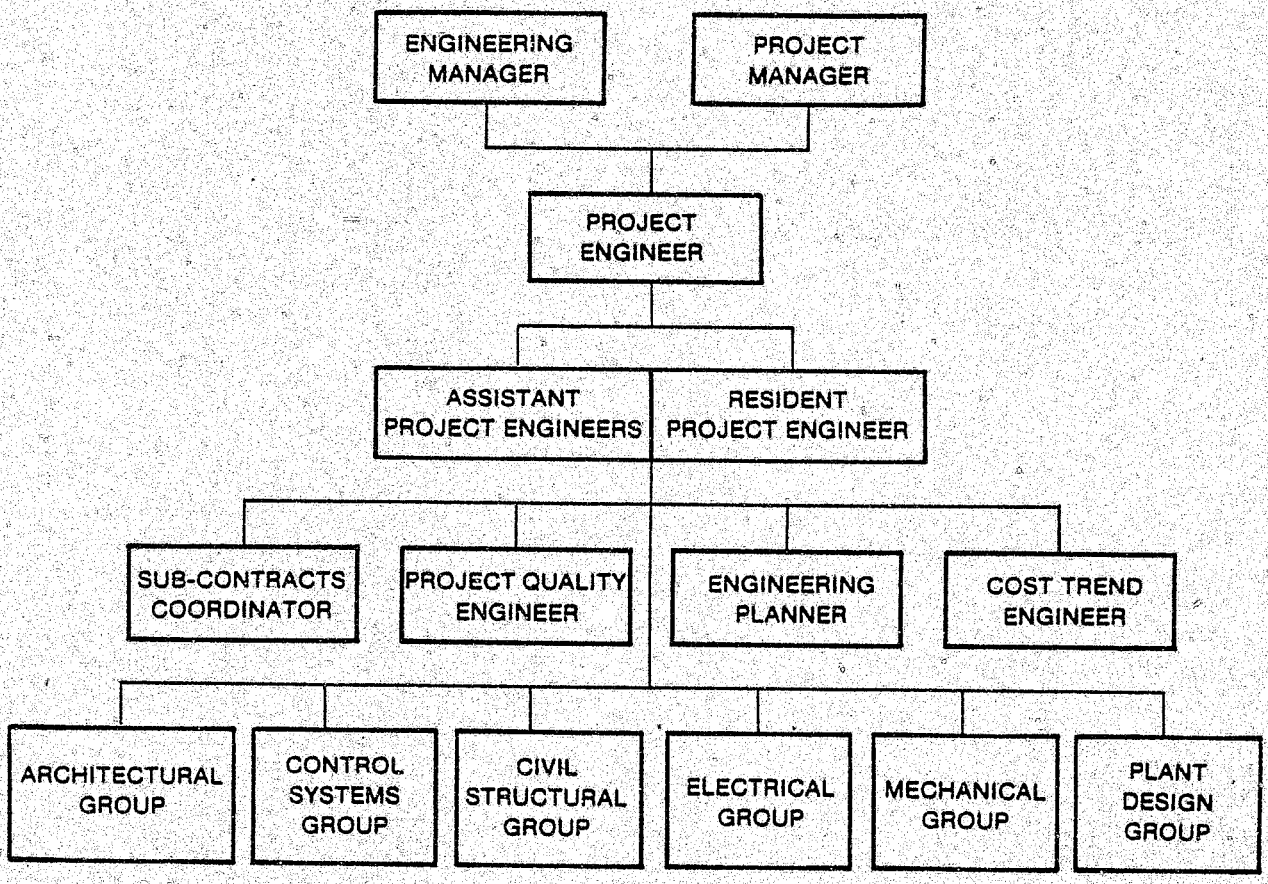
A. The organizational structure for the Limerick Project is shown in Schedule 19. The project was headed by the Project Manager whose responsibility was to manage the project and to provide the interface with Bechtel's corporate management. Reporting to the Project Manager was the Project Engineer who was responsible for managing and coordinating, through the Assistant Project Engineers and Resident Project Engineer, the engineering effort of the various engineering disciplines (civil/structural, electrical, mechanical, plant design, controls and architectural). Each discipline was headed by a supervisor who was responsible for the engineering performed by all the personnel in his group. Each of these groups also had a team of engineers at the jobsite, termed resident engineers, who interfaced with the construction forces at the site and the home office engineering personnel.

Q. PLEASE DESCRIBE THE GROWTH IN BECHTEL ENGINEERING MANHOUR ESTIMATES FOR LIMERICK.

A. The growth of the estimated Bechtel engineering and other home-office manhours (excluding contingency) from the 1970 Order-of-Magnitude estimate of 776,000 manhours to the Forecast 7 estimate of just over 11 million

PHILADELPHIA ELECTRIC COMPANY

BECHTEL POWER ENGINEERING ORGANIZATION
LIMERICK PROJECT
1984



SOURCE: BECHTEL RECORDS

engineering manhours for Unit 1 and Common, is shown in Schedule 20. This Schedule clearly shows the rise in the forecasted Bechtel engineering manhours, and is reflective of the increased engineering required to design a safe, reliable and licensable nuclear plant in the Limerick timeframe, as opposed to that of the Peach Bottom vintage.

Q. HOW DOES THE GROWTH IN MANHOUR ESTIMATES FOR LIMERICK COMPARE TO THE REST OF THE NUCLEAR INDUSTRY?

A. The ability to accurately predict the total engineering manhours required for a nuclear power plant project decreased significantly as the nuclear industry evolved during the 1970s. This is demonstrated in Schedule 21, which shows that the average engineering manpower requirements for a single unit nuclear project increased from 1.7 million manhours in the early 1970s to 2.1 million manhours in the mid-1970s, and then exploded to 5.6 and 6.8 million manhours in the 1977-1981 period and to 10.9 million manhours in 1982-1983. Although comparisons are made difficult due to differences in scope and accounting practices among architect/engineers and projects, Bechtel's estimates for their engineering manhours for Unit 1 and Common including all home office manhours, as shown in Schedule 20, are comparable to these industry averages. For example, the December 1982 Forecast 6 total of 10.994 million manhours is just slightly greater than the 10.9 million manhours average presented for the corresponding 1982/1983 period. The November 1977 Forecast 3 total of 5.66 million manhours is just above the 1977-1979 average of 5.6 million manhours. Moreover, the final Forecast 7 estimate of approximately eleven million manhours, for both Bechtel engineering and home office manhours as of mid-1984 is essentially equal to the industry average of

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BECHTEL ENGINEERING & OTHER HOME OFFICE MANHOUR ESTIMATES

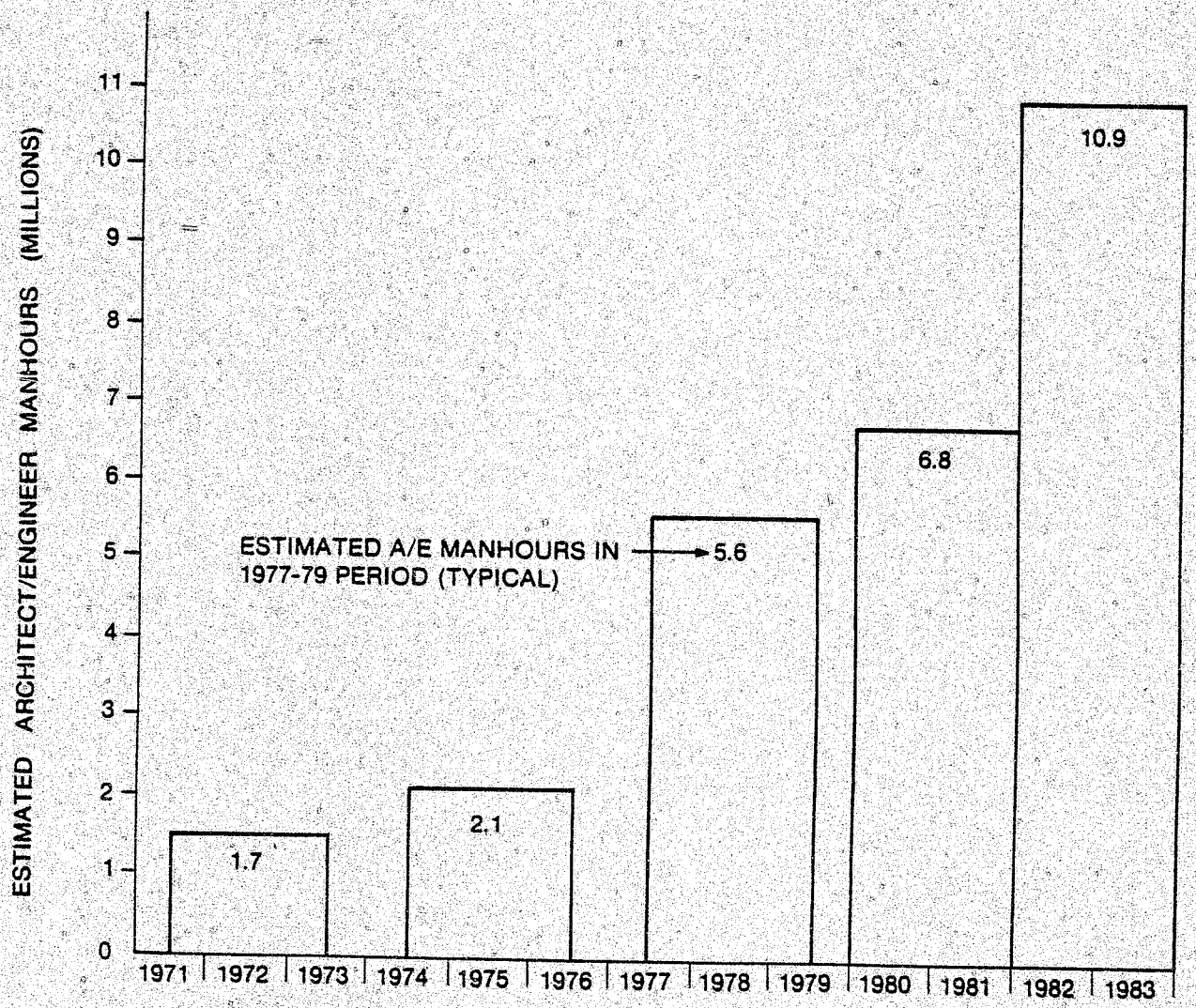
LIMERICK UNIT 1 & COMMON

	MANHOURS (1000'S)	
ESTIMATE/FORECAST	ENGINEERING	OTHER HOME OFFICE
12/70 Order-of Magnitude	548	228
7/72 Preliminary Estimate	1,125	754
8/75 Forecast 1	2,444	1,308
8/76 Forecast 2	3,287	1,901
12/77 Forecast 3	3,524	2,136
12/79 Forecast 4	4,034	2,423
8/80 Forecast 5	5,176	2,787
12/82 Forecast 6	7,221	3,773
6/84 Forecast 7	7,393	3,664

SOURCE: BECHTEL RECORDS; TB&A ANALYSIS

PHILADELPHIA ELECTRIC COMPANY

INDUSTRY AVERAGE ARCHITECT/ENGINEER ESTIMATED MANHOURS FOR SINGLE UNIT NUCLEAR PLANTS



SOURCE: "THE DATA BASE FOR U.S. POWER PLANTS", R. N. BUDWANI, POWER ENGINEERING, JANUARY 1985

10.9 million manhours for the earlier 1982-1983 period.

Q. WHAT IS TB&A'S ASSESSMENT OF THE NATURE OF THE ENGINEERING MANHOUR EXPENDITURES ON LIMERICK?

A. TB&A's reviews and analyses have determined that even though Limerick's engineering manhour expenditures were on a par with the industry, the nature of those expenditures appears to have been different. The initial engineering performed on Limerick, which largely duplicated Peach Bottom, together with the on-going benefits to Limerick of Peach Bottom's operating experience, provided for some efficiencies in Limerick manhour expenditures.

PECO's concerns for the quality of the engineering and technical decision-making caused additional manhours to be expended in the form of studies, analyses and detailed investigations. The fact that these additional engineering manhours were expended, to provide a high degree of confidence that technical decisions on the project met with PECO requirements, is commendable.

Q. PLEASE DESCRIBE THE ROLE OF PECO's RESIDENT PROJECT MANAGER IN BECHTEL'S SAN FRANCISCO OFFICE.

A. PECO established the Resident Project Manager (RPM) position in October, 1975, and was among the first owners to initiate such a position in an A/E's home office.

In actuality, this position grew out of PECO's earlier presence in Bechtel's San Francisco offices since 1973. PECO's use of personnel, who focused their attention on Bechtel's engineering planning and scheduling efforts in these early years, as well as on aspects of engineering's support of the ensuing construction activities, led to the realization of the potential benefits

of having a full-time, formal representative in Bechtel's engineering office.

The RPM was responsible for establishing and maintaining the PECO "presence" in Bechtel's home office and was the focal point of PECO's oversight of Bechtel's engineering and procurement activities. He attended meetings, reviewed Bechtel's planning, scheduling and control efforts, monitored Bechtel problem resolution efforts, coordinated PECO's Philadelphia engineering document review efforts with Bechtel's needs, and in general acted as PECO's "eyes and ears" in San Francisco. He was an integral part of PECO's management, direction, liason, and coordination of Bechtel, General Electric, and PECO groups performing engineering and quality related work associated with the design, procurement and construction of Limerick.

In 1976, PECO augmented the RPM position by assigning two Resident Project Engineers to work with the RPM. These two Resident Engineers, one with a mechanical engineering/construction background, and one with an electrical engineering background, served to closely monitor Bechtel's engineering activities in their respective areas of expertise.

Q. WHY WERE THESE RESIDENT PROJECT MANAGER AND RESIDENT PROJECT ENGINEER FUNCTIONS SO IMPORTANT?

A. The Resident Project Manager and Resident Project Engineers provided PECO with a means to closely monitor Bechtel's engineering and engineering management activities on a daily basis. They acted as vehicles for providing a perspective that was typically not available through the normal owner's oversight activities. Their involvement in Bechtel engineering related meetings, in which engineering status, staffing, scheduling, problems and resolutions were discussed, provided PECO with first-hand knowledge of all

significant project activities. The difference in the depth of knowledge gained and the understanding obtained between this method of involvement and the more conventional meetings, telephone calls and correspondence interactions is substantial. Although not essential, the fact that PECO utilized all of these interaction channels with Bechtel served to provide them with more information regarding engineering activities on the Limerick Project than was normally available to an owner.

Q. WHAT WERE THE ROLES OF THE PROJECT MONTHLY MEETINGS WITH RESPECT TO THE CONTROL OF ENGINEERING ACTIVITIES?

A. The meetings provided a forum for discussions concerning the overall status of the project, identification of problem areas, staffing requirements, progress on the resolution of previously identified areas of concern, schedule, and the overall progress of the engineering on the project. The monthly meetings were one of several tools used by PECO management to closely monitor the progress of Bechtel engineering for the Limerick Project.

Q. WHAT OTHER REGULARLY SCHEDULED MEETINGS WERE HELD REGARDING ENGINEERING RELATED ACTIVITIES INVOLVING PECO PERSONNEL?

A. The PECO Mechanical Engineering Division held monthly meetings (bi-weekly until early 1982) involving the Limerick Project Manager and Section Heads. These meetings, which generally consisted of two distinct parts -- the Project Managers report and the Section Heads report -- addressed all relevant Limerick engineering-related activities such as schedule status, workforce reports, Peach Bottom modifications that could affect Limerick, licensing items, and significant and/or problem items. In addition, the PECO Project

Manager, beginning in 1982, held a weekly conference involving Bechtel home office engineering and site personnel, the PECO site construction manager, PECO startup management and GE home office and field forces. These telephone conferences were directed at addressing problems that required immediate attention and resolution.

Beginning in late 1981, PECO and Bechtel management met quarterly in San Francisco for a "quarterly engineering review meeting". These meetings typically involved the PECO Chief Mechanical and Electrical Engineers, the Resident Project Manager and Resident Project Engineers, the Bechtel Project Manager, Project Engineer, Assistant Project Engineers, Group Supervisors and other PECO and Bechtel engineers. These meetings addressed the status and schedule of engineering activities, significant activities or problems in each engineering group, and action items from the previous meeting.

Q. WHAT REGULAR REPORTS DID PECO UTILIZE TO MONITOR AND ASSESS OVERALL ENGINEERING PERFORMANCE AND ACTIVITIES?

A. The Monthly Project Status Review Report that was prepared for the monthly project meeting contained a comprehensive engineering section. This report typically detailed engineering staffing, both actual and planned, overall and specific engineering status summaries, engineering problems and proposed resolutions, and results of special studies and analyses. The content of the report changed appropriately as the project and engineering activities evolved.

The Bechtel progress report, which was issued monthly to Bechtel and PECO management, also contained a summary of engineering status and major engineering accomplishments for each month.

In addition to these regular reports, tens of thousands of letters were

transmitted between PECO and Bechtel regarding engineering matters, and numerous studies and reports were generated in response to specific concerns and problems. The RPM also prepared monthly reports informing PECO management of the status of Bechtel's engineering activities in San Francisco.

Q. WHAT IS YOUR OVERALL ASSESSMENT OF THE LIMERICK PROJECT ORGANIZATIONS AND RESOURCES ENGAGED IN ENGINEERING MANAGEMENT?

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

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

Bechtel's project-type organization, utilized on all of its contemporaneous nuclear projects, was found to be reasonable. No compelling reason could be found for Bechtel to have deviated from its standard organization structure. The project structure that was utilized is generally most responsive to schedule needs, which is one of the predominant concerns of A/E organizations on nuclear projects.

PECO's combined oversight efforts, including its monitoring of Bechtel

staffing through both their presence in San Francisco and at the monthly meetings, resulted in Bechtel engineering manpower expenditures that were comparable to the industry average. The overall PECO and Bechtel organization structures and the established organizational interfaces allowed for effective communication and interaction channels so that project events, problems and concerns could be appropriately addressed.

B. EVALUATION OF ENGINEERING COST AND SCHEDULE CONTROL

Q. WHAT IS THE PURPOSE AND SCOPE OF THIS SECTION OF YOUR TESTIMONY?

A. The purpose of this section is to: 1) define criteria by which engineering cost and schedule control on a major nuclear power plant project such as Limerick is evaluated; 2) discuss the tools and mechanisms actually utilized by PECO and Bechtel management to control engineering cost and schedule; and 3) assess and evaluate the reasonableness of the management actions of both PECO and Bechtel in their control of engineering cost and schedule.

Q. PLEASE DESCRIBE WHAT IS MEANT BY COST CONTROL AS IT RELATES TO THE MANAGEMENT OF ENGINEERING ACTIVITIES.

A. Cost control, as it relates to the management of engineering activities, encompasses management's actions to control the overall scope (i.e. changes and additions) of engineering tasks and activities and the overall cost of the A/E's engineering services in terms of engineering manhours. The initial scope and cost of engineering services is established by the contractual document with the A/E. However, as the project scope increases, generally due to the external influences on the project, the design changes, additions and

engineering manhour expenditures increase accordingly. Thus, both owner and A/E management tools are necessary to adequately limit and control the associated costs.

The important elements of an effective engineering cost control program include:

- Forecasting total manhour requirements;
- Monitoring both expended and earned manhours against the forecast;
- Identifying and controlling scope increases that increase the forecast expenditures; and
- Taking corrective action as required.

Q. PLEASE DISCUSS THE PROJECT ENGINEERING COST CONTROL PROGRAMS AT LIMERICK.

A. The engineering cost control programs used at Limerick consisted of the forecasting program with its trend updates, a separate program to identify individual engineering scope changes, and a mechanism for reporting both expended and earned engineering manhours.

Q. PLEASE DESCRIBE THE ELEMENTS OF THE BECHTEL FORECASTING PROGRAM THAT ARE IMPORTANT IN THE CONTROL OF ENGINEERING COSTS.

A. The area of greatest importance is that associated with the review of the total engineering scope of work and the estimating of the to-go engineering manhours. In this effort, the Bechtel engineering group supervisors and group leaders each carefully reviewed and quantified their to-go workload, estimating the required engineering manhours for each task or activity, as best as they could be defined. For each new task a Notice-of-Change-in-Design (NCD) form

was completed by Bechtel, identifying the nature of the change, what caused it, the estimated engineering manhours, and its schedule requirements. Each NCD was then subject to review and approval by both Bechtel and PECO management before incorporation into the forecast. The cumulative total of the engineering manhours on all additional NCD's, in conjunction with the existing approved engineering manhour budget, provided the basis for both PECO and Bechtel management's most current projected manhour forecast. The NCD process was a continuous ongoing process, with new NCD's being generated as new scope was identified.

Q. HOW THEN ARE ACTUAL AND EARNED MANHOUR EXPENDITURES MONITORED BY BECHTEL AND PECO MANAGEMENT PERSONNEL?

A. A management tool, termed the Engineering Progress and Performance Report (EPPR) was utilized throughout the project.

In the EPPR, the forecasted or budgeted engineering manhours are subdivided into various activity or functional categories for each engineering group. Manhours, as they were expended, were then charged against these subaccounts, thus providing a mechanism for monitoring actual expenditures against the budgets. Each separate document or group of documents were allocated manhours for their preparation and completion. A pre-designated manhour credit for each milestone for each document was established (i.e. for initial draft, initial issue) which determines the manhour standard for each activity. Unit rate budgets were also established for commodity designs (large pipe, hangers, conduit, etc.) which were monitored based on designs achieved. For level of effort type activities such as supervision, studies, and construction support, manhours were also budgeted and monitored. Thus, by measuring

actual manhours expended by subaccount against the manhour credits determined from the document status updates, an earned manhour factor or performance factor was determined.

The use of these monthly EPPR updates for each engineering group allowed both Bechtel and PECO to assess the rate of increase in expended and earned engineering manhours and to take any necessary action to correct adverse trends. This was a state-of-the-art approach to engineering manhour expenditure control.

Q. WHAT PROCESS WAS USED TO CONTROL THE QUANTITY AND SCOPE OF DESIGN CHANGES ON THE LIMERICK PROJECT?

A. Bechtel and PECO monitored proposed changes through a future work list, the weekly engineering coordination meetings, the Monthly Project Status Review Meetings and the quarterly engineering coordination meetings. Activities that received approval through this process resulted in NCD's being generated for Bechtel and PECO management approval.

Q. PLEASE DESCRIBE THE NCD PROCESS.

The NCD, which is generated by Bechtel, documents changes to the existing engineering scope requiring engineering manhours over and above those budgeted. It was a vehicle for Bechtel to justify additional engineering manhours, and thus the NCD had a direct bearing on cumulative engineering manhours (i.e. added scope) and engineering staffing. The NCD was used by Bechtel as an input into their forecasting and trending program. Thus, the project forecasts, trend reports, monthly meetings and monthly engineering reports served to keep PECO apprised of changes in the engineering scope and required engineering manhours. In November 1976, a program was established

which required that increases in estimated engineering manhours of 100 manhours or more required the approval of the PECO Chief Mechanical Engineer or Chief Electrical Engineer prior to Bechtel proceeding with the work. Prior to this, the project Forecasts as well as the monthly PECO-Bechtel engineering meetings served to keep management apprised of significant engineering scope changes.

Q. WERE ANY OTHER SIGNIFICANT CHANGE CONTROL PROCEDURES IMPLEMENTED IN THE LATTER STAGES OF THE PROJECT?

A. Yes. In 1981, PECO instituted a change control program which required that changes be limited to only those required to make the plant operational, for safety concerns or in order to obtain an operating license. Such programs have also been implemented on many other projects to limit changes to only those absolutely necessary.

The Project Change Request (PCR) is another procedure that was implemented by Bechtel in early 1982 in an effort to further minimize design changes. The PCR change procedure applied to proposed design changes which had a physical impact on the plant, or which could affect the schedule or budget of the project by diverting resources away from to-go work required to complete the project. The PCR served to package all the necessary drawing and document revisions associated with a change and subjected these packages to a formal review for need and schedule impact. Its intent was to freeze the design, and to minimize and control design changes for successful systems completion in order to support the project schedule. An NCD was also prepared and was subject to PECO's review and approval.

Both of the above described Bechtel change control mechanisms, the NCD's and PCR's, were in conformance with Bechtel's generic procedures utilized on many other concurrent nuclear projects and constituted state-of-the-art practice for the industry

Q. WHAT IS YOUR ASSESSMENT OF THE TOOLS AND MECHANISMS THAT PECO AND BECHTEL MANAGEMENT USED TO CONTROL ENGINEERING COSTS?

A. TB&A concludes that PECO and Bechtel used the appropriate tools and implemented the systems and procedures necessary to control engineering manhour expenditures and costs. The forecasting, EPPR, regular PECO and Bechtel engineering meetings, and the NCD mechanism were sound control techniques and served to keep both PECO and Bechtel management informed of changes to the engineering scope,their effect on overall required engineering manhours, and the rate of increase in earned and expended engineering manhours. The engineering manhour projections increased significantly as the project progressed; however, this was generic in the industry, was beyond PECO's or Bechtel's control, and is not a reflection upon management performance.

Q. PLEASE DESCRIBE THE PURPOSE OF ENGINEERING PLANNING AND SCHEDULING.

A. Effective engineering planning and scheduling ensures that the necessary engineering activities are scheduled in response to the needs of the overall project, and that progress is measured and reported against them in a manner such that management (both owner and architect/engineer) will be able to take the appropriate actions to resolve any schedule-related problems. Effective

planning and scheduling of engineering activities increases the probability that the rate and sequence of completion of engineering activities can support the needs of the construction activities at the jobsite.

Q. WHAT IS YOUR OBJECTIVE IN EVALUATING ENGINEERING PLANNING AND SCHEDULING?

A. The purpose of this section of testimony is to determine 1) whether PECO took the appropriate owner actions to ensure that Limerick engineering activities were properly sequenced/scheduled so that forecast completion dates could be reliably utilized to schedule construction activities; 2) whether Bechtel implemented the necessary planning, scheduling, and monitoring tools; and 3) whether PECO actively monitored Bechtel progress in accordance with an established schedule and caused, as appropriate, corrective actions to be implemented to complete tasks on or ahead of schedule.

Q. PLEASE DISCUSS EARLY PROJECT PLANNING AND SCHEDULING EFFORTS.

A. Much of the early engineering on the Limerick project was based on Peach Bottom specifications and design drawings and thus was able to progress at a rapid rate without an extensive amount of engineering planning and scheduling. Extensive engineering planning and scheduling, as is typical today, was not generally done in the industry in the late 1960s and early 1970s. As the project progressed during the 1970-1971 time period and the complexity of the overall industry engineering requirements evolved, PECO and Bechtel instituted an increased level of engineering planning and scheduling to support procurement and early construction planning.

The project schedules used by Bechtel in the early stages of the Limerick project were essentially a manual effort. In late 1974, shortly after construction commenced, more detailed engineering status and planning tools were instituted to integrate the engineering scheduling effort with the construction CPM schedule. This program monitored the field 6-month and 12-month schedules to ensure that all engineering drawings were completed as needed. Variances from the schedule were identified in a "Current Engineering Exception and Action Item List." This program was implemented through the individual Bechtel group supervisor and his group leader and was monitored by the engineering planner and the Project Engineer.

As a result of PECO Resident Project Manager's discussions with Bechtel, this program was further expanded. A Bechtel Assistant Project Engineer was made responsible for all engineering planning and control in May 1976. In addition, individual engineering planners were assigned to the Electrical, Plant Design and Civil engineering groups. These planners worked in their respective group's area assisting the discipline supervisors in scheduling and monitoring work production. At weekly planning meetings, each engineering group reported both on their progress in developing work plans and on the status of the work scheduled.

Q. PLEASE DESCRIBE THE ENGINEERING SCHEDULES THAT RESULTED.

A. The Engineering Schedules were in the form of Gantt charts, one for each facility/elevation. The information shown on the charts for each significant design factor included drawing number, stage of issue, design interface with other engineering disciplines, forecast issue date, lead time for fabrication,

scheduled construction start date, progress, and status of engineering against construction needs.

These schedules provided a framework within which each design group prepared monthly work plans. Each major discipline - Plant Design, Civil, Electrical/Control and Mechanical had a Planning Engineer to prepare and monitor their schedules, and a fifth Planning Engineer coordinated their data on the Facility/Elevation schedules.

The Assistant Project Engineer (Planning and Control) conducted weekly meetings to monitor progress against the Coordination Schedules and Discipline Work Plans. Monthly Status Reports were provided to Bechtel management and PECO, and quarterly updates of the Coordination Schedules were prepared against the quarterly Field 12-Month Schedule. Other schedules utilized included the Procurement Status Report and the Subcontract Award Schedules, both of which were also monitored at the monthly meeting. TB&A's review of this Program indicated that it was successful in that, as will be explained further below, design activities supported construction throughout the Project.

Q. HOW WAS ENGINEERING PROGRESS FOR THE DESIGN OF BULK COMMODITIES MONITORED?

A. Beginning in 1975, schedules were prepared and maintained for the engineering production rates for each of the major bulk commodities. Examples of the schedules that were used include the exposed conduit design schedule, a schematic schedule, small pipe and pipe hanger production schedule, and large pipe and pipe hanger production schedule. These schedules were updated monthly to show actual progress against that scheduled, and to reforecast the

target completion date as the quantities increased and the construction target schedule was extended.

Q. WHAT OTHER CHANGES OCCURRED IN THE ENGINEERING PLANNING AND SCHEDULING EFFORT THROUGH THE REMAINDER OF THE PROJECT?

A. As the need arose, individual engineering schedules were prepared for specific engineering activities and progress against such schedules was monitored on a regular basis. Examples of these include P&S 938 for the FSAR Schedule, P&S 947 for the Mark II Containment Analysis, and P&S 957 for the Plant Security System.

In addition, in the early 1980s, Bechtel initiated a computerized System Engineering Action List (SEAL). The SEAL listed remaining engineering tasks which were not contained in other specific schedules and contained schedule restraint information wherein tasks or input needed to start or complete each schedule item was identified and scheduled. This schedule was also reviewed and updated on a regular basis. This type of schedule is particularly responsive to the needs of a project in its latter stages as many individual tasks remain to be completed that are not explicitly covered by the line items in schedules used in the early and mid-portions of a project.

Q. WHAT IS YOUR OVERALL ASSESSMENT OF THE REASONABLENESS OF ENGINEERING PLANNING, SCHEDULING, MONITORING AND CONTROL AND PECO'S LEVEL OF INVOLVEMENT?

A. The engineering planning, scheduling, monitoring and control methods and tools used on Limerick were effective. The overall planning and scheduling effort evolved significantly, as it did throughout the industry. Indeed, the initial

effort, which consisted of basing the engineering planning on the Peach Bottom experience, was the same method Bechtel used on its other projects.

The use of engineering production schedules for bulk commodities, individual task schedules and their regular updating and review, was appropriate. The methods utilized were commensurate with methods and tools contemporaneously in use in the industry. Moreover PECO's actions throughout the project and their attention to engineering planning and scheduling concerns was indicative of sound and appropriate management oversight action.

C. EVALUATION OF ENGINEERING QUALITY CONTROL

Q. PLEASE DESCRIBE WHAT IS MEANT BY ENGINEERING QUALITY CONTROL ON A NUCLEAR PROJECT SUCH AS LIMERICK.

A. Engineering quality control encompasses the owner's actions in implementing the programs, processes and procedures to assure that the engineering and design activities are accomplished in accordance with the procedural and technical requirements of the project. The quality control project requirements include not only those imposed by outside agencies, such as the NRC and other regulatory bodies, but also those of the architect/engineer, the constructor and the owner.

In reviewing an owner's and architect/engineer's implementation of engineering and design quality control, TB&A's evaluation is based on the following:

- What role did the owner play in ensuring that the appropriate procedures existed or were established to assure technical engineering and design quality?

- What programs were implemented by the owner to review, monitor and control the implementation of technical engineering and design quality by the architect/engineer and others?
- Were these efforts (i.e. the owner's and the architect/engineer's) successful in establishing procedures that offered a high degree of probability that technical engineering and design quality would be achieved?

The overall aspects of the project's formal QA program implementation and the relationship between TB&A's evaluation and the eighteen criteria of 10 CFR 50 Appendix B are discussed in Section IV.

Q. WHAT PROCEDURES WERE ESTABLISHED WITHIN BECHTEL'S ENGINEERING ORGANIZATION TO ENSURE THAT THE ENGINEERING ACTIVITIES WERE APPROPRIATELY CONTROLLED?

A. Both project procedures and engineering quality procedures for control of engineering activities were issued. The project procedures defined the overall PECO and Bechtel roles in the engineering process and their interface. The engineering quality procedures defined the elements of the Bechtel design effort that were mandatory for the design of safety-related systems, structures and components in order to assure compliance with the overall requirements of Bechtel's QA plan. These procedures were termed Engineering Department Procedures (EDPs) and were the documents against which PECO's formal QA audit program measured Bechtel's performance.

For example, Bechtel's EDPs covered a range of subjects, from checking of drawings and calculations to the control of design interfaces between Bechtel and off-project consultants. Bechtel was required to keep documented

evidence of their compliance with the procedural requirements, i.e. to maintain a copy of each drawing that had been checked and annotated so as to indicate the portions that had been checked, by whom and the date. PECO, during its audits of Bechtel, would then perform a spot check of these and other documents to determine the extent to which Bechtel was complying with the QA requirements.

Q. WHAT WERE THE RESULTS OF THESE PECO AUDITS OF BECHTEL?

A. Overall, Bechtel's implementation of the quality assurance requirements, as determined by PECO's audit process, was found to be satisfactory. During each audit PECO would usually find one or more specific items of non-compliance and occasionally one of relative significance.

Q. HOW DID BECHTEL RESPOND TO THESE FINDINGS?

A. Bechtel's responses were generally timely and served to reinforce to the involved engineering personnel the necessity of consistently applying the applicable quality requirements to the tasks being performed. It did not appear that any of the findings were symptomatic of problems with the implementation of overall quality program requirements.

Q. WHAT IS TB&A'S ASSESSMENT OF THIS PROCESS?

A. TB&A concludes that the program in place constituted reasonable and satisfactory performance on Bechtel's part. The fact that these non-compliances were detected by PECO's QA program provides an indication of its effectiveness, especially considering the size of Bechtel's engineering staffing on the project and the thousands of drawings, documents and revisions that were produced. The PECO QA program also ensured that any required corrective action was implemented by following up on open action items in subsequent audits.

Q. WAS PECO THE ONLY ORGANIZATION THAT PERFORMED AUDITS OF BECHTEL?

A. No. Bechtel regularly performed internal auditing within their own organization, both with their quality engineering personnel assigned to the project, and by their corporate QA department. These first level or internal audits are considered the project's primary effort to ensure compliance with the necessary requirements. In addition, the NRC conducted audits of Bechtel.

Q. DID PECO CONDUCT AUDITS OF ANY OTHER ENGINEERING ACTIVITIES BESIDES THOSE PERFORMED BY BECHTEL?

A. Yes. The PECO QA department also conducted audits of General Electric and their activities related to the design and engineering of the NSSS as well as internal audits of the PECO engineering department and their activities associated with both Limerick and Peach Bottom. The NRC has also conducted periodic audits of GE.

In the period through 1984, more than 300 audits were performed on Bechtel, GE and PECO activities.

Q. WHAT INVOLVEMENT DID PECO ENGINEERING PERSONNEL HAVE IN THE FORMAL AUDIT PROCESS OF BECHTEL ENGINEERING ACTIVITIES?

A. PECO engineering personnel participated along with the PECO QA department personnel in the regular audits of Bechtel engineering activities as well as the audits of GE and other vendors supplying equipment for the Limerick project. The PECO engineering department personnel who participated in these were selected based on their expertise in the area being audited.

For example, in March 1977, PECO conducted an audit of Bechtel home office engineering efforts in the area of piping and pipe support design. The

objective of this audit was to verify compliance with the design procedures and to review the steps taken to design the piping and its supports. The PECO audit team chairman was a lead piping and pipe support engineer from the Mechanical Engineering Division.

Q. ASIDE FROM THE FORMAL QA PROGRAM PLEASE DESCRIBE THE LEVEL OF PECO INVOLVEMENT IN THE OVERALL PROJECT ENGINEERING AND DESIGN ACTIVITIES AND THEIR EFFORTS TO ENSURE THAT TECHNICAL QUALITY WAS ACHIEVED.

A. PECO involvement in the overall engineering and design activities on the Limerick project was extensive. PECO's role was established and communicated to Bechtel early in the project and consisted of:

- Reviewing and approving design studies and analyses.
- Reviewing and approving design criteria, functional descriptions and elementary diagrams.
- Reviewing and approving specific categories of design drawings. These drawings were generally non-construction drawings, i.e. drawings that primarily are functionally oriented such as electrical single line diagrams, equipment general arrangements, piping and instrument drawings (P&ID's), site plot plans and architectural plans and elevations.

PECO's role in the project was to communicate to Bechtel, both early and throughout the project, specific requirements in terms of capacity, systems design features and general design criteria for the detailed design effort that was to follow.

Q. DID PECO PERFORM ANY DOCUMENT OR ENGINEERING SYSTEM REVIEWS IN ADDITION TO THE REVIEWS OF INDIVIDUAL DOCUMENTS AS THEY WERE ISSUED BY BECHTEL?

A. Yes. PECO consistently performed various reviews of Bechtel engineering activities in addition to the routine review and approval of designated engineering drawings and specifications. Significant PECO reviews in the 1975 to 1979 period included the following:

- March 1975 - PECO conducted an in-depth review of all facets of Bechtel design and engineering activity using the High Pressure Core Injection (HPCI) and condensate systems as examples.

- September 1975 - PECO conducted a detailed review of Bechtel piping analyses, including a comparison with design codes and specifications, to ensure that all appropriate design conditions were considered. Piping systems reviewed included main steam, HPCI, Residual Heat Removal (RHR) and main feedwater.

- January 1976 - PECO conducted a detailed review of Bechtel electrical calculations in conjunction with a PECO QA audit.

- April 1977 - PECO conducted a review of Bechtel system design development. This review resulted in PECO providing recommendations to its own personnel on how PECO could most effectively monitor Bechtel activities.

- October 1978 - PECO conducted a review of the Bechtel Regulatory Guide review process so as to understand the system and to be aware of the available supporting documentation.

- March 1979 - PECO conducted reviews of Bechtel calculations for selected systems.

- May 1979 - PECO established a quarterly review program of Bechtel calculations which was adopted by Bechtel.

- August 1979 - PECO conducted a detailed technical review of the RHR system regarding various operating mode alternatives including a survey of operating experience at other plants.

- August 1979 - PECO conducted a review of Bechtel calculations for six systems in anticipation of turnover of the Bechtel calculations to PECO.

I should note that this list is far from complete, there being numerous PECO audits or reviews of the quality of Bechtel engineering and design throughout the project. As PECO perceived areas where improvements could be attained, they did not hesitate in communicating this need to Bechtel. One such example of this occurred as a result of PECO's audit of Bechtel engineering calculations in January 1976. PECO identified the fact that Bechtel's Chief Engineers should provide specific guidance to their projects regarding aspects of the design that must be substantiated by formal design calculations. This suggested improvement was adopted by Bechtel.

Q. WHAT IS YOUR OVERALL ASSESSMENT OF PECO'S INVOLVEMENT IN ENGINEERING QUALITY CONTROL ON THE LIMERICK PROJECT?

A. TB&A concludes that PECO was significantly and appropriately involved in both the formal QA and the technical engineering quality control activities on Limerick. The establishment of both QA procedures and project procedures

early in the project and their evolution throughout the project provided an appropriate benchmark against which PECO could audit Bechtel engineering activities.

PECO's audits of Bechtel engineering activities were effective in detecting existing non-compliances and in requiring Bechtel to initiate any necessary corrective action. PECO's use of engineering department personnel to supplement PECO's QA auditors likewise effectively utilized the PECO expertise in a given area to both critique Bechtel's adherence to procedures and to become familiar with the technical details of Bechtel's work.

With regard to PECO's involvement in the technical engineering quality aspects of Bechtel's work, the types of drawings and documents reviewed and approved by PECO and their system and calculation reviews are all in concert with expected owner oversight actions on a major project such as Limerick. The detailed nature of PECO's reviews, their attention to detail, the frequency of their system and calculation reviews, and their identification as necessary of required increases in Bechtel management attention to the project, reflect PECO's concern and involvement with the quality of the engineering and design activities on the Limerick project.

Q. HAVE THERE BEEN ANY THIRD PARTY CONFIRMATIONS OF THE LEVEL OF QUALITY ACHIEVED IN THE ENGINEERING ACTIVITIES ON LIMERICK?

A. Yes. Both Torrey Pines Technology, based on their 1984 Independent Design Verification of the Core Spray System, and the NRC, in their 1984 SALP report, have concluded that the overall engineering and design effort was of high quality.

D. EVALUATION OF MAJOR ENGINEERING ACTIVITIES AND EVENTS

Q. WHAT ARE THE PURPOSE AND SCOPE OF THIS SECTION OF TESTIMONY?

A. This section of testimony addresses four major engineering activities or events that can play a significant role in shaping nuclear project progress. These are: 1) the project's response to the numerous additional regulatory requirements imposed during construction, particularly during the 1979 to 1983 period; 2) the project's efforts to support and expedite NRC licensing activities; 3) the Mark II containment problem; and 4) whether design adequately supported construction.

In each of these areas the nature and timeliness of Bechtel's and PECO's actions in response to the elements impacting the project are assessed.

1. PROJECT RESPONSE TO ADDITIONAL REGULATORY REQUIREMENTS

Q. WHAT CRITERIA DOES TB&A APPLY IN REVIEWING AND EVALUATING THE APPROPRIATENESS OF AN A/E'S AND OWNER'S ACTIONS IN RESPONSE TO CHANGING REGULATORY REQUIREMENTS?

A. The criteria applied in assessing the appropriateness of an A/E's and owner's actions as they relate to the engineering management aspects of regulatory changes include: 1) a determination of the process established within the A/E's and owner's organizations for addressing the new or changing requirements; 2) the methodolgy for achieving compliance or an equivalent licensable position; and 3) the timeliness of the A/E's and owner's actions.

Q. WERE ANY FORMAL PROCEDURES ESTABLISHED THROUGH WHICH THE PROJECT ADDRESSED NEW OR REVISED REGULATORY REQUIREMENTS?

A. Yes. In response to increasing regulatory requirements, PECO required Bechtel to review the new regulatory requirements against the Limerick design and to

regularly report their findings to PECO. PECO stated their position in a February 1975 letter to both Bechtel and GE:

> "As you are aware, the AEC is releasing regulatory guides at a rapid and fairly consistent rate. Since receiving the Regulatory Guide Status Summary transmitted with the reference letter, over twenty-five new guides have been issued. We were informed at a recent AEC meeting that PECO must be able to support any differences between Limerick design and the regulatory positions stated in all regulatory guides issued at least up to receipt of the operating license.
>
> Although compliance to regulatory guides is not a legal regulatory requirement, Limerick should comply with all applicable regulatory guides, where such compliance does not require major design changes at considerable cost or involve serious delays in schedule. To this end, Bechtel Power Corporation is requested to review all regulatory guides issued until receipt of the operating license, to determine whether Limerick design is in conformance with the AEC regulatory guide positions and to report its findings to us on some periodic frequency."

Furthermore, the Project Procedures Manual delineated a formalized method for handling deviations and changes to the Safety Analysis Report. Deviations and changes were individually documented and processed and required approval by PECO's project manager and the affected section head.

Q. COULD YOU PLEASE PROVIDE EXAMPLES OF PECO'S INVOLVEMENT IN CHANGING REGULATIONS IN THE EARLY STAGES OF THE PROJECT?

A. Yes. In 1973, even prior to the above, more stringent criteria for the design of on-site diesel generator power systems were issued. In fact, PECO engineering personnel had expressed concern to Bechtel as much as one year prior to this regarding the adequacy of the subject system to meet the postulated design requirements. At that time, however, the design was deemed to comply with the existing criteria although a trend to more stringent criteria was developing.

The more stringent criteria, which were initially issued in an ACRS and an AEC report for the Newbold Island project, were subsequently studied by Bechtel and reviewed by PECO. PECO, who already had significant knowledge of the modifications necessary, concurred with Bechtel's recommendations to provide separate and independent diesel generators for each unit. PECO's proactive involvement in this issue was found to be representative of their overall involvement in other evolving regulatory requirements. Other examples include:

1. The increased electrical separation requirements, also in the 1973 time period, in which PECO was similarly involved in detailed discussions with Bechtel and GE.

2. Bechtel/PECO meetings to discuss AEC criteria on pipe breaks outside primary containment and their effect on the Limerick design.

3. Bechtel/PECO discussions regarding the position PECO should assume with respect to meeting the AEC's regulations regarding applicable codes and standards for the reactor pressure vessels, pumps, valves and piping.

Q. HOW DID PECO'S INVOLVEMENT CHANGE AS THE PROJECT PROGRESSED?

A. As the quantity of new and revised regulations increased through the late 1970s and into the 1980s, and as their impact on the project status likewise increased, PECO's involvement increased.

For instance, a late 1977 letter from Bechtel to PECO provided a tabulation of licensing issues in which the existing project positions were identified as potential licensing jeopardies. This resulted in a meeting between Bechtel and PECO to discuss and formulate an action plan for each of the issues. As an additional example, in 1978, in response to increased regulations regarding the environmental qualification of electrical equipment, PECO engineering personnel met with Bechtel in order to acquaint Bechtel with

PECO's Peach Bottom experience in that area and to formulate a plan to address the subject concern on Limerick. This is an example of how PECO's Peach Bottom experience permitted early recognition and resolution of regulatory concerns at Limerick, thus avoiding possible adverse cost and schedule effects.

PECO's involvement in other regulatory issues was likewise one of working with Bechtel and being an integral part of the decision-making process.

Q. IS THE DECISION-MAKING PROCESS, AS IT RELATES TO IMPLEMENTING REGULATORY REQUIREMENTS, ONE OF IDENTIFYING THE REQUIREMENT AND THEN IMPLEMENTING THAT REQUIREMENT?

A. Yes, but the process is frequently not that simple. The evolution of the industry fire protection requirements is one such case.

The inclusion of fire protection equipment and systems in a nuclear power plant has always been a requirement. However, since the Browns Ferry fire at TVA's plant on March 22, 1975, fire protection requirements have increased significantly. That fire resulted in significant damage to the plant control systems due to fire propagation through the insulation of electrical cable in the plant. The plant was operating at the time and safe shutdown of the plant, although achieved, was in jeopardy for a period of time.

Following the Browns Ferry fire, the NRC made a comprehensive evaluation of potential fires and their effect on the ability of plants to achieve a safe shutdown condition.

Q. WHAT WAS THE NATURE OF THE INITIAL REGULATIONS THAT RESULTED FROM THE BROWNS FERRY FIRE?

A. The NRC initially issued Branch Technical Position (BTP) 9.5-1 (related to FSAR Section 9.5-1 dealing with Fire Protection) in May 1976. The BTP provided a basis for operating license applicants to determine the increased fire protection requirements against which their design would be reviewed. It contained numerous requirements including additional sprinkler systems, fire rated walls and additional separation of cables required for safe shutdown. Regulatory Guide (R.G.) 1.120, which contained essentially the same requirements as the BTP, was subsequently issued for a 60-day comment period in June 1976. Comments provided to the NRC by various owners and A/E's were numerous and significant. A letter from the NRC distributing Revision 1 of R.G. 1.120 in November 1977 stated:

> "In view of the many changes made as a result of the first public comment period, this guide is being issued for a further extended comment period of one year. At the conclusion of the comment period the staff will consider the public comments in conjunction with an in-depth evaluation of different approaches to plant fire protection for future plants. It is expected that this evaluation will be completed within two years of this issuance of the guide."

Subsequently, the BTP was revised twice and the Standard Review Plan (SRP) was upgraded to reflect the BTP requirements. The later revisions of the BTP and SRP reflect the requirements of Appendix R to 10 CFR 50 which was issued in November 1980. Thus, more than five years elapsed between the Browns Ferry fire and the initial issue of Appendix R; this illustrates the lengthy time that can be involved in developing final regulatory positions on a particular safety issue.

Q. WHAT ACTIONS DID PECO AND BECHTEL TAKE IN RESPONSE TO THESE CHANGING REGULATIONS?

A. PECO and Bechtel began to incorporate many of the BTP and R.G. requirements into the on-going Limerick design.

Following the November 1980 issuance of Appendix R, PECO directed Bechtel to perform a detailed review of Limerick's fire protection provisions against the guidelines of Appendix R. (Although Appendix R was not directly applicable to Limerick, the Appendix R requirements were later incorporated into BTP 9.5-1, which was applicable to Limerick).

PECO worked closely with Bechtel in developing the required analyses and defining the related changes that were necessary.

In an effort to minimize the quantity of necessary fire protective barriers that had to be installed at Limerick, PECO directed Bechtel to perform a major reanalysis of the safe shutdown capability in mid-1983. The overall result of this reanalysis of safe shutdown capability was a significant reduction in the need for raceway fire barriers, which reduced construction's scope of work and aided the project's ability to meet the overall schedule.

PECO's review of Bechtel's safe shutdown analysis methodology was detailed and constituted a very thorough and comprehensive review by an owner.

Q. ARE THERE ANY OTHER ASPECTS OF FIRE PROTECTION ON LIMERICK THAT ARE OF SIGNIFICANCE?

A. Yes. PECO's efforts to minimize the protective coating of structural steel demonstrates state-of-the-art actions by PECO.

A PECO interoffice memorandum relating the events from a December 1983 NRC/PECO meeting reflected the magnitude of this problem which was identified as part of the Appendix R review:

"The meeting opened with J.S. Kemper discussing the seriousness of this issue and the cost and schedule impact resulting from an arbitrary resolution of coating all exposed structural steel per the NRC SER direction."

PECO's strategy was to minimize the amount of structural steel that would have to be coated through the use of heat transfer and propagation analyses/calculations. Realizing that others, besides Bechtel, had more expertise in the field, PECO contracted with Professional Loss Control, Inc. to provide a supportable, realistic and conservative methodology for predicting compartment fires and the response of structural steel.

The seriousness of this issue on the Limerick schedule was reflected in an NRC letter to PECO in December 1983 following the above meeting:

"We informed the applicant that if we find as a result of our evaluation of the proposed model that we have major differing technical opinions regarding the acceptability of the model, the resolution of these differences may impact their construction completion schedule for Limerick."

Both the NRC staff and consultants at Brookhaven National Laboratories became involved in reviewing PECO's analysis of the capability of uninsulated structural steel members to withstand fires.

Q. WHAT IS YOUR ASSESSMENT OF PECO'S DECISION TO PURSUE THIS ALTERNATIVE?

A. Based on the project circumstances, namely the closeness of the fuel load date, the extra site work associated with the more conventional alternative of coating all steel, and the resultant potential impact on fuel load, PECO's decision to develop a compartment fire modeling methodology was appropriate and commendable.

Q. WAS PECO'S METHODOLOGY EVENTUALLY ACCEPTABLE TO THE NRC?

A. Yes. Final acceptance, however, was not communicated until October 1984 after several months of questions and clarifications. The resultant acceptability of PECO's methodology is estimated to have saved in the order of $20 to 30 million in labor and materials. More importantly, however, the Limerick fuel load schedule was able to be maintained. The fuel load schedule would have most probably been impacted if PECO had used the previously accepted methodology within the industry. Indeed, other projects are now following PECO's lead.

Q. HOW WERE THE FIRE PROTECTION ISSUES FINALLY CLOSED OUT WITH THE NRC?

A. The NRC performed two on-site inspections of the Limerick fire protection program.

The first, conducted in April 1984, included an inspection of all fire protection features in place to confirm PECO's commitments in the Fire Protection Evaluation Report and to follow-up responses to NRC Staff questions and NEPA code applicability. Included in the Company's preparation for this inspection was an independent preinspection by an outside consultant, Professional Loss Control. The NRC and consultant inspection identified six minor deficiences, all of which were expeditiously corrected.

The NRC performed a second on-site inspection of Limerick related to safe shutdown fire protection capability in August 1984. PECO fully prepared for this inspection by first attending an industry seminar in February 1984 to discuss NRC expectations concerning implementation of Appendix R. The meeting topics included a review of deficiencies identified by the NRC's I&E inspections of Appendix R implementation at several facilities.

Included in PECO's review were a requirement that Bechtel staff personnel conduct their own audit of the Limerick Project and a trip to Bechtel's engineering office in San Francisco in August to prepare for the NRC site audit. In addition, Professional Loss Control personnel were contracted to perform an audit of particular fire protection aspects. PECO followed up by meeting with Bechtel to ascertain and implement the necessary changes to achieve a licensable design.

As a result of the joint efforts of PECO and Bechtel, "no violations were observed" during the August 1984 NRC audit. According to PECO, Limerick was one of the first plants to pass this audit with no violations.

Q. DID PECO INITIATE ANY SIGNIFICANT ACTIONS IN RESPONSE TO ANY OTHER REGULATORY REQUIREMENTS?

A. Yes. In the weeks following the incident at Three Mile Island Unit 2, a PECO TMI Event Committee was formed. This Committee was charged with performing an independent assessment of the incident and developing recommendations for improving PECO's ability to cope with such a potential incident at its Peach Bottom and Limerick nuclear plants. The committee was comprised of experienced personnel from the various parts of the Company involved in nuclear work. The assessment and recommendations of this group were completed before the first draft of the NRC's TMI Lessons Learned Task Force Report was available and work was well underway on responses to these recommendations before such action was directed by the NRC.

The BWRs Owners' Group was also formed in 1979 to facilitate coordination of the actions of the BWR owners in response to the issues raised by the NRC following the incident at TMI. PECO personnel, in addition to

participating in virtually every Owners' Group activity that applied to Limerick, were also elected to the positions of Owners' Group Chairman, Vice-Chairman and Regulatory Response Group Chairman. Following the resolution of most of the TMI items, the Owners' Group, under PECO leadership, has turned its attention to the proactive resolution of other pending regulatory issues and generic problems such as containment isolation issues and SRV set point drift.

In response to the actual regulations stemming from the TMI incident, PECO quickly established an organization through which TMI-related issues were assigned to appropriate technical personnel for resolution and follow-up activities. This organization, headed by a PECO licensing engineer, was chartered with coordinating and resolving TMI-2 related matters required in the resulting NUREGS. PECO, in its planning and scheduling of TMI-related tasks, identified:

> "• Specific studies and design evaluations required of Bechtel/GE
> • Specific actions to be taken on construction of systems and structures subject to change as a result of TMI-2 evaluations.
> • Changes to be made to the FSAR to incorporate TMI-2 related information."

PECO assembled information for each item in five areas. For each NUREG item, PECO requested that their responsible engineer provide:

> "1. An assessment of the extent to which the present Limerick design complies with referenced NRC positions.
> 2. Actions taken to date, if any, to bring the present Limerick design into compliance.
> 3. An action sequence, listing recommended steps, responsibility assignments, etc. necessary to bring Limerick into compliance with NRC positions. This action sequence should reflect your recent Peach Bottom experience, and should provide specific directions for any studies or design evaluations to be performed by Bechtel, GE, or PECO.

4. Specific direction regarding systems, structures, or portions thereof on which a construction hold should be placed pending the results of studies or evaluations required by (3), above.

5. Any additional information which you feel would be useful in initiating these corrective actions."

Through this effort, PECO and Bechtel identified, implemented and incorporated the changes resulting from TMI. As a specific example, PECO was a driving force among the BWR owners in developing a generic, cost-effective approach to post-accident sampling. PECO recognized that the then existing NRC guidance provided in NUREG-0578 did not precisely reflect what was necessary for BWR post-accident analysis, and thus PECO was instrumental in working with the NRC to achieve an acceptable solution. The timely completion of this effort with a simplified, economical system enabled PECO to meet the TMI Lessons Learned Requirements for Post-Accident Sampling with minimal cost and schedule impact.

Q. IN SUMMARY, WHAT IS YOUR OVERALL ASSESSMENT OF THE PROJECT'S RESOLUTION AND IMPLEMENTATION OF REGULATORY CHANGES IN GENERAL, AND SPECIFICALLY IN ITS HANDLING OF THE FIRE PROTECTION AND TMI ISSUES?

A. TB&A concluded that PECO maintained a proactive involvement in the resolution and implementation of regulatory changes throughout the course of the Limerick Project. Both PECO and Bechtel implemented the necessary procedures to ensure that new or revised regulatory requirements were addressed in an orderly and timely manner.

PECO and Bechtel worked effectively to ensure that the project was responsive to the changing needs that were being imposed not only on the Limerick Project but on the nuclear industry in general. PECO consistently

demonstrated a concern for minimizing cost and schedule impact while ensuring at the same time that the proposed solutions fully complied with the criteria or the intent of the criteria.

Specifically, regarding the fire protection issue, PECO's early recognition of concerns and problems probably avoided a schedule extension. Considering the project circumstances, PECO's aggressiveness in resolving the structural steel coating issue, and minimizing the resultant coating scope while applying a methodology not previously used in the nuclear industry, represented sound decision-making logic.

Regarding TMI, PECO's establishment of an organization to address the TMI issues and, in conjunction with Bechtel, the systematic and orderly identification of the required design changes and specific assignment of the needed resources for resolution, were reasonable and appropriate actions.

2. SUPPORT OF LICENSING EFFORT

Q. WHAT IS THE PURPOSE OF THIS SECTION OF TB&A'S TESTIMONY?

A. The purpose of this section of testimony is to present TB&A's assessment of the reasonableness of PECO management actions in performing the functions necessary to secure a construction permit and a commercial operating license for Limerick, in accordance with federal, state, local and other regulatory requirements.

Q. WOULD YOU PLEASE SUMMARIZE THE MAJOR ACTIVITIES IN THE OVERALL LICENSING PROCESS.

A. A flowchart outlining the standard licensing process is presented in Schedule 22. This flowchart traces the process through its significant events, from initial construction permit application including the Preliminary Safety

Analysis Report (PSAR) and Environmental Report — Construction Permit Stage (ERCP) submittals and resultant NRC issued Safety Evaluation Report (SER) and Environmental statements, through to the Operating License (OL) submittals. The OL phase consists of the Final Safety Analysis Report (FSAR) and Environmental Report - Operating License Stage (EROL) submittal, NRC-applicant questions and answers, NRC issuance of the resultant SER and Final Environmental Statement, presentations to the Advisory Committee on Reactor Safeguards (ACRS), public hearings, and issuance of the OL for both low power and later full power operation.

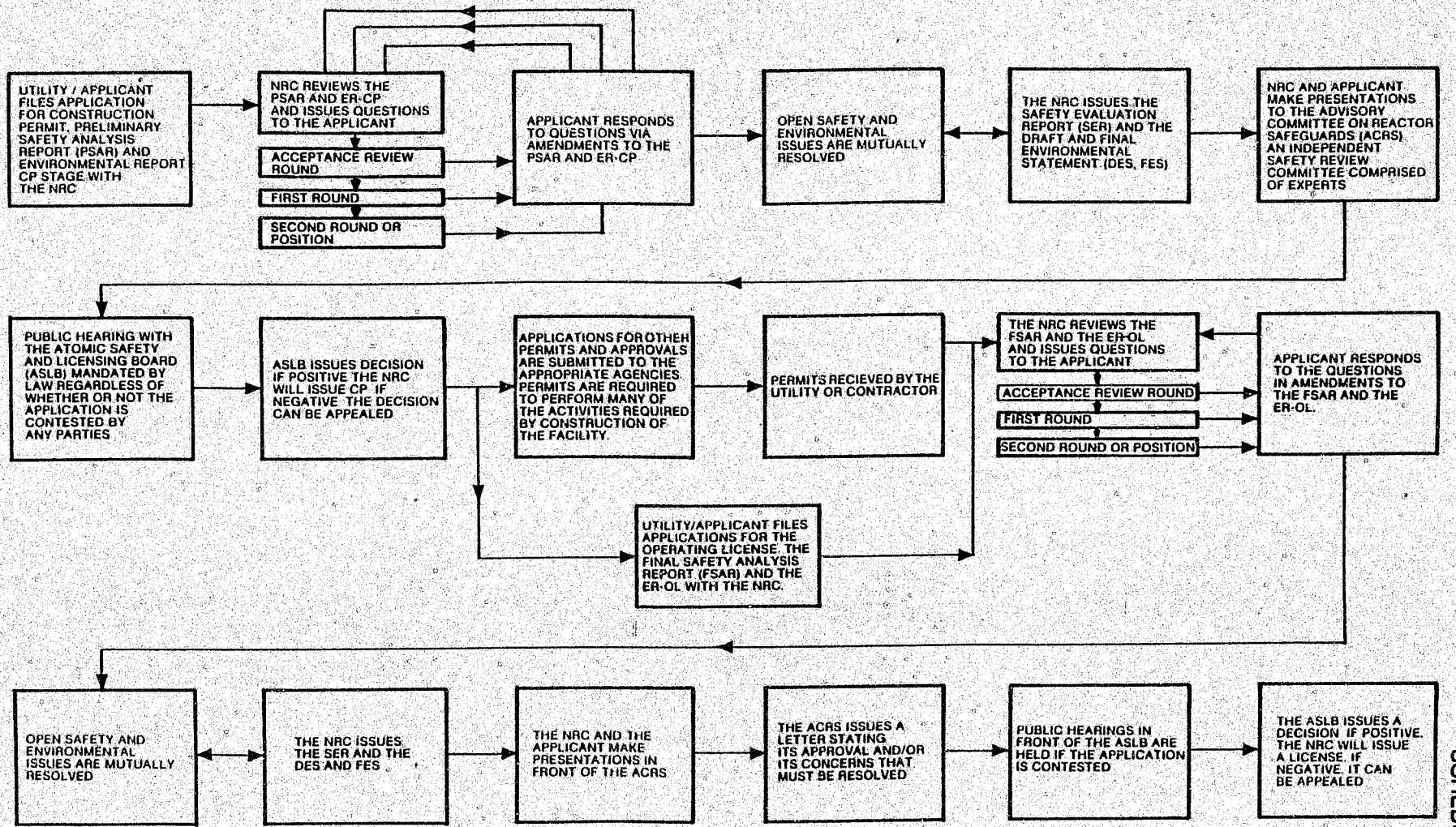
Q. HOW DID PECO MANAGE THE LICENSING ACTIVITIES DURING THE CONSTRUCTION PERMIT PHASE?

A. During the construction permit application phase, two PECO engineers coordinated the Limerick licensing activities of the various PECO engineering divisions. These engineers were from within the Mechanical Engineering Division and had previous licensing experience on Peach Bottom Units 2 and 3. Bechtel provided the technical resources needed to develop the PSAR and also compiled the overall licensing schedule. PECO was responsible for obtaining all jurisdictional right-of-ways, permits, etc., and coordinated the information provided by Bechtel, General Electric, and other consultants as needed. To monitor the numerous ongoing activities and to maintain adequate control over the involved parties, PECO maintained a manual system of assigning responsibilities and tracking responses to the various licensing issues that were raised.

Q. WHAT SIGNIFICANT EVENTS OCCURRED IN CONJUNCTION WITH PECO'S CONSTRUCTION PERMIT APPLICATION FOR LIMERICK?

PHILADELPHIA ELECTRIC COMPANY

STANDARD LICENSING ACTIVITY FLOWCHART



SOURCE: TB&A ANALYSIS

SCHEDULE 22

A. PECO submitted the PSAR to the AEC as part of its application for a construction permit, in February 1970. The environmental report for Limerick was submitted in October 1970.

The ACRS issued a favorable letter to the AEC in August 1971 and the SER was subsequently issued in November 1971. Pre-hearing conferences concerning radiological health and safety issues were held in early 1972 and evidentiary hearings encompassed a total of 17 days but were held over a 23 month period from January 1972 until December 1973. The protracted hearing process was due in large part to concerted intervention efforts by outside parties.

In parallel with the above events, however, the Calvert Cliffs decision was impacting the project licensing process. The Calvert Cliffs decision required, among other things, that the AEC prepare detailed environmental impact statements on all proposed nuclear generating facilities. PECO was thus required to resubmit its environmental report to cover in greater detail the environmental effects of Limerick. PECO completed this revised environmental report and submitted it to the AEC in May 1972.

After a period of discovery and subsequent to the issuance of the AEC's Final Environmental Statement in November 1973, the evidentiary hearings before the Atomic Safety and Licensing Board (ASLB) to consider environmental issues commenced. Including the pre-hearing conference, the environmental hearings lasted 16 days over 10 months. Again, intervention efforts contributed to the lengthy hearing process.

Subsequent to the hearings, and after consideration of all relevant issues, the AEC issued a construction permit for the Limerick Generating Station on June 19, 1974.

Q. WHAT CONCLUSIONS DOES TB&A DRAW FROM THEIR ANALYSIS OF PECO'S LICENSING ACTIVITIES DURING THE CONSTRUCTION PERMIT PHASE?

A. TB&A concludes that, throughout the construction permit development and filing, PECO maintained an appropriate level of staffing and management involvement to support this licensing activity.

Q. SUBSEQUENT TO RECEIPT OF THE CONSTRUCTION PERMIT, HOW DID PECO PREPARE FOR DEVELOPING THE OPERATING LICENSE APPLICATION REQUIREMENTS?

A. The main licensing activities following construction permit receipt consisted of updating the PSAR, reviewing and responding to changes in NRC requirements, and developing the FSAR and EROL. Additionally, PECO had to keep abreast of other requirements for permits and licenses required from state and local authorities.

The major activity, however, was the preparation of the FSAR. Bechtel was responsible for developing and scheduling the FSAR and PECO was responsible for review of all documentation and for coordinating the overall license application effort. Preparation of the FSAR was initiated in 1975 and continued through the late 1970s and early 1980s. The document was submitted to the NRC, along with the EROL, on March 17, 1981, as part of PECO's application for an operating license. The submittal led the anticipated fuel load date (October 1984) by 43 months, contrary to the NRC's practice of

accepting applications with no more than a two and one-half year lead. PECO anticipated a higher level of intervention and associated longer review period.

Q. WHAT STEPS DID PECO TAKE TO MANAGE THE LICENSING ACTIVITIES DURING THIS PHASE?

A. With regard to the overall status of permits and licenses, PECO was regularly notified by Bechtel of the status of permits required for construction and operation. A typical Bechtel transmittal of this kind would indicate the type of permit, the granting and concurring agency, the date required, the subcontracts affected, and relevant remarks or comments concerning the listed permits/licenses. This allowed PECO to track and monitor the status of the required permits and licenses.

The status of the various FSAR sections was tracked by Bechtel through a computerized Division of Responsibility Report. This report listed the organization, group and individual responsible for a particular section, and also identified need dates for first drafts, reviews, and final drafts. PECO also developed a status summary tracking program for various regulatory activities. This system included I. & E. Bulletins, Circulars, Information Notices and findings related to various NRC site inspections. Each tracking activity identified the responsible organization and individual as well as dates on which commitments and responses were due.

In 1978, the Nuclear and the Environmental Sections of PECO's Mechanical Engineering Division were combined to form the Nuclear and Environmental Section (NES) under the direction of one Section Head. Within the NES, two branches were formed, the Nuclear branch and the Environmental branch, each with a senior engineer in charge as the branch head. The Nuclear

branch assumed responsibility for the coordination of licensing activities. Within the Nuclear branch, there were three groups, one of which was the Licensing group. At this time, the Licensing group consisted of a group leader and a licensing engineer. However, by mid-1984, the Licensing group had increased to approximately 7 engineers.

Q. WHAT SIGNIFICANT EVENTS OCCURRED IN CONJUNCTION WITH PECO'S OPERATING LICENSE APPLICATION FOR LIMERICK?

A. As mentioned previously, PECO submitted its application for an operating license on March 17, 1981. The NRC accepted the application for docketing in July 1981. From the period between July 1981 and mid-1983, more than 1,200 questions and issues were responded to by PECO. The Limerick Safety Evaluation Report (SER, NUREG-0991) was issued in August 1983. The level of intervention anticipated by PECO proved to be true. Hearings concerning the environmental and safety aspects of the project began in October 1982, and continued through July 1985.

A deviation in the licensing process from the standard process for Limerick and similar vintage plants of Schedule 22 was that two meetings were held with the ACRS at the operating license stage, instead of the normal one meeting. The first meeting was in October 1983 and dealt with the low power license while the second meeting in November 1984 dealt with the full power license. PECO was issued a 5% low power operating license for Limerick 1 on October 26, 1984.

Q. WHAT SIGNIFICANT EVENTS HAVE OCCURRED SUBSEQUENT TO PECO'S RECEIPT OF THE LOW POWER OPERATING LICENSE?

A. Subsequent to the issuance of the low power license, activities focused on the

steps necessary to close conditions required prior to the NRC's issuance of the full power operating license. These activities included transmittal of information to the NRC for review and approval, confirmation that certain required actions were completed, closure of certain NRC Region I items related to construction completion, testing and inspections, as well as the completion of the low power testing program. The low power testing program was satisfactorily completed by March 1, 1985 and construction completion items required before the license could be obtained were completed by March 22, 1985.

Following extensive public hearings on safety and environmental issues, PECO was granted a full power license for Limerick Unit 1 on August 8, 1985. This allowed PECO to begin full power ascention testing above 5% of Limerick's rated design power.

Q. WHAT HAS TB&A CONCLUDED REGARDING PECO'S INVOLVEMENT IN THE OPERATING LICENSE ACTIVITIES FOR LIMERICK?

A. TB&A concludes that, throughout the operating license application phase, PECO exhibited a continuously high level of aggressive involvement in the regulatory relations and licensing activities. PECO's involvement and coordination of the overall Limerick licensing activities resulted in the timely development of their operating license application and response to the many outstanding issues and contentions raised by both the NRC and the external intervenors.

PECO's status summary tracking program was effective and compared favorably to those contemporaneously available within the nuclear construction industry. The results of a TB&A analysis of PECO's responses to various I.E.

Bulletins showed that, although the complexity and quantity of the bulletins and issues increased over time, PECO's tracking program maintained adequate control over this aspect of licensing and provided timely responses to the NRC issues.

In sum, TB&A concludes that PECO's licensing support activities have been reasonable and appropriate.

3. MARK II CONTAINMENT

Q. WHEN DID PECO REVISE THE LIMERICK DESIGN TO INCORPORATE THE MARK II CONTAINMENT?

A. The Mark II containment had not been used in a commercial plant prior to the start of Limerick; however, the Long Island Lighting Company had committed to using the Mark II containment for its Shoreham project. PECO directed Bechtel to perform a comparative analysis between the Mark I and Mark II containment designs on August 27 and 28, 1969 during the project kick-off meetings.

The subsequent Bechtel analysis identified significant advantages of the Mark II design (referred to as the Over-Under design) over the Mark I design. In their October 1969 letter (BLP-40), Bechtel stated:

> "We believe the results indicate some important incentives favoring the Over-Under containment, over the contemporary Torus-type design. Also, the Over-Under possesses an unusual advantage for a concept lacking actual design and construction precedent, in that cost risks appear minimal and there is good potential for additional savings.
>
> The study shows that the several plans of the Over-Under containments realize estimated cost advantages in the range of $3,900,000 to $4,500,000 over the Torus-type containment, for two units."

In addition, Bechtel also stated that the Over-Under containment had advantages in scheduling, licensing, and technical features. The schedule for

the project could be potentially shortened 2 months for Unit 1 and 4 months for the station. From a technical standpoint, Bechtel stated:

> "Structural design of the Over-Under containment and its reactor building is more simple than with the Torus-type, and performance of the pressure suppression system appears quite predictable. Also, operating economies should result from a better equipment arrangement in the reactor building. This judgement is based on this study, our experience with other concrete containment designs, and earlier investigations of Over-Under containment."

Bechtel's analysis recommended that the containment design for Limerick be changed to the Mark II design, which PECO subsequently approved.

Q. WHAT ARE THE MARK II CONTAINMENT NEW LOADS?

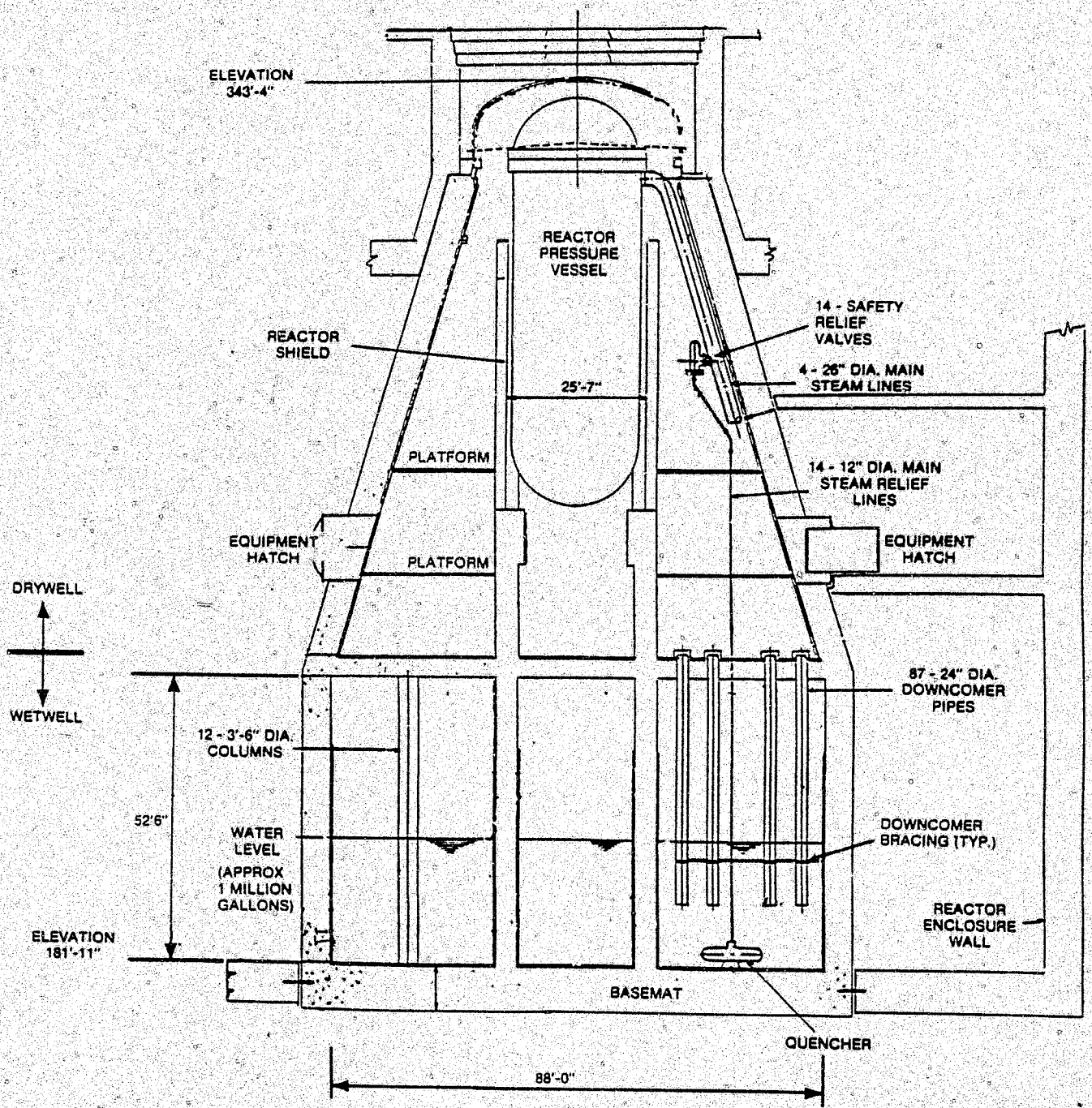
A. A previously unidentified category of forces associated with GE-BWR Mark II containments was identified by GE in 1975. These forces (known as hydro-dynamic loads) could be generated in the reactor containment following a LOCA and the lifting of the safety relief valves as a result of air and steam being rapidly forced into a water filled suppression pool located in the containment.

Schedule 23 illustrates in cross section the reactor containment building with its significant elements identified, including the suppression pool. Certain dimensions are included to provide a physical size perspective. Although most of the equipment and piping located in the containment is not shown, the noted quantities and sizes of the piping illustrated provide a perspective regarding the resultant congestion.

At the time these loads were recognized, the containment structure design was based only on seismic and LOCA criteria. Like seismic loads, the Mark II hydro-dynamic loads affect the containment structure, all equipment contained within it, and adjacent structures and contained equipment.

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LIMERICK CONTAINMENT CROSS SECTION



SOURCE: ADAPTED FROM LIMERICK DESIGN ASSESSMENT REPORT

Q. DID THE MARK II CONTAINMENT NEW LOADS AFFECT OTHER OWNERS WITH GE BWR MARK II CONTAINMENTS?

A. Yes. All eight owners of the eleven BWR Mark II units were affected by the new hydro-dynamic loads. Those units and their associated owners, architect/engineers and constructors are listed in Schedule 24.

In May 1975, all of the utilities owning Mark II plants joined to form the BWR Mark II Owners' Group to jointly participate in and share the cost of the analyses necessary to resolve the problem. GE was hired by the Owners' Group as the program manager. The impact of the new loads on each of the Mark II plants was significant but varied depending on the status of engineering and construction of each unit. The three plants that were the furthest along in construction and which were projecting the earliest fuel load dates, i.e. Zimmer, LaSalle and Shoreham, were designated the "lead plants." Specific aspects of the overall resolution effort were directed at supporting the efforts of the lead projects. A significant element of the lead plant program was that the design criteria were extremely conservative (i.e. higher design forces than might actually be required), a result of the fact that time did not permit more definitive criteria to be developed. It was expected, however, that further work and data from tests would permit less conservatism in some areas for later plants in the Mark II series.

The overall scope of the Mark II resolution effort increased significantly as the analytical work and testing progressed. Initially, the full scope was unknown. The eight owners contracted with GE in 1975 to perform the initial analytical work. The pro rata share of the GE analytical cost for each unit was then less than $10,000. This initial work resulted in a short-term program and a

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MARK II PROJECTS, OWNERS, ARCHITECTS/ENGINEERS & CONSTRUCTORS

Plant	Utility	Architects/Engineers	Constructors
Bailly 1	Northern Indiana Public Service Company	Sargent & Lundy	--
WPSS-2	Washington Public Power Supply System	Burns & Roe	Burns & Roe
LaSalle 1 & 2	Commonwealth Edison	Sargent & Lundy	Commonwealth Edison
Limerick 1 & 2	Philadelphia Electric Company	Bechtel	Bechtel
Nine Mile Point 2	Niagara Mohawk Power Company	Stone & Webster	Stone & Webster
Shoreham	Long Island Lighting Company	Stone & Webster	Stone & Webster Long Island Lighting Compan
Susquehanna 1 & 2	Pennsylvania Power & Light Company	Bechtel	Bechtel
Zimmer	Cincinnati Gas & Electric Company	Sargent & Lundy	Kaiser

SOURCE: TB&A ANALYSIS

long-term program, which were submitted to the NRC in June and August 1975, respectively.

The Mark II Containment Program was based on the philosophy that a common analytical methodology could be developed. Each plant could then be analyzed individually for structural adequacy utilizing the generic methodology with plant unique inputs.

Q. HOW WAS THIS PROGRAM STRUCTURED?

A. The program consisted of the following three major elements:

1. Dynamic Forcing Functions Information Report (DFFR) - which provided a common basis methodology for applying phenomenological forcing functions to determine loads. The initial issue of the DFFR was prepared by GE and Sargent & Lundy, reviewed and approved by the Mark II Owners and their A/E's, and submitted to the NRC in October 1975. DFFR methodology tells how to apply phenomena occurring during LOCA or SRV actuation to determine what load values result, based on hydro-dynamic knowledge developed in early testing.

2. Design Assessment Reports (DAR) -- utilities and A/E's apply DFFR methodology using individual plant geometry to obtain unique load values for design and analysis. DAR's tell what the actual loads are for a specific plant and show the relationship of those loads to plant structural capability. Preliminary plant DAR's based on the initial issue of the DFFR were submitted to the NRC during the first half of 1976. Final DAR's were submitted in the same time frame as the FSAR's for each project.

3. Supporting Program--consists of testing and analyses in support of the

DFFR analytical methodology.

Q. WHAT WAS PECO's INVOLVEMENT IN THE OWNERS' GROUP?

A. PECO was actively involved in the BWR Mark II Owners' Group. In addition to participating in the regularly scheduled meetings, the PECO Vice-President of Engineering and Research was on the Mark II Management Committee and PECO's Structural Branch Head was the Program Manager for the Mark II LOCA Technical Committee and later became Vice-Chairman of the Owners' Group.

Q. WHAT SPECIFIC OWNERS' GROUP AND INDUSTRY ACTIVITIES OCCURRED IN THE PERIOD BETWEEN 1976 AND 1981 WHEN THE FINAL NRC ACCEPTANCE CRITERIA WERE ISSUED?

A. Regularly scheduled owners' group meetings were held including all owners and their A/E's. In one such meeting, in March 1976, GE identified still additional load concerns, referred to as "chugging", that were not previously believed to be significant. The overall resolution effort was also identified then as a long-term three to four year commitment, thus indicating that the Mark II problem resolution efforts would be a lengthy process.

By April 1976, the cost estimates for the generic analytical testing work increased to $2 to $4 million with completion of this work extending until September 1977. In August 1976, Mark II owners retained an outside consultant, Nuclear Services Corp., to act as a program monitor for the owners.

In 1977, various owners' group members made visits to Japan, Germany, Italy and Sweden in an effort to make use of technologies/tests conducted by others. KWU of Germany felt that it had solved the SRV problem associated

with the rapid discharge of the steam into the water filled suppression pool by use of a device called a "quencher", which had been approved and licensed for use on Mark III plants (GE's latest containment design). In May 1977, GE announced that by using German methodology, loads for the Mark II plants would be reduced by about 40% of the then current, conservative lead plant loads.

In September 1977, GE identified a new and more severe design condition, involving multiple safety relief valve actuations resulting from Mark III analytical work. In November 1977, a Mark II Containment Program Estimated Schedule, presented at an ACRS subcommittee meeting, showed the completion of tasks extending into late 1980. In 1978 and early 1979, most Mark II owners, including PECO, initiated efforts to utilize KWU for testing and development of the quencher to resolve the SRV discharge problem in the wetwell.

Also in October 1978, the NRC issued NUREG 0487--"Lead Plant Load Evaluation Report" for LOCA related hydrodynamic loads. Further supplements to this NUREG were issued in September 1980 and in February 1981. In August 1981, the NRC issued NUREG 0808--"Mark II Containment Program Load Evaluation and Acceptance Criteria", approximately six years following GE's identification of the problem. Two further NUREGs followed, NUREG 0783--"Suppression Pool Temperature Limits for BWRs" (November 1981) and NUREG 0802--"SRV Quencher Load Evaluation for BWR Mark II/III Containments".

Q. WHY IS IT THAT SUCH A LONG TIME PERIOD WAS REQUIRED IN ORDER TO GENERATE THE FINAL ACCEPTANCE CRITERIA?

A. The long time period involved can be primarily attributed to the complexity of the problem. Not only did this problem involve all Mark II plants, but the 16 utilities owning Mark I plants and all Mark III utilities as well, were working on solving the problem. It was not until years after the initial identification of the problem that all of the forces and resultant effects were known and understood. This was also the first time in the nuclear power industry that all involved owners and A/E's joined forces to pool their resources and generate solutions. Indeed, the NRC likewise retained many expert consultants to aid their efforts in understanding the problem so that the required regulations could be drafted and issued for use. The process of generating the new regulations was lengthy and iterative, involving many drafts and revisions by both the NRC, their consultants and industry participants.

Q. WHAT SPECIFICALLY DID PECO DO INITIALLY IN RESPONSE TO THE MARK II CONTAINMENT PROBLEM?

A. In February 1975, when they became aware of the problem, PECO, together with Bechtel, General Electric, and Pennsylvania Power & Light Co. (PP&L), participated in a joint effort to resolve the Mark II containment concerns GE had identified. At this time, GE intended to conduct tests, the majority of which were to be completed by the end of 1975, to confirm the criteria needed for the containment structural design.

PECO also placed a hold in April 1975 on containment work that might be affected by the problem (this included the critical path activity of containment wall pours) and so notified the NRC. PECO's strategy was to solve the problem as expeditiously as possible and to return to the critical path at the earliest feasible date.

By May 1975, the Mark II Owners' Group was formed, which both PECO and PP&L joined, thus dissolving their own working group with GE and Bechtel. PECO and Bechtel at this time were working toward an August 1980 fuel load. After a two month period, the hold on containment work was released (June 1975); however for conservatism, additional rebar was installed in the containment walls, and anchor bolts and shear tires were added in the slab between the wetwell and drywell to allow for the increased forces that might result from the problem resolution efforts. The design of the suppression chamber internals and piping was not on the critical path, however, and thus their design was delayed. Design of other equipment and components that would be directly impacted was also placed on hold.

Prior to releasing the containment construction hold, PECO held a meeting with the NRC to review its proposed action. It advised the NRC that the original design of the affected structures would be adequate for the newly identified loads. For conservatism and in order to proceed with construction, the modifications to the original design discussed above were to be incorporated. The NRC expressed no objection to this course of action.

Q. AFTER CONSTRUCTION RESUMED, WHAT IMPACT DID THE ONGOING OWNERS' GROUP AND LIMERICK-SPECIFIC RESOLUTION ACTIVITIES HAVE ON ENGINEERING AND CONSTRUCTION?

A. Construction activities continued and incorporated the design conservatisms believed to be adequate to meet or exceed the ultimate criteria that would result. GE verification testing for the owners' group continued in parallel with the analytical work.

In April 1976, Bechtel issued to PECO a design alternatives report. The

number of alternatives was largely due to the lack of complete design information from the Mark II analytical efforts. At this time Bechtel began an evaluation of the design, construction and installation schedules required to satisfy the desired fuel load date for Unit 1.

Bechtel determined, as a result of this evaluation, that the suppression pool analysis for the newly identified hydro-dynamic loads would not be required to begin until the last quarter of 1977 to meet the projected fuel load date for Unit 1 of October 1981. The timing coincided with the Owners' Group Long Range Program which was also scheduled for completion in late 1977.

Q. WHEN WERE ADDITIONAL SCOPE INCREASES INITIALLY IDENTIFIED TO PECO?

A. A GE letter to PECO in July 1976 identified two additional evaluations that would be required. GE stated that these two evaluations were due to forces induced by phenomena that were not explicitly considered in the original design basis. The "chugging" phenomenon proved to be the cause of considerable analysis and testing in order to determine its associated design criteria.

Further, in September 1976, GE presented to PECO a review of the effort necessary to determine the effect of the newly identified containment dynamic loads on NSSS equipment supplied by GE. GE's estimate was that it would cost $500,000 to $800,000 and require 16 to 20 months. GE also proposed additional testing as part of the long-range program to better define the chugging phenomenon.

A PECO/Bechtel meeting, held January 1977, reviewed the Mark II alternatives available to PECO and their potential schedule impact. Option 1 was based on using available but very conservative data (highest design

forces). Option 2 would allow time for the owners' group activities to generate less conservative criteria, which were scheduled to be available by January 1978. Option 3 would provide the least conservative design criteria but would not be available until January 1979, allowing PECO little time to make the required modifications for an October 1981 fuel load. PECO thus chose Option 2.

The status and schedules of the earlier Mark II projects were an important factor in PECO's decision-making process. At this point in time, Limerick Unit 1 fuel load was projected to be 42 months behind the lead plant, Zimmer (October 1981 vs. April 1978). For comparison, Shoreham was projecting a fuel load in February 1979, LaSalle in November 1978 and Susquehanna in May 1980.

Q. DID MARK II DESIGN WORK BEGIN ON JANUARY 1, 1978 AS SCHEDULED?

A. No, it began well prior to that time. In August 1977, PECO directed Bechtel to begin work based on analytical models developed in the program to date and to evaluate the Limerick containment for bounding loads and for newly identified phenomena.

Bechtel issued a schedule for Mark II Containment Analysis work (P&S 947.1) in September 1977 based on the then identified scope of work. That schedule supported a March 1981 fuel load and required PECO to make a decision by January 1, 1978 on whether to use the KWU or GE quencher (devices used to dissipate steam into a pool of water and designed to minimize the resultant forces from the sudden steam/water impact). Bechtel recommended in December 1977 that PECO investigate the use of the KWU quencher due to its advantages in scheduling, licensability and design loading

over the GE quencher.

Bechtel and PECO held a meeting in 1978 to discuss quencher alternatives. Three alternatives existed:

	Alternatives	Schedule Impact
1)	GE quencher and actual loads	Negative impact for an October 1982 fuel load
2)	GE quencher and conservative loads	Supports an October 1982 fuel load
3)	KWU quencher and actual loads	Supports an October 1982 fuel load if decision made by January 1979

The third alternative was the obvious choice. The use of actual loads in lieu of conservative loads was advantageous due to the fact that they were lower, thus potentially requiring fewer modifications. Thus, PECO requested a proposal from KWU for quenchers in January 1979, with both PECO and KWU agreeing to conditions in May 1979.

Although Forecast 4, issued in December 1979, identified the fact that the Mark II analysis was behind schedule, the driving force for analysis completion was the LOCA chugging loads issue for which final load data was not to be available until the fourth quarter of 1980. PECO and Bechtel made the decision that if the final loads were not available by December 31, 1980, the Limerick project would proceed with the best available information.

At a Bechtel-PECO meeting in April 1980, it was determined that additional work could be done to potentially reduce the impact of the Mark II loads on reactor building piping and equipment. Bechtel developed a three-dimensional analytical model of the reactor-containment building. In addition, an in-plant test was conducted in December 1980 using the Limerick Unit 2

containment to calibrate the model. The above decisions resulted in the overall analysis being delayed 6 to 7 months in order to allow the new criteria from the model to be developed.

By this time, however, the project construction target schedule had been extended for other reasons, resulting in an October 1984 fuel load schedule.

Q. WAS THE CHUGGING LOAD INFORMATION AVAILABLE BY DECEMBER 31, 1980?

A. The chugging data was presented by GE to the NRC on March 11, 1981 and received tentative concurrence pending review and approval of the final report. Bechtel had proceeded to use the interim data prior to this, as decided above, to comply with the project schedule requirements.

Q. HOW WOULD YOU ASSESS THE REASONABLENESS OF PECO'S ACTIONS IN INITIALLY RESPONDING TO THE MARK II CONTAINMENT PROBLEM?

A. PECO's initial actions, which consisted of joining forces with PP&L, GE and Bechtel, placing a hold on the affected portions of containment, incorporating conservatism into the design, reviewing their proposed actions with the NRC, and releasing the hold in order to maintain the containment critical path activities, were sound and judicious. The two month critical path delay caused by the hold was necessary to ensure that significant construction modifications would not later be required which could have caused a more time-consuming and costly impact on the project schedule.

Q. HOW WOULD YOU ASSESS THE REASONABLENESS OF PECO'S DECISION MAKING PROCESS IN ARRIVING AT THEIR JANUARY 1977 DECISION TO BEGIN FINAL DESIGN IN JANUARY 1978 AND TO THUS TAKE MAXIMUM ADVANTAGE OF LESSONS LEARNED ON THE EARLIER MARK II

PROJECTS?

A. PECO's decision was found to be sound and logical. The earlier Mark II projects were as much as 42 months ahead of Limerick, based on their fuel load dates, and PECO was in a position to benefit from their experiences. PECO appropriately chose not to go with the option (option 3) that yielded the least conservative results and potentially the least modifications due to their concerns that it would not support their fuel load date. PECO also appropriately chose to continue selected design and construction activities that could be impacted by Mark II because of the manpower densities that could result from delaying these activities.

Q. HOW WOULD YOU ASSESS THE REASONABLENESS OF PECO'S ACTIONS IN DELAYING THE MARK II RESOLUTION IMPLEMENTATION EFFORTS IN 1978 FOLLOWING THE CONSTRUCTION TARGET SCHEDULE EXTENSIONS?

A. PECO's decision to delay both Bechtel's and GE's efforts in order to utilize the least conservative criteria and thus minimize the scope of modifications was reasonable. This decision still allowed the identified scope of work to be completed in time to support the construction target schedule.

Q. HOW WOULD YOU ASSESS THE LOGIC ASSOCIATED WITH PECO'S ACTIONS IN PURSUING LOAD REDUCTION TECHNIQUES IN 1980 TO REDUCE THE SCOPE OF POTENTIAL CHANGES?

A. PECO's actions were once again found to be reasonable and appropriate. The project circumstances at that time included the realization that the long-term program resolution efforts were not yielding significant load reductions in comparison to the conservative lead plant criteria, as it was earlier believed would occur. With the project schedule extensions that occurred in 1980,

PECO's efforts to attempt to achieve as much load reduction as possible by utilizing more precise analyses and tests, was an appropriate management decision. The potential load reduction benefits that could result made the three-dimensional modelling and Unit 2 containment calibration testing decision logical.

Q. OVERALL, WHAT IS YOUR ASSESSMENT OF PECO'S DECISION-MAKING PROCESS AND THE DECISIONS MADE TO RESOLVE THE MARK II CONTAINMENT PROBLEM?

A. Based on the facts reviewed, TB&A concludes that PECO's actions were reasonable and appropriate. PECO's decisions consistently reflected a concern for ensuring that the least conservative design criteria, consistent with supporting the project schedule requirements, would be utilized. Indeed, the fact that four other Mark II plants were projecting fuel load dates as much as 42 months ahead of Limerick caused PECO to appropriately expect that significant benefits could be derived from the "lessons learned" from the lead plants. It was also reasonable for PECO to expect that the continuing industry tests and analyses, in support of the long-term program, would also remove significant design load conservatism.

4. SUPPORT OF CONSTRUCTION SCHEDULE

Q. WHAT EXACTLY IS MEANT BY ENGINEERING SUPPORT OF CONSTRUCTION AND WHAT CRITERIA DID TB&A USE FOR ITS EVALUATION?

A. Engineering support of construction refers to the timeliness of the issue of engineering drawings and information to the construction forces on the jobsite so as to not delay construction activities. Due to the complexity of the

engineering and design process for a nuclear power plant project and the difficulty of predicting the needs of the construction activities, limited specific cases will generally exist wherein certain engineering information is not available on the construction need date. These specific cases, unless they are the result of serious inadequacies in identifying construction needs, or result in an identifiable delay in the project, are not an indication of improper management performance. Rather, the issue is whether significant engineering information was issued to construction in an untimely manner.

This examination consists of a review of the overall engineering completion rate as well as the timing of issue of the drawings and documents required for the installation of bulk commodities such as cable tray, conduit, piping, and piping hangers.

Q. WHAT WAS THE REPORTED PERCENTAGE COMPLETE OF ENGINEERING AT THE TIME OF RECEIPT OF THE CONSTRUCTION PERMIT?

A. Engineering on the Limerick project was reported as approximately 60% complete at the time of issuance of the construction permit.

Q. IS THAT A SUFFICIENT QUANTITY OF ENGINEERING TO HAVE COMPLETED AT THE START OF CONSTRUCTION?

A. Yes, very much so. The fact that the engineering effort was not decreased or halted during the extended period associated with receipt of the construction permit allowed Bechtel to engineer a significant portion of the plant prior to the start of construction.

Q. WHAT IMPACT DID THIS SIGNIFICANT ENGINEERING PROGRESS HAVE ON INITIAL CONSTRUCTION ACTIVITIES?

A. Initial construction activities were able to progress without significant

restraint from engineering.

Q. WHAT TECHNIQUE DID THE PROJECT ADOPT TO ENSURE THAT ENGINEERING ACTIVITIES DID IN FACT SUPPORT CONSTRUCTION NEEDS?

A. As stated earlier, an important element of the overall engineering planning and scheduling effort was the monitoring and updating of engineering progress against the site 12-month schedule, to ensure that construction's needs would be met.

In addition, the bulk commodity design schedules incorporated the necessary lead times between the completion of the engineering work and the beginning of site activities. For example, the design schedule for large pipe segmented the plant by elevation and facility, and for each such area illustrated the engineering release dates and field need dates, taking into account the necessary lead times for pipe fabrication. To complement the above schedules, the project also developed a "Hanger Schedule Monitor System," which once again by facility and elevation, tracked the hangers through stages of design, fabrication and delivery and highlighted associated problems and resolutions.

Q. HAS TB&A ANALYZED THE RESULTS OF THE PROJECT'S BULK COMMODITY DESIGN EFFORT?

A. Yes. TB&A reviewed the overall progress of the engineering and design of certain bulk commodities to determine whether there were any significant impacts to construction activities that might be reflective of inadequate management practices.

Q. WHAT WERE THE RESULTS OF YOUR REVIEW?

A. TB&A found that bulk commodity engineering progress generally supported

construction needs. The following summary provides a basis for this conclusion:

	Large Pipe Hangers	Small Pipe	Conduit	Wire & Cable
Year design started:	Early-70s	1975	1976	1973
Year significant construction started:	1976	Early-78	1/78	Mid-81
% Design complete when construction began:	74%	80%	50%	82%

As the above illustrates, a large quantity of each of these commodities was designed at the time when significant construction began.

Q. WHAT DETERMINATION OF ENGINEERING SUPPORT OF CONSTRUCTION CAN BE MADE FROM THE REPORTED ENGINEERING PERCENT COMPLETE?

A. The reported engineering percent complete is an indicator of the engineering manhours expended as a percentage of the total engineering manhours currently identified as being required, including new scope and trend manhours. As such, it provides an indication of the overall completion of engineering.

The overall engineering reported percent complete is illustrated in Schedule 2. As this illustrates, engineering progress was relatively rapid through mid-1976, reaching over 70% at that time. Construction at this time was reported to be on the order of 25% complete for Unit 1 and Common. The continual increase in engineering percent complete from the beginning of the project through the middle of 1976 is indicative of the initial engineering planning, wherein it was intended that all of the engineering be complete by the end of 1977. By the third quarter of 1978 reported engineering completion was approaching 90%. Considering that the scope had increased, the overall project schedule had been extended and that almost 90% of engineering was reported

complete within one year of when it was originally scheduled to be completed (1977), this performance represents commendable achievement.

New regulatory requirements which added scope to the project in the 1979 to 1983 period reduced the reported engineering percent complete to as low as 63% in later years. Through increased engineering staffing in the 1980s, however, significant and rapid engineering progress was achieved to support the project schedule. Between early 1981 and mid-1983 the reported engineering percent complete increased from over 60% to over 90%. Scope increases in mid-1983 reduced the reported completion back to approximately 85%. However, continual increasing progress was reported thereafter, reaching virtually 100% for Unit 1 and Common by fuel load in October 1984. Again, throughout this period engineering supported construction with only insignificant exceptions.

Q. WHAT IS TB&A'S OVERALL ASSESSMENT OF ENGINEERING'S SUPPORT OF CONSTRUCTION ACTIVITIES?

A. TB&A concludes that the appropriate management process was in place to provide a high degree of probability that engineering would support construction activities. These processes included the use of construction's 12-month schedule to determine priorities and schedules for engineering activities, and the use of bulk commodity engineering production curves which incorporated lead times for engineering activities.

Furthermore, the project had in place the necessary monitoring tools, such as the monitoring reports and production curves, to allow actual progress to be measured.

The fact that engineering was not slowed down during periods of overall

project extensions was appropriate. This also allowed engineering to increase its lead over construction. Eventually, however, in the 1979-1981 time period, when large additional scope increases were being identified due to additional regulatory requirements, the lead between engineering and construction activities necessarily decreased. This, however, was beyond PECO's or Bechtel's control. Even with this decreased lead time, no examples could be found where the lack of Bechtel engineering design progress for known design criteria was significantly impacting the project's ability to meet the overall fuel load schedule.

E. PROCUREMENT OF ENGINEERED EQUIPMENT, SUBCONTRACTS AND OTHER SUPPLIES

Q. WOULD YOU PLEASE DEFINE WHAT CONSTITUTES PROCUREMENT OF ENGINEERED EQUIPMENT, SUBCONTRACTS AND OTHER SUPPLIES?

A. As the preliminary design is ending, the procurement of engineered materials and subcontracts generally begins. This consists of purchase order placement, contract administration, and the management of material deliveries.

Until equipment is ordered, it is not possible to know the specific sizes, weights, foundation requirements, electrical requirements and other engineering information necessary to finalize the design. The equipment and materials required for the plant are identified from the preliminary drawings. The placement of purchase orders requires writing specifications based on the information from the preliminary engineering plan. These specifications are used to obtain quotations from various equipment suppliers. These bids are evaluated, the work is awarded to the successful vendor, and a purchase order is written and signed.

The second activity, contract administration, consists of monitoring all the activities associated with the fulfillment of the purchase order terms and conditions, including processing technical or commercial changes to the contract and ensuring that the contract is both fulfilled and closed expeditiously. During this time, system design is continuing and, as information is received from the manufacturer, changes may have to be made in either the system, the equipment, or both. This process of exchanging information and modifying the design commonly occurs several times on most purchase orders.

The last aspect of the procurement function is the management of equipment and material deliveries. This consists of ensuring that the material or equipment is delivered before it is needed by the construction forces.

Q. WHAT MAJOR MANAGEMENT ACTIONS ARE REQUIRED RELATIVE TO ENGINEERING PROCUREMENT?

A. The major management actions taken by the A/E relative to engineering procurement are the planning and scheduling of the procurement-related activities so that the development of specifications, performance of bid evaluations, and placement of purchase orders is coordinated with detailed engineering design and construction activities. Sufficient lead times for equipment delivery and for detailed engineering completion after receipt of vendor data must be allowed in the overall schedules so as not to significantly impact the engineering or construction activities.

With respect to the engineered equipment procurement, the owner is concerned with ensuring that a standard sequence of activities is established and is in accord with the project schedule. Typically, several steps in this sequence will involve the owner so that sufficient quality and budget control is

ensured. The owner also monitors the placement of the purchase orders to ensure timeliness, and frequently oversees any subsequent administration of changes to the contracts.

The purchase order placement involves numerous interfaces among the owner, architect/engineer and vendors. This is a critical sequence in the overall process of delivering engineered equipment and material to the job site for installation and, therefore, normally involves substantial owner oversight attention. For a major project such as Limerick, several hundred purchase orders are commonly processed. Appropriate owner involvement should include ensuring the establishment of appropriate detailed procedures, plans and schedules, and monitoring the overall progress of placing purchase orders and subcontracts.

Q. WHAT ACTIONS DID PECO TAKE TO ENSURE THAT A STANDARD SEQUENCE OF ACTIVITIES WAS ESTABLISHED?

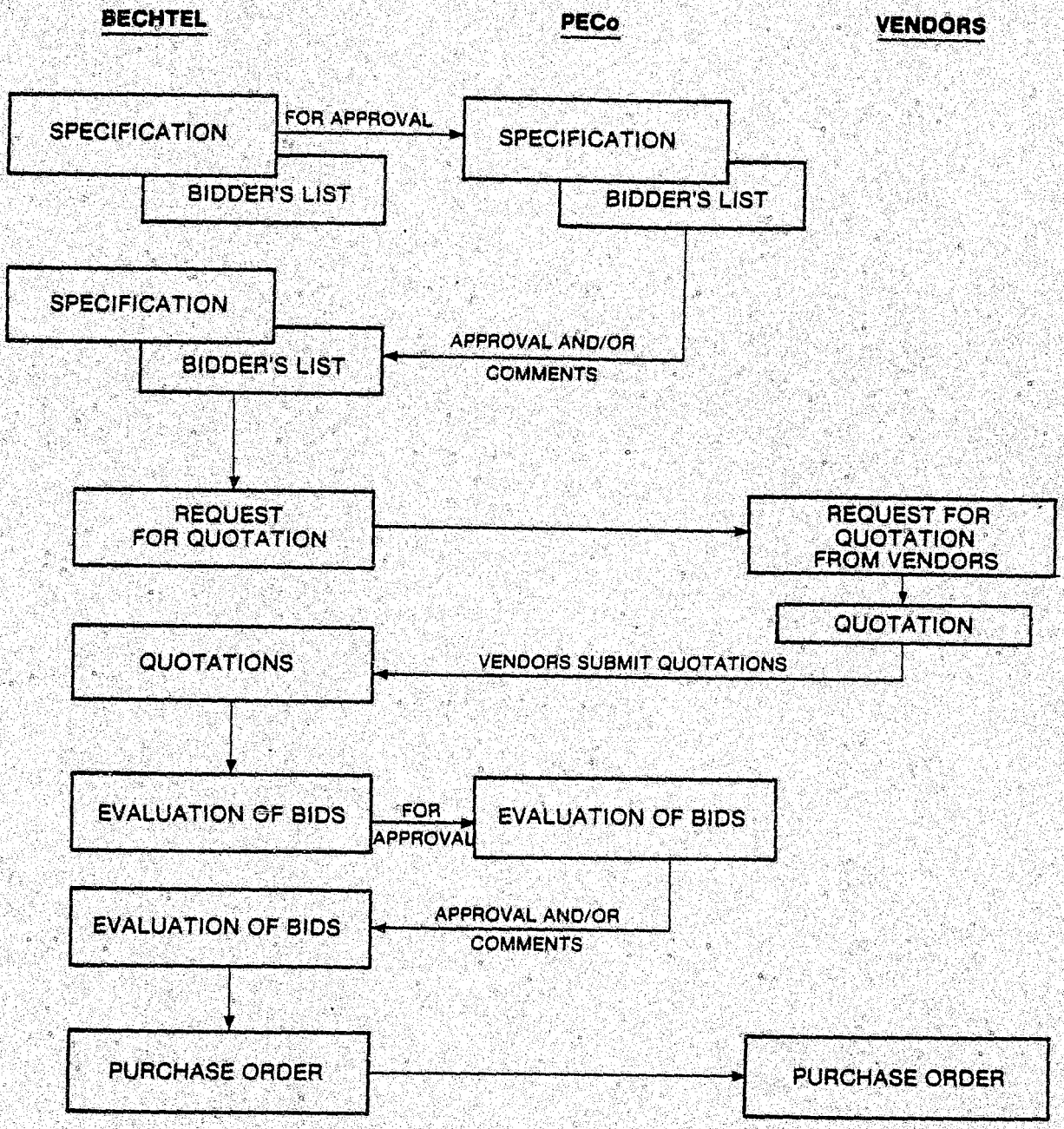
A. The PECO role in the procurement process was established with Bechtel early in the project. PECO's role was to:

- Review and approve specifications prior to issue.
- Review and approve the bidders list.
- Review and approve bid evaluations and recommendations prior to award.
- Review purchase orders and change orders (generally concurrent with issue to the vendor).

A flow chart depicting the overall procurement sequence of events and the above PECO involvement is shown in Schedule 25. This process was utilized for each of the several hundreds of specifications and resultant purchase orders

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ENGINEERING EQUIPMENT PROCUREMENT PROCESS



SOURCE: TB&A ANALYSIS

on the project and is similar, if not identical, to that used by most owners and A/E's.

Q. WHAT WAS THE PURPOSE OF PECO'S INVOLVEMENT IN THIS PROCESS?

A. The overall purpose of PECO's involvement was to assure that their technical, schedule, cost and quality concerns were appropriately addressed in the various procurement documents.

The specifications for the technical criteria and requirements for the equipment being purchased were reviewed by PECO prior to being issued for quotations, to ensure that their requirements had been appropriately addressed. The bidders list, tabulating those vendors to whom the specification was to be transmitted for quotations, was likewise reviewed by PECO to allow additions or deletions based on PECO's knowledge of or past experience with specific vendors.

Following receipt of the quotations or proposals from the vendors, Bechtel proposed an evaluation of the bids and a purchase order award recommendation. This also was reviewed by PECO to ensure that all pertinent aspects of the proposal were appropriately considered and that the resultant commercial terms were acceptable. Elements requiring consideration included overall cost, delivery schedule, exceptions to the technical requirements, quality assurance and control programs, payment terms and escalation clauses.

Finally, the purchase order when proposed would undergo a PECO review for appropriate incorporation of all of the above requirements and considerations into the contractual document with the vendor.

Based on the above PECO involvement, Bechtel established a computer based schedule entitled the "Procurement Status Report" (PSR) to schedule and

monitor the progress of the approximately 250 initial purchase orders for engineered equipment. The PSR tabulated for each purchase order the scheduled dates and actual dates for the significant Bechtel, PECO and vendor activities. This schedule was updated and issued monthly to reflect the latest progress and procurement schedule changes in accordance with the overall project schedule.

Q. WHAT PROGRESS WAS MADE IN THE EARLY STAGES OF THE PROJECT WITH REGARD TO ENGINEERING PROCUREMENT ACTIVITIES?

A. Initial progress was significant. As noted earlier, 33 plant systems were to be duplicates of Peach Bottom Unit 2 and 3 systems. This allowed Bechtel to utilize the equipment specifications from Peach Bottom, with some changes for plant specifics for Limerick, and allowed the procurement process to progress relatively rapidly.

For example, by mid-1972, 280 of an estimated 333 specifications had been prepared and 113 purchase orders of an estimated 293 had been issued to the vendors for purchase. At this time, the construction permit was anticipated to be issued in January 1973.

Q. WHAT WAS THE IMPACT OF THE SUBSEQUENT DELAYS IN RECEIPT OF THE CONSTRUCTION PERMIT ON THE OVERALL PROCUREMENT PROCESS?

A. In August 1973, when the service dates for Units 1 and 2 were rescheduled to July 1979 and December 1980, the overall procurement process status was reviewed. An analysis of the economic benefits of accepting delivery as originally scheduled versus delaying the delivery was performed for all equipment which had been ordered but not yet delivered.

This analysis compared the vendor escalation charges for delayed delivery to PECO's cost of capital for the dollar amount involved for each applicable purchase order. For most purchase orders the most economic result was to delay delivery in accordance with the new schedule requirements and incur the vendor charges.

At this time, GE also stopped all procurement action on much of the equipment to be provided for the Nuclear Steam Supply System.

Procurement activity continued, with additional specifications being generated and purchase orders placed, but with minimal deliveries occurring during the January 1972 - July 1973 construction suspension period.

By the time of receipt of the construction permit in June 1974, however, overall procurement of engineered equipment was significant with over 190 purchase orders having been placed.

Q. SUBSEQUENT TO RECEIPT OF THE CONSTRUCTION PERMIT, DID PROCUREMENT ACTIVITIES SUPPORT CONSTRUCTION?

A. Generally, yes. By July 1976, Bechtel was reporting that procurement activities were to be essentially complete by the third quarter of 1976. Specific instances can be found where the delivery of materials occurred later than the initial construction need date. This is not atypical on nuclear power construction projects. As the engineering scope increased in the mid-to-late 1970s, largely due to new regulatory requirements, the schedule requirements did not always allow sufficient lead time between equipment need identification and construction need date for timely purchase order placement. Thus, in these later stages of the project, the late identification of equipment needs contributed to equipment delivery delays beyond the

construction need dates. These delays, however, were beyond the control of PECO and Bechtel.

Q. WHAT WAS THE NATURE OF THE ITEMS THAT WERE IMPACTING CONSTRUCTION AND WHAT WAS THE EXTENT OF THE IMPACT?

A. A review of the project documents indicated that one of the earliest delivery concerns was for containment suppression pool pipe spools in January 1975. This was only a potential concern at the time - the impact of which was negated later in 1975 by the hold placed on containment activities caused by the Mark II problem. However, this potential concern caused management to implement a program to better control pipe fabrication and delivery schedules in accordance with installation needs. As a result, the entire cycle of engineering, procurement, fabrication and receiving was considered, flow charted and outlined by function so as to facilitate its understanding.

By December 1975, the Procurement Status Report was showing nineteen purchase orders with negative float (i.e. behind schedule). The negative floats ranged from one to fourteen months. The reasons stated for the delays were varied and not atypical, ranging from difficulty in obtaining bidders, to lead time increases, to rewriting specifications to comply with PECo comments. Various solutions were implemented to alleviate the effect of these negative float items, including typical construction work around techniques such as inserting "dummy" valves in piping until the actual values were delivered. In addition, the extensions in the construction target schedules negated the negative float impact of these deliveries.

Q. WHAT TOOLS DID PECO AND BECHTEL MANAGEMENT USE TO MONITOR AND CONTROL THE OVERALL PROCUREMENT OF ENGINEERED EQUIPMENT AND MATERIALS?

A. The three primary reports utilized were the Procurement Status Report which was discussed earlier, the Status of Negative Float Items, and the Expediting Report.

The report on the Status of Negative Float Items, as referred to earlier, included those purchase orders where the status of activities was projected to cause a schedule delay as compared to the established detailed schedule. This report detailed for each applicable purchase order the status, float, cause, and the engineering action required.

The Critical Items Report, issued bi-weekly by the project expeditors, reported on those items involving Bechtel expediting actions at the vendor's facilities when the anticipated delivery did not meet the job site requirements. The report listed for each purchase order involved, the specific items, quantity, current ship date, required delivery date, float, a statement of the problem, action required and the responsible organization.

The associated problems discussed in these reports included engineering holds, engineering reviews of drawings, vendor submittals of drawings to engineering, and various vendor procurement and fabrication problems.

Q. WHAT OTHER REVIEWS AND ANALYSES DID TB&A UTILIZE TO ASSESS THE REASONABLENESS OF PECO'S ACTIONS IN THE AREA OF ENGINEERING EQUIPMENT PROCUREMENT?

A. TB&A conducted analyses of a number of representative purchase orders, including one subcontract. These analyses focused on the significant PECO and

Bechtel actions from specification origination to purchase order award.

Q. WHAT WAS THE RESULT OF THESE ANALYSES?

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

PECO relied on Bechtel's expeditors to identify, implement and resolve most vendor problems encountered after purchase order award and to identify delivery problems. These items were addressed in the Monthly Project Status Review Meetings and PECO took the required action, as necessary, to ensure that resolutions were implemented in a timely and appropriate manner.

In the early stages of the project up to the mid-1970s, the delivery of engineering equipment was not a problem due to the project schedule extensions. Later in the project, as the scope increased significantly and additional equipment was required to be purchased, deliveries did have more of an impact on construction activities as some delays occurred. Such cases, however, are to be expected as late scope increases, due largely to increased and evolving regulatory requirements, caused late identification of equipment requirements and did not allow time for the normal lead period between purchase order placement and construction need.

TB&A concludes that PECO's involvement in the engineering equipment procurement effort was reasonable and appropriate, and reflected PECO's overall concern for thoroughness in the decision-making process. This involvement was one of consistently ensuring that the decision-making process included the pertinent and necessary inputs.

IV. CONSTRUCTION AND STARTUP MANAGEMENT

Q. DESCRIBE WHAT TB&A DEFINES AS CONSTRUCTION AND STARTUP MANAGEMENT?

A. Construction management consists of: 1) owner and A/E site organization, staffing and communications; 2) construction schedule monitoring and control; 3) construction cost monitoring and control; 4) construction quality management; 5) construction manpower planning and management; and 6) construction materials and equipment management. These functional areas are analyzed in this section. In addition, major construction events and activities are evaluated.

Startup management consists of: 1) startup organization and staffing; and 2) scheduling and monitoring of startup activities. In addition to analyzing these functional areas, key events and activities relating to startup activities are also evaluated.

A. CONSTRUCTION MANAGEMENT

Q. PLEASE DESCRIBE CONSTRUCTION MANAGEMENT IN GREATER DETAIL AND HOW TB&A EVALUATES THE REASONABLENESS OF SUCH MANAGEMENT.

A. Construction management consists of organizing, coordinating, managing and controlling all the site-based resources required to construct a large project.

On complex nuclear power plant projects, the management of site resources encompasses the actions of the construction manager (CM) and/or the owner in developing, implementing and monitoring the performance of site located manpower, materials and equipment in the construction of the plant as dictated by the inputs from the engineering design, procurement and quality control/licensing functions.

The overall site management responsibilities should include: 1) the deployment of an effective site organization with the capability to effectively manage all the key aspects of construction activities such as engineering/ construction interface, schedule and cost monitoring and progress review, construction quality control, and subcontractor management; 2) the development and implementation of effective systems and procedures to manage the deployment of an appropriate quantity of qualified labor resources, and the timely acquisition of required construction material and equipment resources; 3) the selection and implementation of management control tools to ensure that all these site based resources are managed and controlled effectively at all times; and 4) the deployment of an effective program reporting system to provide appropriate information to permit timely corrective actions by site based management, if and when necessary.

Effective site management, therefore, ensures that a sound organization equipped with appropriate management tools is in place during the plant construction and that available resources are being utilized with reasonable efficiency in an effort to complete the project within the required budget and schedule guidelines.

Q. WHAT IS THE APPROPRIATE DIVISION OF RESPONSIBILITY BETWEEN OWNER AND THE CONSTRUCTION MANAGER?

A. Within the nuclear power industry, owner involvement in site management varies from one of complete responsibility as construction manager, to one whose responsibility is limited to monitoring and reviewing the activities of the construction manager. This range in the degree of owner involvement stems from a number of factors, including the size of the owner/utility, the degree of the owner's experience in handling large construction projects and the utility's previous efforts at direct construction management and its success in those efforts.

In those instances where the owner hires an outside construction manager and limits its own role to that of an oversight and monitoring function (as was the case in the Limerick Project), the construction manager's tasks typically include such activities as setting up and staffing its site organization; assigning responsibilities and resources for the deployment and management of site based resources (direct, indirect and supervisory manpower; construction materials and construction equipment); planning, scheduling and managing construction related activities; hiring the needed subcontractors (with the owner's participation and approval); developing and implementing a site procedures manual; selecting and implementing effective tools to monitor project schedule and cost progress; and providing the owner with timely, accurate and meaningful progress reports.

The owner's oversight tasks typically include defining the role and responsibilities of the construction manager; reviewing the latter's site organization and key staffing; setting up and staffing its own site organization

to participate in and review key site management decisions, including hiring of major subcontractors; reviewing construction manager developed cost and schedule progress reports; conducting independent cost and schedule progress analyses; supporting the construction manager's efforts to maximize the effectiveness of site-based resources; providing timely actions for problem resolution; and monitoring any corrective actions to be taken by the construction manager.

1. EVALUATION OF CONSTRUCTION SITE MANAGEMENT ORGANIZATIONS

Q. WHAT CRITERIA FOR DETERMINING APPROPRIATE ORGANIZATION, STAFFING AND MANAGEMENT REPORTING DID TB&A USE IN ITS REVIEW OF THE SITE CONSTRUCTION ACTIVITIES AT THE LIMERICK PROJECT?

A. In evaluating the reasonableness of the construction site management organizations, TB&A applied the following general criteria:

- The specific responsibilities of the owner and the construction manager should be clearly defined.
- The site management organizations (CM's and owner's) should be established prior to the beginning of construction activities, and evolve over time to satisfy the changing requirements at the project site.
- The organization structures should cover all the defined areas of responsibilities for the owner and the construction manager and should have clearly defined reporting relationships with adequate spans of control.
- The key positions in these organizations should be staffed with

personnel with a good blend of experience in: 1) large construction projects; 2) nuclear plants; 3) power plant operations; and 4) the local construction environment.

- There should be reasonable continuity of personnel in key positions over the duration of the project.

- Formal and informal mechanisms to facilitate adequate communications through management reports, project status control reports, and meetings should be used.

Q. PLEASE DESCRIBE THE PECO SITE ORGANIZATION AND THE RESPONSIBILITIES OF PECO CONSTRUCTION DIVISION PERSONNEL.

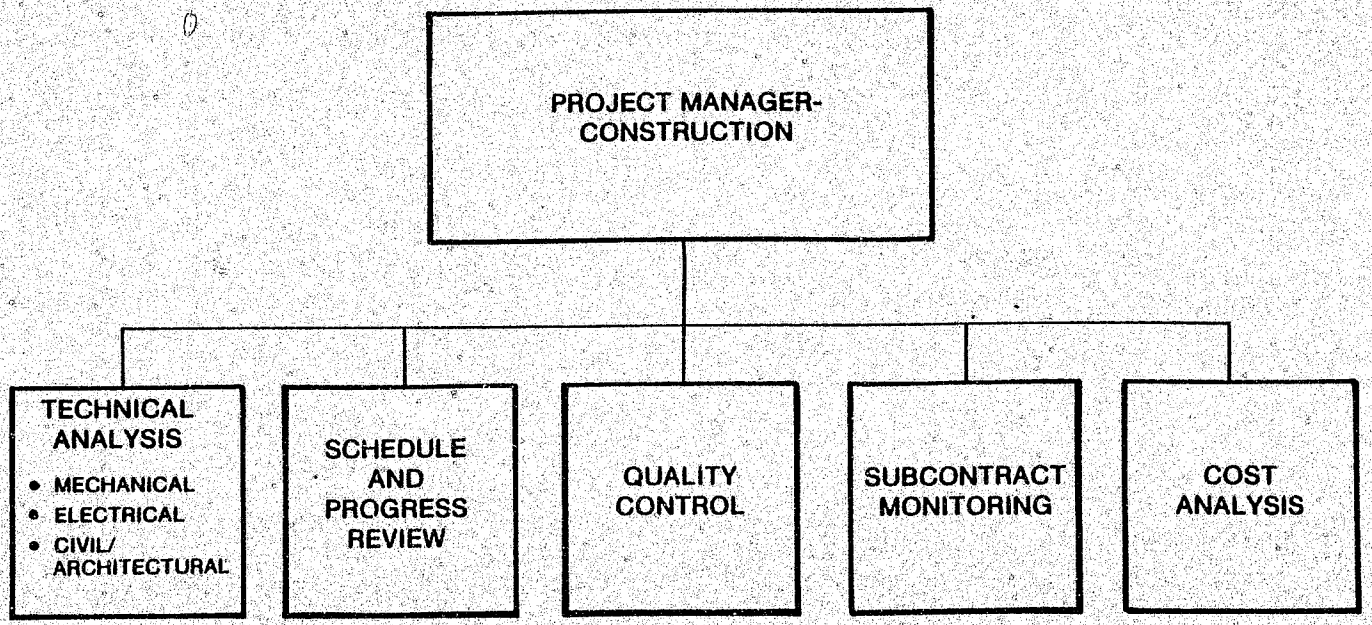
A. The PECO construction organization is illustrated in Schedule 26. PECO's site organization was headed by the PECO Construction Manager who reported to the General Superintendent of PECO's Construction Division. The organization was structured functionally under the PECO Construction Manager into five groups - Technical Analysis, Scheduling, Subcontract Monitoring, Cost Analysis, and Quality Control.

The Technical Analysis Group was composed of field engineers whose responsibilities included performance of any technical reviews accomplished at the site. This included review and comment on project drawings and specifications, and response to NRC questions concerning field activities. The Scheduling Group was comprised of field engineers whose responsibilities included the monitoring of construction progress and attainment of schedules. The Subcontract Monitoring Group maintained PECO participation in the area of subcontracts beginning with pre-bid meetings, subcontractor selection and approval through the monitoring of the subcontractor's performance until

PHILADELPHIA ELECTRIC COMPANY

PHILADELPHIA ELECTRIC COMPANY—LIMERICK SITE CONSTRUCTION ORGANIZATION

1984



SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

SCHEDULE 26

completion of the job.

The Cost Analysis Group was responsible for monitoring project construction costs in the areas of field labor staffing, materials, labor performance and field procurement. The Quality Control Group was responsible, while utilizing formal inspection procedures and checklists, for the inspection of nonsafety-related construction activities for quality of workmanship, completeness and improved plant operability. This program was implemented by PECO management to assure the quality and reliability of the entire plant.

Q. HOW DID THIS ORGANIZATIONAL STRUCTURE EVOLVE OVER TIME AND WAS THERE CONTINUITY OF PERSONNEL IN KEY POSITIONS?

A. The basic organizational structure shown in Schedule 26 was maintained throughout the project. However, additional full-time, permanently assigned employees were added as necessary to reflect the increasing complexity and size of the construction effort. TB&A's review of project organizational charts indicated that during the 1971-1975 period there were approximately 13 full-time PECO field engineers on site. As the project evolved, this number increased to about 25 full-time field engineers by 1980. In addition, as many as 26 quality assurance personnel were assigned to the field to perform audits and surveillances as part of the formal PECO QA/QC program.

The continuity of PECO site management personnel in key functions is demonstrated by the fact that positions such as the PECO site Project Manager-Construction and Vice-President of Engineering and Research (previously Manager-Engineering and Research) were held by the same individuals for the entire duration of the project. Many of the field engineers

spent four to six years at the site before being promoted to positions at corporate headquarters that directly utilized their Limerick-specific experience.

Q. WHAT TYPE OF BACKGROUNDS AND QUALIFICATIONS DID THE PECO SITE MANAGEMENT PERSONNEL POSSESS?

A. PECO generally assigned experienced construction personnel to the site organization at Limerick. Capitalizing on the experience gained from the construction of Peach Bottom 2 and 3, as well as drawing from the Company's other non-nuclear construction work, PECO was able to assemble a highly experienced construction team. Representative of the experience that PECO was able to bring to bear on the construction of Limerick, was the Project Manager of Construction, who at the time of his assignment to the job in 1970 had over 13 years of major construction experience. PECO, throughout the course of Limerick construction, adequately staffed its site organization with sufficient personnel with the construction experience that contributes to the successful completion of a nuclear power plant.

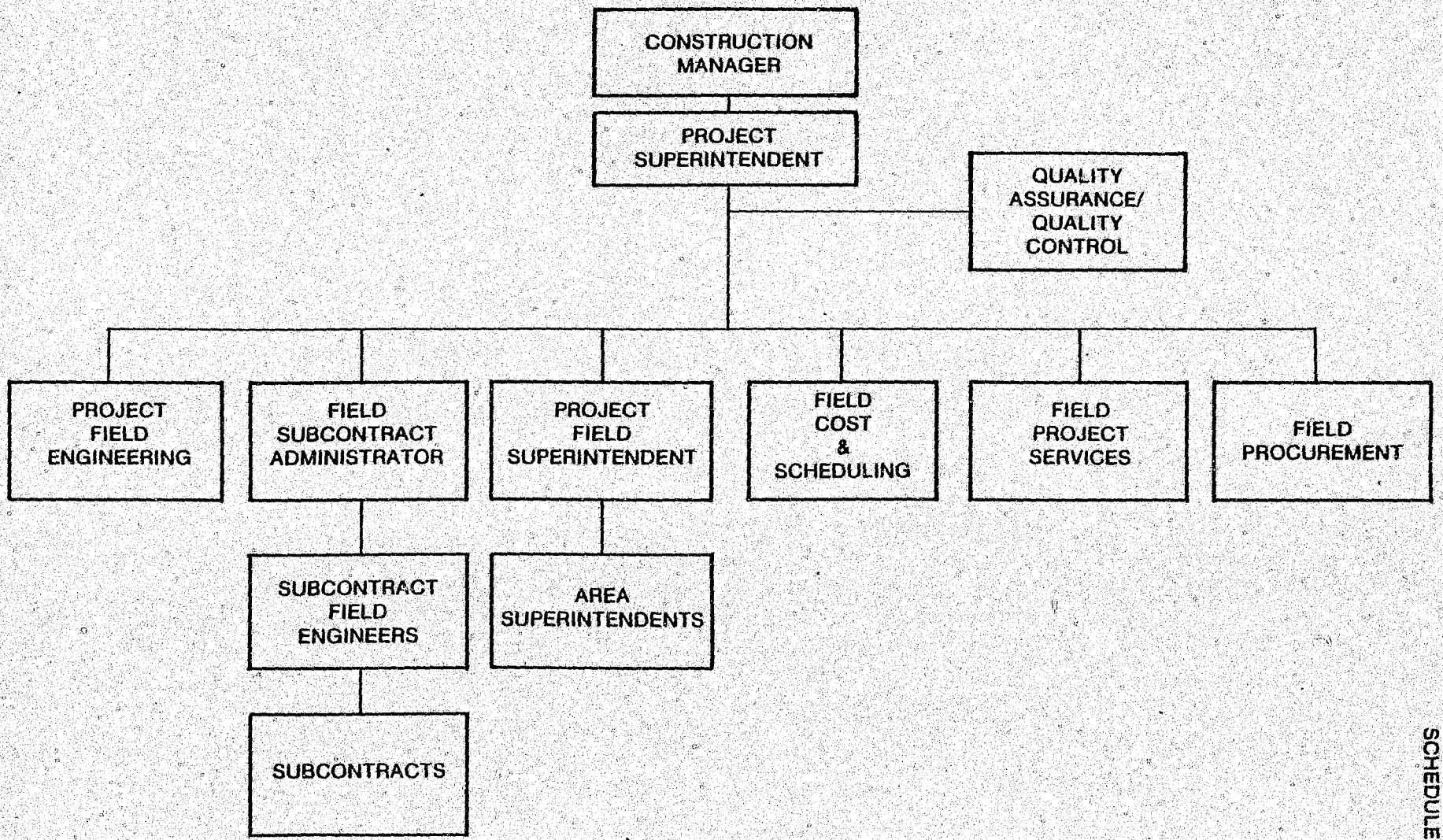
Q. HOW WAS BECHTEL'S CONSTRUCTION MANAGEMENT ORGANIZATION STRUCTURED AT LIMERICK?

A. Bechtel's organization, like PECO's, evolved throughout the project as scope and emphasis dictated. Schedule 27 shows the basic organization structure used for site management. The organization was headed by a Project Construction Manager responsible for the overall construction effort, supported by a Project Superintendent, Project Field Superintendent and Project Field Engineering staff. Superintendents for each of the major areas of construction, including mechanical, instrumentation, electrical and civil, reported to the Project Field

PHILADELPHIA ELECTRIC COMPANY

BECHTEL LIMERICK SITE CONSTRUCTION ORGANIZATION

1984



SOURCE: BECHTEL RECORDS

SCHEDULE 27

Superintendent. The construction organization also contained a number of support services, including safety, security, training, labor relations, and cost and scheduling.

Q. WHAT LEVEL OF EXPERIENCE DID BECHTEL PROVIDE IN STAFFING THE SITE ORGANIZATION?

A. Bechtel generally provided experienced personnel in the key positions at the site throughout the project. Bechtel used the same Project Manager throughout the project's construction.

Q. HOW WAS PECO ABLE TO ASSURE THAT BECHTEL PROVIDED EXPERIENCED PERSONNEL FOR THE LIMERICK PROJECT?

A. PECO reviewed resumes for key Bechtel employees prior to their assignment to the project, paying particular attention to the level of experience necessary for the completion of Limerick.

Q. HOW WELL DID PECO'S SITE ORGANIZATION MESH WITH BECHTEL'S CONSTRUCTION MANAGEMENT ORGANIZATION?

A. To a large degree, PECO's site organization mirrored that of Bechtel. The area engineers were responsible for essentially the same geographical areas as Bechtel's superintendents. This facilitated communications between the parties and eliminated uncertainty as to who was responsible for specific tasks. The PECO field engineers responsible for areas such as cost or schedule analysis worked with comparable Bechtel staff on a daily basis, assuring easy access by PECO to Bechtel information and PECO's timely input into key decisions.

Q. WHAT FORMAL MECHANISMS WERE DEVELOPED FOR DEFINING SITE RESPONSIBILITIES AND PROCEDURES?

A. As previously described, a comprehensive project procedures manual was

initially issued in 1971, prior to the start of construction, and covered all administrative procedures of the project, including those relating to site management. The manual, based upon Bechtel's corporate procedures for major construction projects and enhanced through PECO review and recommended modifications, provided the site organization with a well-defined set of responsibilities and procedures. The project procedures manual, after review and approval by PECO, was modified on numerous occasions during the project, with the latest revision being Revision 7, which was issued in February 1984.

The project procedures manual detailed organization structures, responsibilities, interfaces, and administrative procedures. This included defining the construction organization, its responsibilities, and its function within the overall project. The manual was divided into three major sections, Departments, Administrative Functions and Third Party Interfaces. Within the Departments section, descriptions of the functions of each department on the project were provided, including Engineering, Construction, Procurement, Division Services, Project Administration, Quality Assurance and Startup. The Administrative Functions section provided procedures for the project's accounting, communications, and reports. A description of the Bechtel/GE interface was provided in the final section.

Q. WHAT CHANNELS DID PECO AND BECHTEL UTILIZE FOR BOTH FORMAL AND INFORMAL COMMUNICATION?

A. Schedule 28 lists some of the key regular reports that TB&A examined while reviewing PECO's site management records. The topics indicate that the type, depth and focus of information available for management decisions changed appropriately as the project evolved. For example, in an effort to better report

PHILADELPHIA ELECTRIC COMPANY

MAJOR CONSTRUCTION REPORTS

REPORT TITLE	ORIGIN	FREQUENCY	REPORT FUNCTION
PE Schedule Analysis	PECo Construction	Monthly	Project status by system, facilities, subcontractors, commodities and other key areas
Monthly Cost Report	PECo Construction	Monthly	Reports actual vs. budget expenditures, commodity performance, special reports
Construction Div. Activities	PECo Construction	Monthly	Reports on the activities of the construction division, including status of system work
Bechtel Force Report	Bechtel	Daily	Total manpower count by craft
High Spot Report	PECo	Monthly	Items of interest at PECo generating facilities
Items of Interest	Bechtel	Monthly	Comments on engineering items of interest
Procurement Status Report	Bechtel	Monthly	Identifies lead times necessary to place PO's and schedule of actual procurement activity
Subcontract Award Status	Bechtel	Monthly	Identifies subcontractors and critical activities
Subcontractor Award Schedule	Bechtel	Monthly	Summary level subcontractor bid and construction schedules
Adwin Monthly Expenditures Report	Bechtel	Monthly	Summary of material and expenditures
Work In Progress Trial Balance	Bechtel	Monthly	Total costs of Limerick work order by subdivision account (current month, year to date, total)
Critical Item List Action Report	Bechtel	Monthly	Identifies items and activities that could potentially impact schedule

SOURCE: PROJECT RECORDS

construction progress and performance, PECO Construction began issuing the Monthly Cost Report in January 1977, which detailed actual versus budgeted expenditures, commodity performance and summaries of special cost studies. In addition to the Monthly Cost Reports, the monthly Philadelphia Electric Schedule Analysis (PESA) and the Construction Division Activities Report were prepared by PECO's construction organization. These reports provided a formal mechanism for PECO Field Engineers to communicate with upper management and were utilized to report concerns relative to cost, schedule, quality and other construction activities.

The central document for communications among all parties involved, however, was the Monthly Project Status Review Report, which was produced by Bechtel from 1974-1984 and was distributed at the regular monthly meeting. The topics covered in the report and at the meetings included schedule progress, budget and cost control, project quality, procurement, manpower, engineering progress, and other key issues. The scope and emphasis of material covered changed over time as the project evolved.

Some of the beneficial results of these monthly reports and meetings included consistency in communication between all parties involved, identification of problems, assignment of responsibilities and reporting on problem resolution.

Two weeks prior to the Monthly Project Status Review Meeting, a meeting on construction-related issues was held, with attendees including Bechtel site personnel and the Project Manager, PECO's Project Manager, construction superintendents, field engineers and subcontractor representatives. The meeting provided a forum for the various parties involved

in the construction to discuss issues in detail and resolve them prior to the monthly meeting.

Weekly meetings were also held between subcontractors, area engineers and area superintendents to discuss project progress. In addition, PECO and Bechtel functional groups met regularly to share information and to analyze and report on key parameters. Other ad hoc meetings, reports, letters, etc. were also used to assure that adequate communications were maintained during the day-to-day activities at the site.

Q. WHAT CONCLUSIONS DID TB&A REACH RELATIVE TO THE SITE ORGANIZATION, STAFFING AND REPORTING ON THE LIMERICK PROJECT?

A. TB&A has concluded that PECO's management actions relative to the deployment of its own site management organization and to the oversight and monitoring of Bechtel's organization structure and staffing were appropriate and reasonable.

PECO's on-site management organization was set up at the beginning of the construction and evolved over time to reflect the changing needs of the project. This organization structure properly satisfied the owner's primary responsibilities relative to the oversight and monitoring of the Construction Manager's activities. PECO's site organization was appropriately staffed and reflected reasonable continuity in the key positions. PECO's use of many of its experienced construction personnel from Peach Bottom and other major construction projects, such as Eddystone, was sound.

Bechtel's site organization was likewise defined early and was set up at the beginning of the construction at Limerick. Bechtel's organization structure

was similar to that utilitzed by Bechtel on other construction projects and was well-proven. It reflected satisfactory continuity and experience levels in the key positions. Owner and construction manager's responsibilities, along with many other site related procedures, were appropriately documented in the Procedures Manual early in the project. TB&A concludes that this is indicative of PECO management's concern over the need for clear definition of responsibilities and the identification of appropriate site procedures.

TB&A concludes that the reports, meetings and other channels for communication on the Limerick Project were reasonable and effective. The regular reports described in Schedule 28 provided adequate information to all involved parties in a timely fashion. The monthly review meetings and reports provided an effective forum for problem resolution and for project review and planning. In addition, other regularly scheduled and ad hoc meetings provided opportunities for close coordination of efforts by all involved parties.

2. EVALUATION OF SUBCONTRACT MANAGEMENT ORGANIZATIONS

Q. PLEASE DESCRIBE WHAT IS MEANT BY SUBCONTRACT ADMINISTRATION.

A. Subcontract administration focuses on the management of subcontractors by the Construction Manager and owner. This area includes the coordination, monitoring and implementation of the requirements of the subcontract following the selection of a successful bidder. In sum, the administration of the subcontract concerns itself with the effective management of a subcontractor to ensure the fulfillment of his contractual obligations.

Q. DURING ITS REVIEW OF PECO'S AND BECHTEL'S SUBCONTRACT MANAGEMENT ORGANIZATIONS, WHAT CRITERIA DID TB&A EMPLOY TO EVALUATE PECO AND BECHTEL PERFORMANCE?

A. TB&A examined the subcontract administration organization at Limerick to ensure the following: 1) the specific responsibilities of the subcontractor, owner and Construction Manager were clearly defined; 2) the reporting relationships and levels of controls by the owner and Construction Manager over the subcontractor were clearly defined and implemented; 3) the organization was established prior to the beginning of a subcontract; and 4) procedures were established for handling backcharges, subcontractor scope and design changes, and default and termination of a subcontract.

Q. WHAT WAS THE DIVISION OF RESPONSIBILITIES FOR SUBCONTRACT ADMINISTRATION BETWEEN PECO AND BECHTEL AT THE LIMERICK PROJECT?

A. Most subcontracts for the Limerick project were executed between Bechtel and the subcontractor. Bechtel handled most direct administration of subcontractors, with PECO providing an oversight role over both Bechtel and the subcontractor. However, PECO management was actively involved in the resolution of subcontractor problems.

Q. PLEASE DESCRIBE THE ORGANIZATION THAT BECHTEL AND PECO PUT IN PLACE FOR SUBCONTRACT ADMINISTRATION.

A. As shown on Schedule 27, which illustrates the entire Bechtel construction organization, subcontract administration at the site was handled by the Field Contract Administrator. His function was to serve as the responsible supervisor to the Bechtel Subcontract Administration Group, to monitor performance of subcontractors in the areas of quality and schedule, and to coordinate with the Field Engineer, Field Superintendents at the jobsite, and the Contracts Supervisor in Bechtel's home office. He reported directly to the

Project Superintendent. Reporting directly to the Field Contract Administrator were the Bechtel Subcontract Field Engineers. Each Subcontract Field Engineer was assigned one or more subcontracts, and was responsible for assuring compliance by the subcontractor to contractual terms and conditions. His duties included monitoring actual performance of construction work and coordination with other subcontractors and the Bechtel construction forces.

PECO maintained an organization structure for subcontract administration within its construction organization. Its organization paralleled that of Bechtel, but served a different purpose. PECO's Subcontract Administration Group monitored both Bechtel's and the subcontractors' performance on the project, beginning with attendance at pre-bid meetings, subcontractor selection and approval, through monitoring of performance and completion of the job.

Q. WHEN WERE THE SUBCONTRACT ORGANIZATIONS ESTABLISHED FOR PECO AND BECHTEL AT THE SITE?

A. Both PECO and Bechtel established their subcontract management organizations at the site at the same time the overall construction organization was established.

Q. WERE THE RESPONSIBILITIES OF THE OWNER, SUBCONTRACTOR AND CONSTRUCTION MANAGER CLEARLY DEFINED AT THE OUTSET OF THE PROJECT?

A. Yes, two major administrative procedures manuals were issued prior to receipt of the project's construction permit, which clearly defined the responsibilities and interfaces between owner, construction manager and subcontractor. The Limerick Project Procedures Manual detailed the overall project procedures

including the management of subcontracts. More importantly, with respect to subcontract administration, Bechtel issued, in December 1973, the Subcontract Administration Procedures Manual which provided detailed information on all aspects of handling subcontractors at the Limerick project.

Q. HOW WERE CHANGES TO A SUBCONTRACT HANDLED BY THE PROJECT?

A. Both PECO and Bechtel recognized the fact that on occasion changes may be necessary to a subcontract. Changes that are necessary include such items as design changes caused by design evolution or regulatory impacts, deterioration of financial conditions of the parties involved in the contract, or efforts to improve efficiency and performance in completion of the contracted work. One example of a subcontract that required renegotiation was the HVAC subcontract, which is described in detail later. Another example was the subcontract for the cooling towers which was renegotiated in September 1975 to minimize cash flow due to PECO's cash constrained condition.

Bechtel maintained formal procedures for handling a subcontractor-requested amendment to the contract. A subcontractor would submit a proposal detailing the change and the reasons for it to the Field Contract Administrator for review to determine the merit of the request. If indeed the reason was valid, and if PECO concurred, the subcontract would be amended.

Q. WHAT DOES THE TERM "BACKCHARGE" MEAN, AND HOW DO BACKCHARGES OCCUR?

A. A backcharge is a reimbursable cost sustained by the Construction Manager or Owner on account of the actions of a subcontractor which is charged back to that subcontractor.

A backcharge may result from: 1) services performed by the

Construction Manager, at the subcontractor's request, for work within the subcontract scope; 2) costs sustained by the Construction Manager or PECO as a result of a subcontractor's operations; or 3) costs sustained by the Construction Manager or PECO as a result of a subcontractor's act of omission.

Q. WAS THERE A FORMAL PROCEDURE FOR HANDLING BACKCHARGES?

A. Yes, Bechtel maintained a formal procedure for backcharges to subcontractors on the project. During the pre-award meeting between Bechtel and the subcontractor, the subject of backcharges was discussed. The subcontractor was advised that a backcharge may result from either a request of the subcontractor or from his performance or failure to perform, thereby necessitating action on the part of Bechtel. Backcharges required authorization by the Field Construction Manager after approval from the PECO Project Manager - Construction.

Q. DID THE PROJECT HAVE A PROCEDURE FOR HANDLING SUBCONTRACTOR DEFAULT AND SUBCONTRACT TERMINATION?

A. Yes, Bechtel maintained a formal procedure for handling the default and termination of a subcontract. When it appeared on the project that it was inevitable that the Construction Manager and the Project and/or Owner would sustain an unacceptable level of damage as a result of the subcontractor's actions, the subcontractor would be notified that he was in default of the contract. A remedy would be stated and the time frame in which the correction needed to be made, with failure to do so resulting in the termination of the subcontract. Any termination of a subcontract required the approval of PECO.

Q. WHAT ARE TB&A's CONCLUSIONS RELATIVE TO THE AREA OF SUBCONTRACT MANAGEMENT ORGANIZATIONS AT LIMERICK?

A. TB&A concludes that the organization structures that were utilized by both PECO and Bechtel were appropriate for administration of subcontracts at Limerick. These organizations were instituted in a timely fashion at the outset of the construction project. The Subcontract Administration Procedures Manual and the Project Procedures Manual, each of which was also instituted in a timely fashion, provided clear definition of specific roles and responsibilities of the subcontractor, Construction Manager and Owner at the Limerick Project, and served as a sound and proper basis for managing subcontracts. These management tools provided reporting requirements for the subcontractor and set forth the necessary levels of control by the Owner and Construction Manager over the subcontractor. Effective control mechanisms were established from the outset of the construction project for handling major areas of subcontract management, including backcharges, amendments, defaults and terminations of a subcontract. TB&A concludes that both PECO and Bechtel established a reasonable and effective organization for management of subcontracts at the Limerick Project.

3. EVALUATION OF CONSTRUCTION QUALITY CONTROL

Q. PLEASE DEFINE CONSTRUCTION QUALITY CONTROL AND DESCRIBE TB&A'S REVIEW OF THIS ASPECT OF THE LIMERICK PROJECT.

A. Achievement of specific levels of quality at a nuclear power plant is required in order to license the plant for operation. Formal programs for attaining these necessary levels of quality are developed for all nuclear power plants pursuant to Nuclear Regulatory Commission regulations, 10 CFR 50. A nuclear plant's

quality program encompasses all those policies established, procedures implemented and actions taken by management to provide adequate assurance that the technical and quality requirements applicable to the project are met.

Q. WHAT CRITERIA DID TB&A EMPLOY TO EVALUATE PECO'S CONSTRUCTION QUALITY MANAGEMENT?

A. TB&A identified four specific elements which are necessary for an effective construction quality program: 1) a well-organized, structured and staffed quality organization which is independent of the organizations being audited and which has adequate authority to effectively monitor compliance with technical requirements; 2) owner commitment to a high level of quality and a communication of that commitment to site personnel; 3) work product acceptance, i.e. inspections and other steps taken to assure that work is being performed in compliance with applicable requirements; and 4) timely corrective action to remedy nonconforming conditions and a defect prevention process to eliminate root causes of recurring problems. These four elements embrace the detailed NRC quality requirements of 10 CFR 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants."

TB&A, in its review of construction quality assurance, measures the quality assurance efforts of the owner and Construction Manager at the construction site, and evaluates these efforts against the requirements of the NRC and actions typically taken by other utilities involved with nuclear construction projects.

Q. WHICH ORGANIZATIONS HAD FORMAL RESPONSIBILITY FOR QUALITY ASSURANCE (QA) AND QUALITY CONTROL (QC) AT THE LIMERICK NUCLEAR PROJECT?

A. Quality assurance at Limerick was ultimately the responsibility of the owner, PECO. However, all participants in construction had a formal role in complying with the requirements of 10 CFR 50, Appendix B. PECO had a group of up to 26 QA field personnel located at the site with responsibility for audits and surveillance of construction. This group was directly responsible to the QA Section Engineer-In-Charge who was responsible for the overall quality assurance program.

In addition, Bechtel had both a Quality Assurance group and a Quality Control group at the site. The site QA group was responsible for assuring that all material and equipment met the required standards when used in safety-related systems. The QC group was responsible for assuring that installation was accomplished according to approved procedures and for conducting inspections of completed work. The Bechtel QC group consisted of as many as 219 quality control engineers. Finally, each subcontractor and supplier had to maintain an approved quality assurance and quality control plan for material supplied or work done on safety-related systems.

Q. DID PECO MAKE EFFORTS TO IMPROVE THE QUALITY OF CONSTRUCTION AT THE SITE THROUGH ANY OTHER MEANS?

A. Yes. In addition to the formal QA/QC program that PECO maintained, there was also a QC group associated with the construction management division located at the site. This group was formed at the beginning of the project to monitor the quality of non-safety-related systems and components which could interact with safety systems. For most of the project, the group consisted of 2 field engineers, 7 inspectors and 2 construction assistants. Results of inspections and suggestions for improvements were forwarded through

appropriate channels for quick resolution. This group also reviewed Bechtel's QC inspection plans to ensure that a sufficient level of detail was included.

Q. WAS PECO'S QUALITY FUNCTION ORGANIZED TO PROVIDE THE INDEPENDENCE REQUIRED TO ENSURE QUALITY?

A. Yes. The Section Engineer-In-Charge reported to PECO's Vice-President of Engineering and Research, giving quality assurance the independent authority to implement actions in deficient areas. The Section Engineer was thus independent of the groups his organization was required to audit.

Q. DID PECO ENSURE THAT THE QUALITY ASSURANCE AND QUALITY CONTROL ORGANIZATIONS HAD THE AUTHORITY TO EFFECTIVELY MONITOR COMPLIANCE WITH TECHNICAL REQUIREMENTS?

A. Yes. In addition to the organizational independence of the QA/QC organization, PECO also ensured through the QA procedures that the QA personnel had the power to monitor compliance with technical requirements.

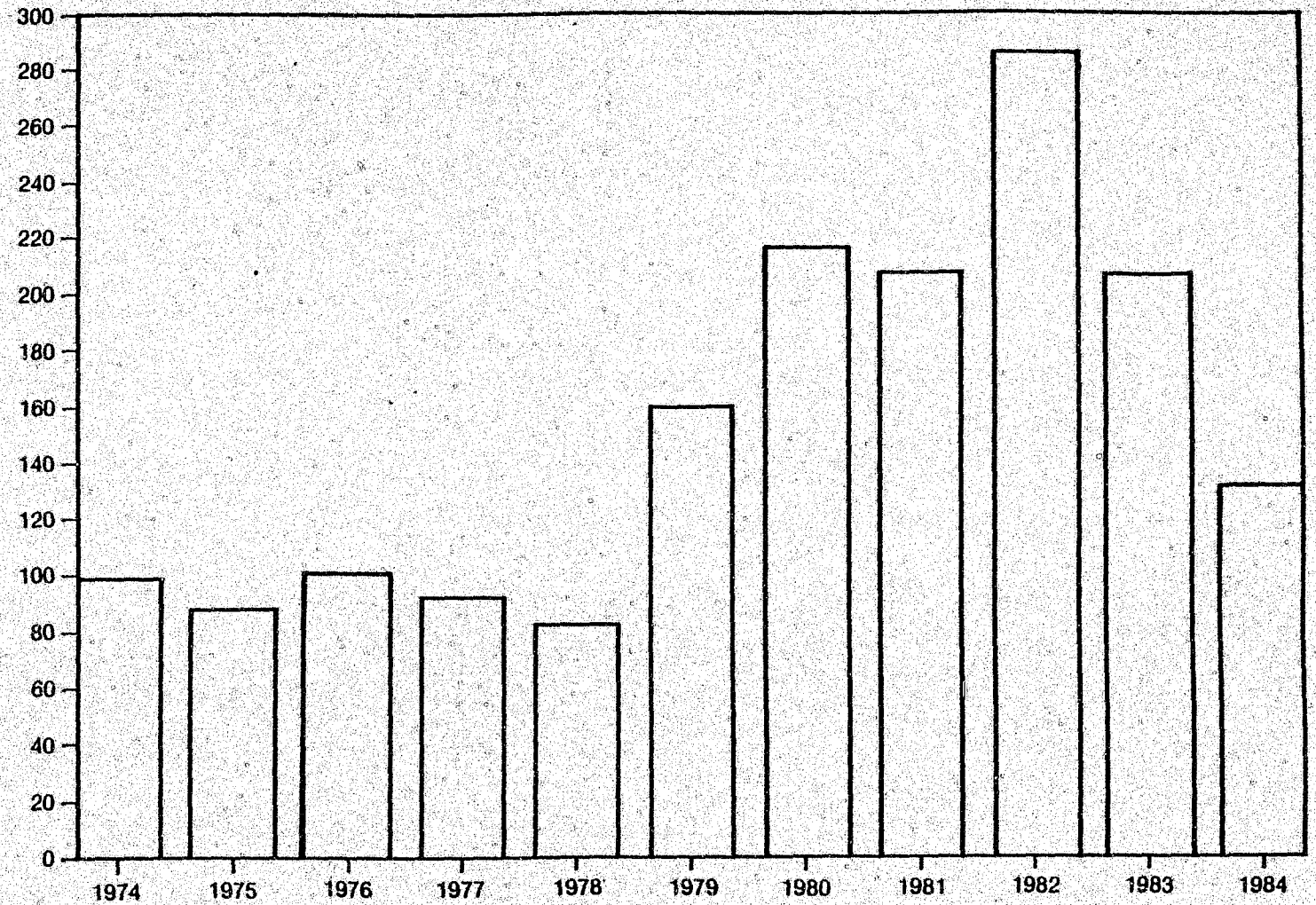
Audits were conducted by both PECO and Bechtel QA. Unsatisfactory findings required formal corrective actions by the organizations that were judged deficient. In those cases where the quality organizations considered an item to be a major problem, they could issue a "stop work order." This action was taken on Limerick in a number of specific cases, but no project-wide or major functional work area stop work order was ever issued.

Q. DID TB&A ASSESS PECO'S IMPLEMENTATION OF PROGRAMMATIC AND MANAGEMENT AUDITS?

A. Yes. The PECO site QA group conducted numerous audits. Schedule 29 shows the number of site audits performed by the PECO QA Department by year from 1974 through 1984. These audits addressed the work performed by Bechtel and

PHILADELPHIA ELECTRIC COMPANY

QUALITY ASSURANCE SITE AUDITS



*YEAR IN WHICH AUDIT WAS INITIATED

SOURCE: PHILADELPHIA ELECTRIC COMPANY FIELD QA AUDIT LOG; TB&A ANALYSIS

SCHEDULE 29

General Electric as well as the PECO efforts. Bechtel received the largest number of audits since Bechtel was responsible for the primary activities at Limerick.

PECO's QA field branch conducted and documented over 3200 surveillances and audits throughout the project. A review of the field audits indicated that the audit program was a useful management tool as the number of audits increased over time.

Q. WHAT WAS TB&A'S APPROACH TO ASSESSING THE AREA OF MANAGEMENT COMMITMENT TO HIGH QUALITY?

A. In evaluating management commitment to high quality, TB&A addressed the following questions:

1. Was PECO's commitment to a high level of quality for Limerick communicated to all concerned?
2. Did PECO assure that lines of authority were defined and that implementing procedures were issued?
3. Did PECO make provision for programmatic and management audits through which to monitor and improve performance where indicated?

Q. WHAT ARE TB&A's FINDINGS IN THE AREA OF MANAGEMENT COMMITMENT TO HIGH QUALITY?

A. PECO demonstrated a commitment to a high level of quality. During the initial organization of the project, PECO defined a QA program that addressed specific quality requirements for construction but went beyond NRC requirements. For example, PECO worked with Bechtel to develop detailed pre-pour plans for difficult concrete pours. Examples such as this demonstrated PECO's strong commitment to quality management.

Quality assurance and quality control matters were important agenda items at the Monthly Project Status Review Meetings since the early days of the project. PECO established a program wherein all of the participating project organizations implemented those elements of quality control that were applicable to their area of responsibility

PECO Quality Assurance worked with Bechtel in defining improvements to the quality program. In the 1976 PECO QA report to management, PECO QA reported that all the desired amendments for Limerick had been accepted. The amendment process was progressive and had occurred over a four year time period with PECO constantly working to improve various parts of the Bechtel quality program.

Q. WHY IS IT IMPORTANT TO ACCOMPLISH WORK PRODUCT ACCEPTANCE EFFECTIVELY?

A. It is essential to verify that plant systems are constructed in accordance with the approved design. Also, effective work product acceptance, inspection and surveillance/audit programs will result in the timely identification of nonconforming conditions requiring correction. Work product acceptance, corrective action and defect prevention together characterize an effectively executed and functioning quality program. When work product acceptance reveals a problem, corrective action must be taken. If further analysis reveals that there are a number of such problems, a training program is necessary for the personnel involved so that the defect is prevented in the future.

Q. WHAT WAS TB&A'S APPROACH TO ASSESSING THE AREA OF WORK PRODUCT ACCEPTANCE?

A. TB&A evaluated two specific areas in assessing PECO's oversight of work

product acceptance:

1. Did PECO assure that detailed work product acceptance and inspection programs and procedures were implemented in a timely manner?

2. Were provisions made by PECO to assure timely documentation and verification of work product acceptance steps?

Q. WHAT ACTIONS DID PECO TAKE IN IMPLEMENTING ITS WORK PRODUCT ACCEPTANCE OVERVIEW ROLE?

A. PECO took steps to ensure that work product acceptance procedures and programs were implemented for construction and material control activities. PECO provided the quality personnel used in conducting surveillances over Bechtel.

PECO QA established yearly goals that included improvement in the Bechtel quality programs. This type of goal setting provided PECO with specific objectives to be accomplished during specific time periods. The objectives were developed as a result of observed problems or concerns with the various programs.

Q. HOW IMPORTANT IS IT TO HAVE A SATISFACTORY CORRECTIVE ACTION AND DEFECT PREVENTION PROGRAM?

A. Satisfactory corrective action programs will ensure that problems are resolved quickly. Unnecessary delays in correcting problems can result in additional costs for deferred rework and delays in completing subsequent work and system testing. Defect prevention programs reduce the number of potential items that might require corrective action.

Q. DESCRIBE TB&A's APPROACH TO ASSESSING THE AREA OF CORRECTIVE ACTION AND DEFECT PREVENTION?

A. TB&A reviewed the area of corrective actions and defect prevention implemented during the construction of Limerick to ensure that: 1) a reasonable system was instituted by PECO to document and report nonconforming conditions; 2) corrective actions were taken by PECO to resolve nonconforming conditions; and 3) the system permitted PECO to identify adverse quality trends and prevent their recurrence.

Q. WHAT STEPS WERE TAKEN BY PECO IN THE AREA OF CORRECTIVE ACTION AND DEFECT PREVENTION?

A. PECO took steps to assure that systems were in place to document and report nonconforming conditions. As described earlier, PECO had established a site surveillance program. Discrepancies found during audits and surveillances by the PECO QA personnel were documented. Bechtel performed the work product acceptance inspections and was responsible for documenting nonconforming conditions. Bechtel used a Nonconformance Report (NCR) to document nonconforming conditions. PECO frequently reviewed Bechtel's NCR log during periodic surveillances to ensure that timely corrective action was being taken to resolve NCRs.

PECO also took a number of steps to prevent defects. The early implementation of a quality program, the requirement for quality defined in Bechtel's contract, the ongoing reviews and audits of the quality program and the favorable trends being identified during the audit process -- all indicate a solid PECO involvement in defect prevention.

A Joint Utilities Management Audit (JUMA) of the Limerick Quality Assurance Program that was conducted on March 29, 1981 and April 1, 1982 resulted in the conclusion that:

"It is the opinion of the JUMA Auditors that the Quality Assurance Program pertaining to construction of the Limerick Generating Station meets the Regulatory requirements committed to in the PSAR."

The combination of the analysis gained from the internal audit program that was conducted by PECO, the JUMA reports and the NRC SALP reviews, which were also favorable, equated to an active program by PECO to prevent defects.

Q. DID PECO'S AUDIT PROGRAM ADDRESS DOCUMENTATION OF NONCONFORMING CONDITIONS?

A. Yes. PECO's field QA organizations conducted audits of Bechtel, General Electric and PECO. The findings from those audits were documented and tracked.

PECO established a computer program to track and follow up on the findings. The program was established in late 1973 for the PECO home office and in 1974 for the Limerick Site. The program made it possible to respond to the unsatisfactory findings identified by the audit/surveillance programs.

Q. WHAT OTHER EFFORTS WERE MADE TO IMPROVE QUALITY OF CONSTRUCTION AT THE LIMERICK PROJECT? .

A. PECO's commitment to quality construction is also seen in the numerous labor management programs that were instituted. These included Quality Circles, employee suggestion programs and formal training programs. Illustrative of this commitment to quality was a videotape produced onsite by Bechtel to teach pipefitters and welders how to inspect hangers during installation so as to assure that the hangers were within the required tolerances. By providing this type of training, overall quality was improved and failures during Bechtel's QC inspection were reduced. This in turn minimized overall construction costs.

Q. PLEASE SUMMARIZE YOUR FINDINGS ON PECO's MANAGEMENT OF THE

QUALITY PROGRAM AT LIMERICK?

A. TB&A concludes that PECO and Bechtel made a very strong commitment to project quality. PECO recognized the importance of an effective quality program, acknowledged and accepted direct responsibility for the overall program, and took appropriate steps at all management levels in obtaining a firm management commitment to the Limerick quality program on the part of Bechtel.

PECO's commitment to a high level of quality was established early in the Limerick Project and was communicated throughout the duration of the project. PECO participated actively in the preparation and implementation of the quality program policies and procedures.

PECO effectively used programmatic audits to monitor performance of the quality program participants. PECO took steps to follow up on corrective actions that resulted from those audits.

PECO also took steps to ensure that Bechtel, General Electric, and their suppliers implemented corrective action systems to promptly correct nonconforming conditions. Systems were implemented early in the project to prevent recurrence of specific nonconforming conditions identified in surveillances and audits. The Limerick Project was not affected from a schedule standpoint by a breakdown of the quality program.

4. EVALUATION OF CONSTRUCTION SCHEDULE AND COST CONTROL

Q. PLEASE DESCRIBE WHAT TB&A DEFINES AS CONSTRUCTION COST AND SCHEDULE CONTROL AND EXPLAIN WHY IT IS BEING SEPARATELY EVALUATED?

A. TB&A defines construction schedule and cost control as: 1) the development of

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

Proper cost and schedule control is the key to site management's ability to successfully manage the construction of a complex project such as Limerick. It is for this reason that TB&A examines cost and schedule controls separately.

Q. WHAT CRITERIA DOES TB&A APPLY IN ASSESSING THE REASONABLENESS OF NUCLEAR PROJECT COST AND SCHEDULE CONTROL EFFORTS?

A. TB&A employs several criteria in evaluating the reasonableness of major project cost and schedule control efforts. These include evaluating whether:

- Cost and scheduling tools are representative of contemporaneous techniques and should be implemented at the outset of construction.
- Schedules with various levels of detail are available to the site management to provide an overall perspective and the planning tools necessary for detailed scheduling of site resources. Typically the minimum number of schedules used by management is three: 1) overall milestone schedule; 2) mid-range 12-month schedule; and 3) detailed schedule by area/elevation on anywhere from a weekly to a quarterly basis.
- Schedules are updated on a regular basis to reflect current conditions.

- Management takes reasonable corrective actions to manage identified schedule slippages.
- Cost control systems are well-developed, made effective early in the project's development, and changed over time as needed because of project status changes.
- Cost control systems present a reasonable performance standard against which project progress can be measured, permit identification of deviations from the project plan and facilitate identification of the causes of such deviations, and permit the development of reports and data useful at all levels of project management.
- The owner takes reasonable actions to assure that cost and schedule control systems which meet its changing needs are implemented on the project.
- The cost and schedule control systems work as an integrated management planning tool.

To satisfy these criteria, a cost and schedule control system must provide for compilation of reasonably accurate data regarding past installation and projected future installation of materials and equipment, development of a reasonably achievable and logical plan for project progression, and progress reports on cost and scheduled use of the several resources employed in project construction, i.e. materials, equipment, manpower and cash. The scheduling system should contain useable and reasonably detailed construction logic, and schedule and cost baseline plans should be revised/updated with reasonable regularity.

a. Schedule Control

Q. PLEASE DESCRIBE THE TYPES OF SCHEDULES UTILIZED ON THE LIMERICK PROJECT FOR MANAGING CONSTRUCTION ACTIVITIES.

A. PECO and Bechtel utilized a number of different types of schedules on the Limerick project to coordinate both construction and startup activities. For construction, four levels of schedules were utilized: 1) a milestone summary schedule for reporting to management; 2) a master project schedule for long-term planning; 3) a mid-range, 12-month planning schedule for individual facilities and elevations; and 4) a set of highly detailed short-term schedules for allocating day-to-day resources at the site.

Changes in the type and format of these schedules occurred as necessitated by the changing project requirements. For example, in 1978 PECO construction management recognized that, as the project shifted from installation of civil commodities to that of mechanical and electrical commodities, a change was needed in scheduling techniques. This change provided Bechtel and PECO with a schedule that more accurately monitored that phase of the project, and thus permitted better schedule control by PECO and Bechtel construction management. These changes reflected the evolution of the project from early civil and structural construction, to bulk commodity installation and finally to system turnover and startup. Also, scheduling methods evolved or were replaced as improvements in scheduling technology became available during the course of the project.

Q. PLEASE PROVIDE FURTHER DETAIL REGARDING THE USE MADE OF THE SEVERAL SCHEDULES EMPLOYED ON THE LIMERICK PROJECT.

A. The milestone schedule provided a summary of construction progress to keep

upper management informed of project status. It was appropriately designed to convey an overview of present status and schedule after only limited study. This schedule was not generally used by the construction forces since its level of detail was, because of its purpose, limited.

The long-range scheduling tool initially utilized at the Limerick Project was the computerized "Management Schedule and Control System" (MSCS). It was originally implemented in 1973 and was revised quarterly to reflect actual progress and other changes. This schedule relied upon the Critical Path Method (CPM), whose basic component is a network of arrows that run between nodes indicating the beginning and end of all discrete activities required to complete the project. Through the use of logic and a computer program, the thousands of activities required to construct a nuclear plant were analyzed and graphically represented in this network. The duration for each activity, its interrelationship with other activities, and the excess time available to accomplish each activity (float time) were all displayed in a manner that provided the construction manager with detailed and understandable information.

Beginning in the fall of 1978, a new schedule, termed the "Intermediate Construction Schedule" (ICS), was included with each issue of the MSCS schedule. After the ICS had been successfully parallel-tested with the MSCS, it replaced the original system. The last issue of the MSCS schedule was on April 2, 1979 with the 21st quarterly revision.

Q. WHY WAS THE MSCS REPLACED WITH THE ICS IN 1979?

A. In 1978, as the project moved from the civil/structural and major equipment installation phases to the bulk commodities installation phase, PECO

determined that there was a need for a scheduling system that provided better control of commodity installation for each elevation and area of the plant than the MSCS schedule allowed. More specifically, PECO was concerned that the MSCS, with its emphasis on tracking progress on a macro level by systems and project milestones, was not adequately monitoring construction progress by task and subtask by building elevation and area location. Ease of installation of a bulk commodity varies throughout the different areas of a plant. MSCS treated the ease of installation of a bulk commodity the same, regardless of location. Furthermore, PECO concluded that the ICS scheduling method accommodated sequencing changes to a much greater degree than the MSCS. The critical path modelling used in the MSCS is inflexible in that it requires a rigid sequencing of activities. This rigidity is appropriate for the civil/structural phase of a project, where construction sequence is of necessity controlled by the natural sequence of building installation. However, bulk commodity installation requires that a scheduling system be flexible to permit rearrangement of installation sequences due to factors such as material or equipment unavailability, redesign, interferences and other typical construction processes.

Finally, PECO believed that ICS provided a more accurate assessment of schedule progress due to its use of the earned-value concept of schedule attainment. The earned-value concept assigns credit for installation of material based upon the degree of difficulty and complexity, which eliminates distortions in reported progress resulting from accomplishment of less difficult work. Because this method considered the degree of difficulty of installing such commodity, it provided a more reliable and flexible schedule monitoring

tool.

Q. WHEN DID THE ICS SCHEDULE GO INTO FULL TIME USE, AND WHAT SPECIFIC FUNCTIONS DID IT PERFORM?

A. Beginning in February 1979, the ICS schedule was used to establish construction completion dates on a facility and commodity basis in order to meet dates for system startups and fuel load. The ICS utilized the project data base in the Forecast, Control and Updating System (FOCUS) to develop bulk commodity quantities and manhours required for various construction activities, thereby providing the essential integration of the scheduling and cost control systems. Using this information, work on various commodities was scheduled at each elevation of a facility. The progress of each commodity and elevation was monitored using the earned value concept described above. The result was a detailed, accurate and flexible scheduling system. Bechtel later utilized this system on other nuclear projects under the name of "Construction Control Schedule" (CCS).

Q. PLEASE CONTINUE WITH YOUR DISCUSSION OF SCHEDULING TOOLS, PARTICULARLY THE MID-RANGE (1 YEAR) SCHEDULE.

A. For mid-range planning, a 12-month schedule was prepared by field supervisors and planners. This mid-range schedule was specific to each section and elevation of the site facilities. It was effectively used for detailed planning purposes at the site and as a barometer to gauge the construction progress on a monthly basis. This schedule was revised and re-issued every three months in order to reschedule incomplete tasks, reflect the completed tasks and add the new tasks to be performed during the next period. This updating of the mid-range schedule served as an important monitoring tool.

Each revision of the 12-month schedule was distributed to all organizations involved with site management following a review by PECO's Construction Division and comparison to the project's long-term schedule. In addition, the 12-month schedule was compared to the ICS schedule to determine impacts to the overall performance and progress of construction, and whether the schedule of the project was being maintained.

The flexibility and detailed nature of the 12-month schedule are the keys to its strength as a management planning and scheduling tool. It presented the scheduling information in a form that allowed rapid determination of slippages, difficulties and detailed progress not possible in the longer, more macro level long-range schedule of the project.

Q. WHAT DETAILED SCHEDULES WERE UTILIZED BY SUPERINTENDENTS AND FOREMEN FOR DAILY PLANNING AND ALLOCATION OF SITE RESOURCES?

A. A three to four week construction schedule was prepared by the area superintendents to plan daily activities and to ensure that work crews performed in the most efficient manner possible. This schedule was highly detailed and provided specific construction information at the pipe spool, pipe hanger, instrument, etc. level. Weekly field meetings attended by PECO and Bechtel engineers focused on resolution of problems, coordination between work crews, and ways to improve performance to meet established completion dates.

Q. WERE ANY SPECIAL PURPOSE SCHEDULES UTILIZED DURING THE CONSTRUCTION OF LIMERICK?

A. Yes, a number of special purpose schedules were used during the construction

of Limerick. These schedules focused on a particular area of the plant that was critical to meeting the overall project schedule or was difficult to complete. The schedule was for the duration required to complete the area or system, and at a detail level similar to the three to four week construction schedules described earlier. The purpose of these schedules was to ensure that the overall project schedule would not be impacted by difficulties encountered with completion of these important construction tasks.

Q. HOW WERE THE VARIOUS CONSTRUCTION SCHEDULES UTILIZED BY PECO AND BECHTEL MANAGEMENT IN MAKING MAJOR PROJECT DECISIONS?

A. As discussed above, the long-range, mid-range and short-range schedules were used for the efficient planning and implementation of construction activities. The schedules were also used in the Monthly Project Status Review meetings to reallocate materials and manpower so as to maintain optimal schedule progress, and to inform various project entities of project status and upcoming events. Finally, these scheduling processes were an integral part of the upper management decision-making process when questions of budget, project completion date and manpower availability arose. For example, Bechtel performed an analysis which developed schedules and fuel load dates with cash unrestrained and restrained and with differing levels of labor effectiveness. These analyses were employed in resource and other planning related to the project, including overall project planning for Limerick.

Q. WHEN SCHEDULES FOR CONSTRUCTING LIMERICK WERE DEVELOPED, WHAT INPUTS HAD TO BE CALCULATED OR ESTIMATED, AND HOW DID THE ACCURACY OF THESE ESTIMATES AFFECT THE PROJECTED SCHEDULED COMPLETION DATE OF THE PROJECT?

A. Based upon an extensive review of Project documents, TB&A carefully analyzed the early Project schedules and the causes of deviations from those schedules. A number of factors had a significant impact on the final scheduled completion of the Limerick project. These factors are outlined below:

- Scope of the project includes the actual amount of material (concrete, pipe, wire, etc.) to be installed, which had to be estimated at various points during the project. Initially, material quantity estimates were based on experiences with Peach Bottom, and then became more precise as final designs were completed. However, significant increases due to evolving design and increasing regulatory complexity resulted in additional manpower requirements and congestion in the work areas, which hindered installation and adversely affected the optimal density of the workforce.

- Unit rates, which define the number of manhours needed to install a unit of a commodity (manhours/cu. yd for concrete, manhours/linear foot for pipe, etc.), were estimated based on expected improvements due to the learning curve effect from other projects. However, significant increases were experienced due to increased regulatory complexity and congestion as described further below.

- Budget constraints caused cutbacks in available cash and led to less than desired staffing levels during certain periods of cash constraints.

- Manpower estimates assume certain levels of availability of craft

personnel. Unanticipated shortages of certain crafts disrupted scheduled work, requiring rescheduling or other actions to resolve.

- Sequencing of commodity installation in order to minimize interferences and provide maximum flexibility during actual construction was sub-optimal due to regulatory change.

Such factors, as the result of their adverse effect upon initial project schedule estimates, prevented attainment of early project schedules.

Q. WHAT MAJOR CHANGES TO THESE ESTIMATES WERE NECESSARY?

A. As noted, each of the variables mentioned above needed some modification during construction of the Limerick Project and affected PECO's and Bechtel's ability to develop attainable schedules for the project. For example, the amount of material to be installed increased significantly, requiring additional work. Unit rates (which are addressed in detail later) varied relative to those estimated for different commodities, requiring additional manhours to accomplish a given workload. Shortages of pipe welders and sheetmetal welders resulted in inadequate staffing during the 1978-1980 period. Sequencing of installation was also adversely affected by these problems and the regulatory design changes which largely underlay them.

Q. WHAT DID TB&A CONCLUDE RELATIVE TO PECO's ABILITY TO MEET THE SCHEDULES THAT WERE DEVELOPED THROUGHOUT THE PROJECT?

A. Successful accomplishment of scheduled work hinges on the ability of the owner and Construction Manager to bring the resources needed for the project together in a timely manner. These resources include material, equipment, manpower, controls and management. Throughout the project, PECO and

Bechtel supplied appropriate schedule control systems and management expertise to effectively control the project. These systems and their features and usage appropriately evolved or were updated over time. Using these tools, PECO and Bechtel management recognized schedule slippages and their causes and sought to take corrective action.

However, cutbacks in funding due to PECO's financial condition, scope changes and increases in total quantities due to the continuing evolution of the nuclear industry and the design impacts of TMI, Mark II, seismic requirements and other regulatory requirements, and their associated detrimental impact to productivity led to a shortfall in construction progress during certain periods. Shortages of key crafts, such as welders in 1978-1980, led to staffing levels below those required.

As a result of all of these factors, during the period from 1974-1980, construction progress at Limerick consistently missed scheduled targets. In analyzing the reasons for these schedule slippages, TB&A has concluded that they were beyond the control of PECO and Bechtel site management personnel.

b. Cost Control

Q. WHAT IS MEANT BY THE TERM "COST CONTROL"?

A. Cost control is the monitoring of project costs by management for determination of a project's actual performance against that which was estimated. By accurately tracking project costs, management is in a position to determine those areas that are at variance with the current cost projection, and thus take corrective action to mitigate the variance.

Q. HOW SHOULD THE PROJECT ESTIMATE FOR COST CONTROL PURPOSES

BE DEVELOPED?

A. The development of a reasonable project cost estimate is essential to establish a proper basis for cost control. The determination of a reasonable project cost estimate requires a "bottom-up" approach, in which the cost estimate is prepared by determining the detailed quantities of materials, labor and equipment required for constuction of a particular plant system. A good estimating process is detailed enough to include determination of not just, for example, the amount of pipe that is required, but rather how much 4-inch diameter special alloy pipe is required. Once the accurate quantities of materials, labor and equipment have been estimated for each system and area of the plant and their associated costs, an overall project cost estimate for the project can be calculated.

The project's cost control system is then used to track the performance of installation of materials, equipment and associated manhours against those quantities estimated in the project cost estimate. In this manner, management can accurately determine project progress both in terms of cost and quantities of materials installed.

Q. WHAT TYPE OF RESOURCE PLANNING AND MEASUREMENT SYSTEM WAS UTILIZED ON THE LIMERICK PROJECT?

A. Bechtel used the Forecast, Control, and Updating System (FOCUS) to accomplish cost control and manpower planning. FOCUS is a fully integrated system that was developed by Bechtel in the early 1970s to: 1) document cost performance; 2) pinpoint areas requiring greater management attention; and 3) provide a mechanism to forecast the impact of problems for management. It is used to compile both historical data on quantities and productivity and to

forecast labor needs based upon design requirements and projected unit rates.

Q. HOW WAS DATA COMPILED FOR USE BY THE FOCUS SYSTEM?

A. Data was compiled in computerized data bases that were developed specifically for Limerick. This data was collected for commodity quantity identification through five distinct data bases: 1) concrete construction; 2) large pipe; 3) small pipe; 4) equipment and instrumentation; and 5) electric circuits and raceway. These five data bases established codes for major material quantities. Other non-unique materials received suspense codes which were later manually allocated.

This system, which was known as the Limerick Resource Management System (LRMS) and more specifically the Quantity Tracking System (QTS) within the LRMS, permitted the unique identification of all commodity items by the time they were designed. The QTS system contained six critical milestones: Design, Procurement, Delivery, Installation, QC Inspection and Turnover for Startup. These key milestones are critical because responsibility was often transferred to different groups within the project organization at these points.

Q. HOW WERE CRAFT LABOR COST ESTIMATES DEVELOPED?

A. Craft labor estimates were developed using the QTS by assigning unit rates to the commodities. This was done by cross-referencing labor codes to QTS cost codes on a facility or, in some cases, an elevation basis. The correlation between the coding of quantities and the 4000-plus installation activities was done by the FOCUS Program. The quantities and unit labor rates were adjusted periodically to reflect changes in design requirements, labor productivity and procedures.

Q. PLEASE DESCRIBE HOW THE FOCUS SYSTEM COMPARED THE ACTUAL HOURS SPENT ON AN ACTIVITY TO THE NUMBER OF HOURS BUDGETED.

A. This was done through the labor cost management system, which compared actual hours expended to install various commodities to the established or budgeted estimates for that task. Craft labor hours, which were estimated based on experience with other projects and input from construction superintendents, were assigned through the QTS cost codes along with specific commodity amounts.

Q. HOW WERE PERFORMANCE RESULTS FOR INSTALLATION OF SPECIFIC COMMODITIES REPORTED?

A. Reporting on commodity installations was accomplished on a weekly basis through the Summary Weekly Labor Cost Report. This report provided summary data for each identified commodity, including quantities, actual manhours and unit manhours for the week and to date. The weekly report also included the forecast of to-go manhours for specific quantities and information on performance ratios and trend forecast performance. One of the primary purposes of the Weekly Cost Report was to give detailed weekly and to-date performance data to field supervision in order to minimize deviations from schedule. Labor cost variances and future labor reallocations were projected through the FOCUS Performance Report-Summary of Total Project, which showed the differences between the Trend Forecast Manhours and the Forecast Estimate. TB&A found that considerable time was expended by both Bechtel and PECO site management personnel in evaluating labor cost variances to determine the causes and means of correction.

Q. DID THE UNIT RATES ESTIMATED FOR EACH WORK AREA BY FOCUS REMAIN THE SAME THROUGHOUT THE PROJECT?

A. No. A unique and very important feature of FOCUS was the recognition that labor unit rates usually vary by both location in the facility and percent complete of a particular commodity, i.e. some areas are more difficult to work in, and as completion nears, the work becomes more difficult. These differences were resolved through the application of multiplier curves, called the FOCUS curves, which corresponded to the relative stage of commodity installation. They were developed by examining historical data and the specific difficulties associated with the task being performed.

Q. HOW WAS THE FOCUS SYSTEM UTILIZED IN FORECASTING TO-GO WORK?

A. The first step in forecasting to-go work involved revising the total quantities used on the project. This was done by accessing information from both drawing take-offs and engineering estimates stored in the LRMS.

The FOCUS system provided the amount of materials installed to-date for each bulk material. Based upon the percent complete of the material, coupled with the FOCUS curves and their associated to-go unit rates for that bulk material, the number of manhours required for completion of the task (to-go work) were determined.

Q. HOW WAS SUPPORT LABOR TAKEN INTO ACCOUNT?

A. Support labor was grouped into two classifications: 1) activity-related accounts; and 2) time-dependent accounts. Estimates for the activity-related accounts were done on a crew basis; time-dependent accounts were forecasted on the basis of expenditure rates per time period and expenditure rates as a percentage of the bulk commodity installation activities.

Q. HOW WERE CRAFT LABOR COSTS DEVELOPED WHEN DIFFERENT CRAFTS CONTRIBUTED TO THE INSTALLATION OF A COMMODITY?

A. Craft labor costs were developed by the use of a craft-account matrix. This matrix was based on historical information and showed data relative to percentage breakdowns of various crafts needed to install a given amount of each commodity. The craft hours were then combined with a wage rate analysis for each craft and a schedule that projected how many manhours would be worked by each craft during each year. Using wage rate escalation estimates, yearly and total manual labor costs could be calculated.

Q. HOW WERE MATERIAL COSTS DEVELOPED FOR THE PROJECT?

A. Cost codes were used to assemble the material quantities, which were then entered into a cost and commitment program. Using a material pricing review, which included recent trends, costs for all materials were developed. The total forecast was then made by taking the forecasted unit prices and the quantity of to-go commodities, calculating to-go costs, and adding this amount to to-date expenditures to obtain the total estimated material costs.

Q. WHAT DID TB&A CONCLUDE ABOUT COST CONTROL TECHNIQUES UTILIZED ON THE LIMERICK PROJECT?

A. TB&A has concluded that PECO and Bechtel used sound cost control techniques that provided key information to those who needed it and allowed both PECO and Bechtel to maintain an accurate awareness of the status of the project at all times.

TB&A concluded that PECO and Bechtel utilized state-of-the-art cost control and estimating tools for the Limerick Project. These efforts included the Monthly Cost Reports to identify and report key information to upper

management, Special Cost Reports to identify specific cost saving programs, work sampling programs to improve employee productivity, and extensive involvement in analysis of Bechtel's Project Forecasts. These efforts enabled PECO site management to remain informed of project costs and developing trends, and to appropriately inform upper management when necessary.

PECO site management also worked closely with Bechtel in controlling costs so as to assure maximum progress within the constraints of the limited budgets that existed for much of the project. This included implementation of FOCUS, development of ICS, and institution of major programs for improving employee morale and productivity. TB&A found that PECO construction management was accurately informed and aware of the project's cost and schedule performance through the various construction reports shown in Schedule 28. Based on these efforts, TB&A concluded that PECO and Bechtel were reasonable in their efforts to control construction costs for the Limerick Project.

5. EVALUATION OF MANPOWER PLANNING AND LABOR MANAGEMENT

Q. PLEASE DESCRIBE WHAT IS MEANT BY MANPOWER PLANNING AND LABOR MANAGEMENT.

A. Manpower planning encompasses the timely identification and deployment of the required manpower resources on the construction site in order to complete the various tasks within the cost and schedule constraints. Effective labor management relates to the group of management actions and processes necessary to ensure that the manpower resources at the job site are being soundly managed. These actions generally refer to the areas of optimization of labor efficiency, minimization of labor delays both within a crew and of the

crew itself, craft labor supervision, ratio of indirect to direct labor, use of overtime and shift work, manpower training, labor relations, work rules, personnel safety and site security.

Q. HOW DID TB&A EVALUATE WHETHER PECO AND BECHTEL WERE REASONABLY EFFECTIVE IN THEIR MANAGEMENT AND USE OF LABOR RESOURCES AT THE LIMERICK PROJECT?

A. TB&A examined the labor management practices at Limerick to ensure the following: 1) management appropriately forecasted overall manpower requirements throughout the duration of the project; 2) reasonable levels of non-manual and supervisory personnel were used; 3) overtime and shiftwork were used in a controlled fashion for specific reasons, such as schedule recovery; 4) appropriate efforts were undertaken to monitor, and if necessary, to improve labor effectiveness, including methods improvements; and 5) labor relations, security and safety programs were implemented to address the specific needs of the project.

Q. WHAT TECHNIQUES DID SITE MANAGEMENT UTILIZE FOR MANPOWER PLANNING AT LIMERICK?

A. The primary tool used by Bechtel for manpower planning was FOCUS, as described previously. This system provided estimates for the remaining quantities of materials to be installed, and coupled with unit rates used in the system, also provided the number of manhours associated with those quantities. Using this information and the crew sizes and manpower densities established by the construction supervisors allowed the various construction activities to be scheduled and the manpower loading estimates to be prepared. TB&A found that this integration of the cost and scheduling systems yielded an

appropriate manpower planning tool that provided both PECO and Bechtel management with information necessary to accurately plan for the manpower needs of the project.

Q. DESCRIBE THE HIERARCHY OF SUPERVISORY PERSONNEL ON THE LIMERICK PROJECT THAT DIRECTLY MANAGED MANUAL LABOR?

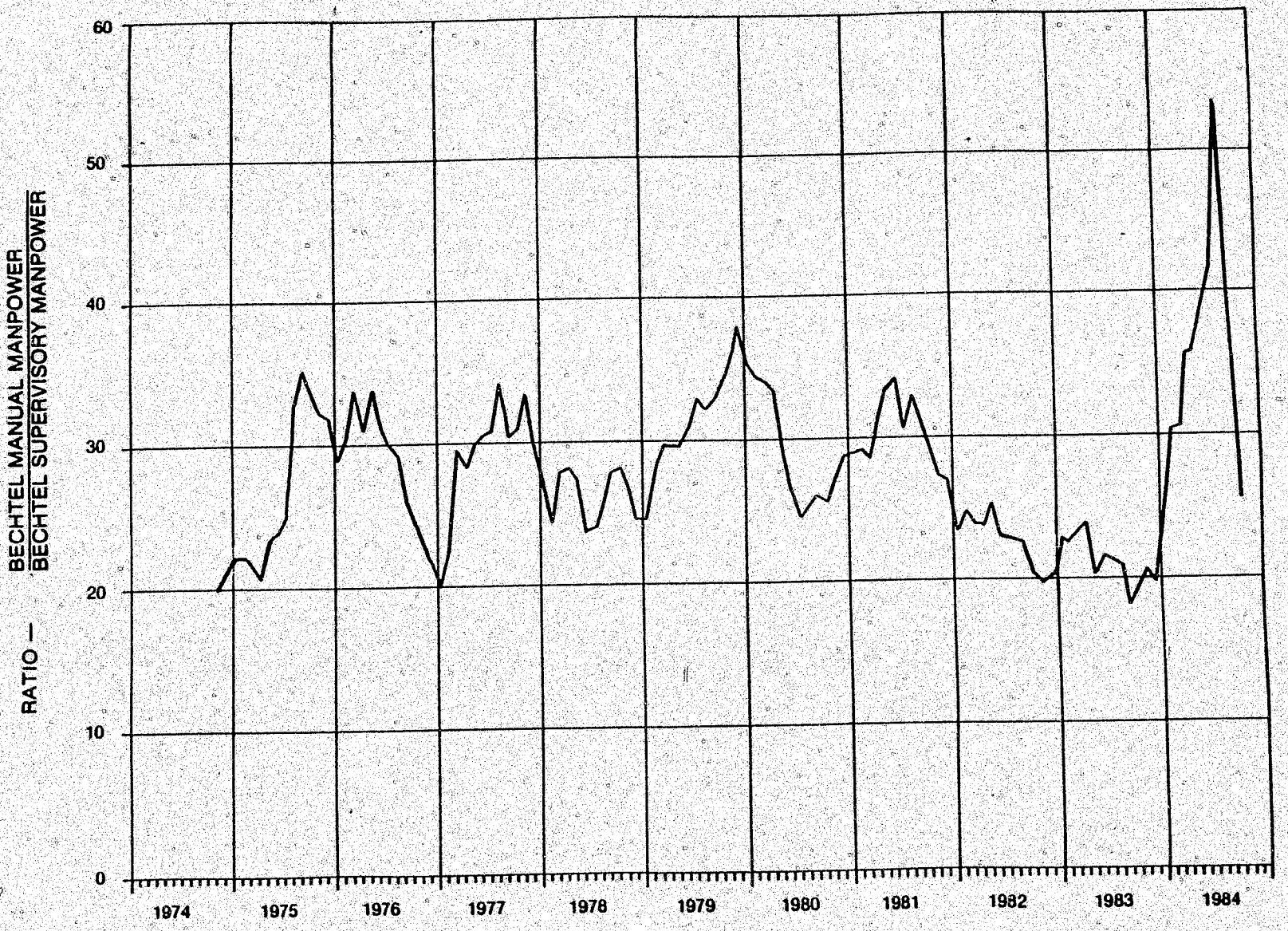
A. From interviews with PECO and Bechtel Project Management, TB&A learned that a ratio of 35 craftsmen to 1 superintendent was the normal Bechtel target for a project such as Limerick, but that this ratio would vary depending on specific job requirements. Each superintendent was responsible for a number of foremen (generally 3 to 4) who in turn had 8 to 10 craftsmen reporting to them. TB&A reconstructed the ratio of manual manpower to effective supervisory manpower. Effective manpower is based upon a standard forty hour work week for determination of manpower levels, with additional hours worked reflected in higher effective manpower. As shown in Schedule 30, Bechtel maintained this ratio below 35 to 1, except for a short period late in 1979, when manual levels were increasing at a faster rate than supervisory levels, and prior to fuel load when manual levels were decreasing at a slower rate than supervisory levels. TB&A concludes that levels of supervisory personnel were reasonable.

Q. WAS THE PERCENTAGE OF NON-MANUAL LABOR TO TOTAL SITE STAFF AT LIMERICK REASONABLE?

A. The percentage of Bechtel non-manual labor (which includes all onsite supervisory, clerical, engineering and staff personnel) to Bechtel total site personnel is illustrated in Schedule 31. For the majority of the project, the percentage of non-manual was in the 20% to 30% range. This percentage

PHILADELPHIA ELECTRIC COMPANY

RATIO-BECHTEL MANUAL: SUPERVISORY MANPOWER LIMERICK 1 & 2

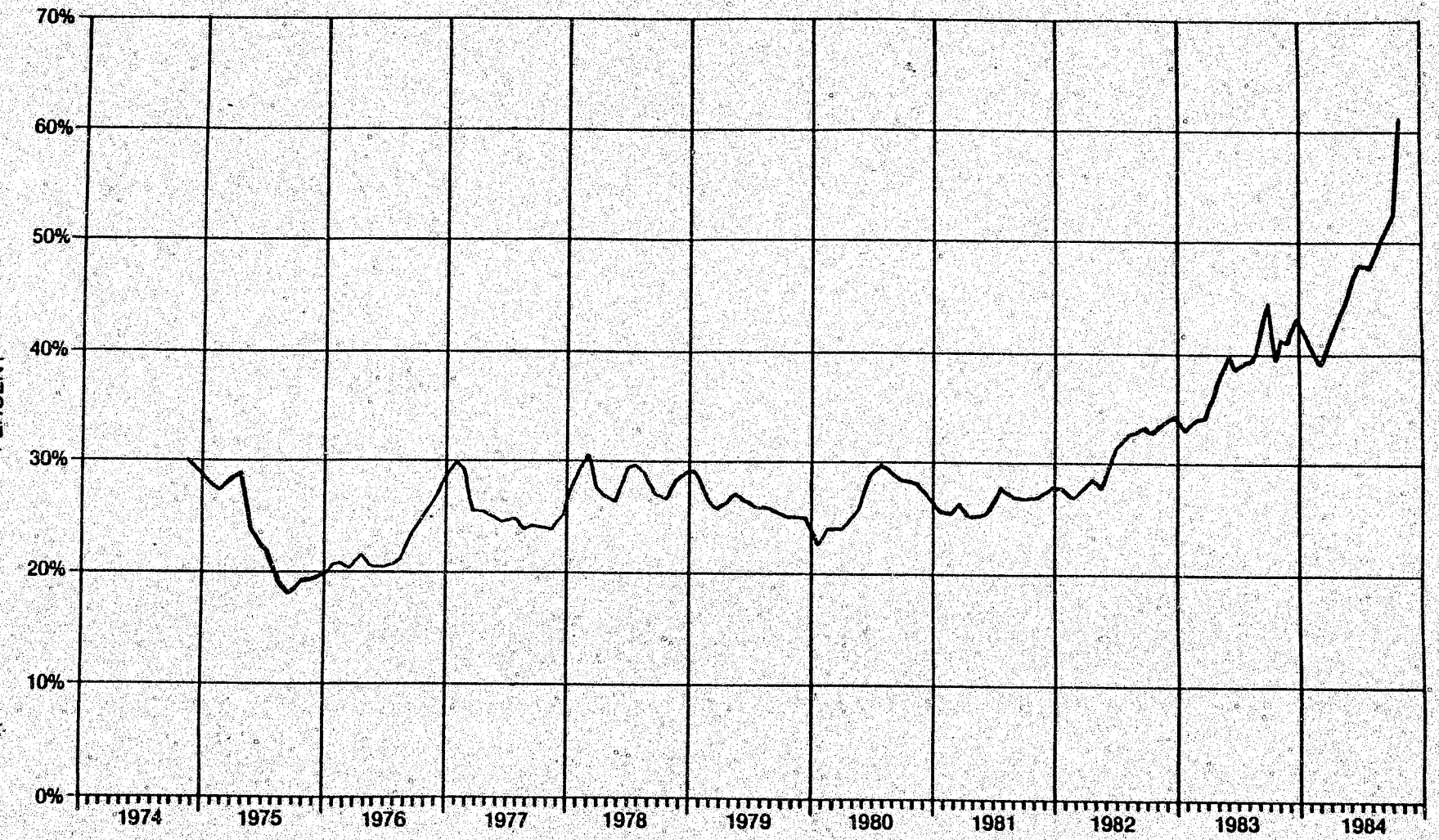


SOURCE: BECHTEL MONTHLY PROJECT STATUS REPORTS

SCHEDULE 30

PHILADELPHIA ELECTRIC COMPANY

PERCENT BECHTEL NON—MANUAL OF BECHTEL TOTAL SITE STAFFING
LIMERICK UNITS 1 & 2



SOURCE: BECHTEL MONTHLY STATUS REPORT

SCHEDULE 31

consistently exceeded that range only after mid-1982, when system turnover and startup began. At this point the percentage increased, as expected, reflecting a need for increased inspection and documentation associated with startup and preoperational testing.

Q. TO WHAT EXTENT WAS OVERTIME USED ON THE LIMERICK PROJECT?

A. As a policy, PECO and Bechtel limited the use of overtime at Limerick to schedule recovery. Overtime, as illustrated in Schedule 32, was 5.5% cumulative for the entire project, with levels exceeding 10% only in the 1982-1984 period when cash became available and recovery schedules were instituted to maintain the 1984 fuel load date. TB&A concludes that this use of overtime was reasonable.

Q. DID PECO MANAGEMENT MONITOR THE EFFECTS OF OVERTIME ON LABOR EFFECTIVENESS DURING PERIODS WHEN IT WAS USED?

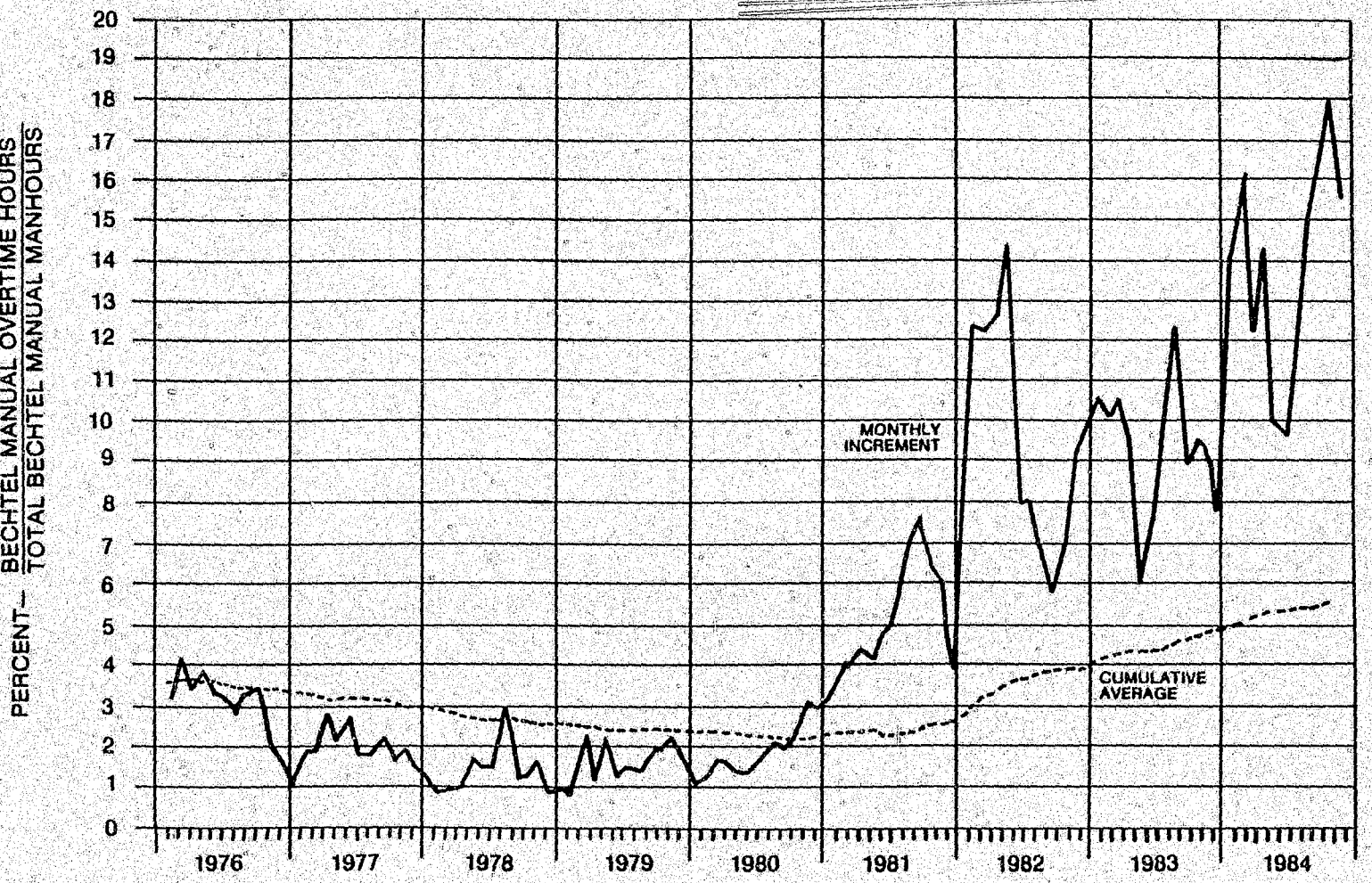
A. PECO management showed significant concern for the effects of overtime on labor effectiveness. For example, a special cost study was conducted by PECO in February of 1982 to determine the effect of overtime on employee absenteeism and productivity at Limerick. TB&A has found that the utilization of overtime at Limerick, a concern of both PECO and Bechtel, was closely monitored and controlled. PECO's reluctance to use overtime in an excessive manner is also in accordance with a Business Roundtable study entitled "Scheduled Overtime Effect on Construction Projects," which concluded that the long-term use of overtime generally results in a decrease in labor productivity.

Q. TO WHAT EXTENT WAS SHIFTWORK UTILIZED ON THE PROJECT?

A. Shiftwork was used throughout the project, primarily to maintain or recover

PHILADELPHIA ELECTRIC COMPANY

BECHTEL MANUAL OVERTIME
(PERCENT OF TOTAL BECHTEL MANUAL MANHOURS)



SOURCE: BECHTEL RECORDS

SCHEDULE 32

schedule for critical path items or to prevent high densities of personnel in congested work areas. Shiftwork was also used to recover schedule in specific locations and to avoid out-of-sequence installation. For example, in October of 1980 when HVAC was determined to be a critical path activity, a second shift to work on this commodity was established in the Reactor Enclosure. However, the continuous, across-the-board use of shiftwork at the Limerick Project was not feasible as cash constraints and manpower shortages generally precluded using higher levels of staffing. Under the circumstances that prevailed on the Project, TB&A concludes that the use of shiftwork was reasonable.

Q. WHAT EFFORTS WERE MADE BY BECHTEL AND PECO TO IMPROVE LABOR EFFECTIVENESS?

A. Efforts were made throughout the project and specifically included: 1) Bechtel's Production Engineering Group; 2) special cost studies by PECO's Field Engineers; 3) work sampling studies by both PECO and Bechtel resulting in a work methods improvement program; and 4) specialized training to improve efficiency and quality of installation.

Q. WHAT WAS THE OBJECTIVE OF BECHTEL'S PRODUCTION ENGINEERING GROUP AND WHAT STUDIES DID THEY PERFORM?

A. The Production Engineering Group was formed in 1980 to provide an independent method for examining the effectiveness of labor deployment and to provide feedback to senior personnel responsible for jobsite activities. This group performed special studies for Project Management aimed at identification of problem areas and recommendations for corrective actions, in an effort to improve labor effectiveness.

Q. WHAT ADDITIONAL STUDIES DID PECO AND BECHTEL UNDERTAKE TO ASSURE EFFECTIVE USE OF LABOR RESOURCES?

A. Between 1978 and 1983, both PECO and Bechtel performed 12 work sampling studies at the site. Work sampling is a statistical sampling procedure used to quantify and classify how a worker spends time at the jobsite into various categories. The data and statistics accumulated through work sampling allow management to make inferences relative to the time spent on various functions. These functions include both productive time such as direct work, carrying and transporting tools and material, receiving instructions, and reviewing drawings and plans, and non-productive time which generally includes late starts, early quits, personal time, waiting, traveling, breaks, station fill and other unaccountable or unexplained waiting.

Analysis of the statistical results of the work sampling program indicated that the ratio of productive work (which includes direct work, receiving instructions, reviewing drawings and prints, and receiving and transporting tools) varied between 38% and 55% throughout the sampling period.

PECO also performed numerous special cost studies by their field engineers, dealing with a broad range of subjects such as budget deviations, labor statistics, forecasting accuracy, plant cost comparisons, productivity, and budget status. These studies were used to monitor performance, identify improvement areas, and provide recommendations to PECO construction management for corrective actions. These studies were summarized for Project Management in PECO's Monthly Cost Reports.

Q. WHAT ACTIONS WERE TAKEN BY PECO IN AN EFFORT TO IMPROVE

LABOR EFFECTIVENESS?

A. PECO constantly looked for ways to improve labor effectiveness through the implementation of the Work Sampling Program and the recommendations of the Production Engineering Group. Actions taken included the following:

- Employee work breaks were standardized (i.e. one 10 minute break for all crafts) to prevent abuse of the work break procedure.

- A lunch whistle was added and specific superintendent locations were assigned to prevent late starts and early quits.

- Time spent traveling and waiting for elevators was reduced by adding tool rooms and work cabinets in the power block, erecting additional bathrooms, and adding more elevators.

- When lower effectiveness due to congestion was identified, manpower levels were reduced at specific work locations.

- Priority punch lists were developed to provide alternate work when primary work could not be performed.

- Area coordination meetings with required attendance by foremen were established to increase their involvement in labor resource planning.

- A color tape system was developed to identify work items in the field and improve release/work-off of punch list items.

- Training sessions were established to minimize the time spent giving and receiving instructions in the field.

Q. WERE PROGRAMS INSTITUTED TO PERMIT COMMUNICATION TO PROJECT MANAGEMENT OF PROBLEMS OR IDEAS IDENTIFIED BY THE CRAFTSMEN THEMSELVES?

A. Yes. The "Quality Circle Program," with 54 circles, was implemented in the field in November 1980. This program consisted of non-manual contractor employees who met in small groups on a weekly basis to discuss problems and their possible resolution. Suggested solutions were passed on to construction management for consideration for implementation. Moreover, the "Employee

Suggestion Program," implemented in December 1981, consisted of cash awards to employees submitting cost-saving ideas.

Q. WHAT ARE WORK RULES AND WHY ARE THEY IMPORTANT?

A. Work rules set forth the general working requirements for personnel at the construction site. The work rules generally encompass acceptable employee work behavior, including start and quit times, safety precautions, break times and durations, and other general administrative procedures of the site.

Work rules provide a consistent set of requirements for all personnel working at the site. By distributing the work rules, management can most effectively monitor and control a large workforce in a consistent manner and thus minimize personnel related problems and issues.

Q. DID THE PROJECT DEVELOP AND DISTRIBUTE WORK RULES TO ALL EMPLOYEES?

A. Yes. Bechtel made a conscientious attempt to disseminate work rules. This was accomplished through the "Jobsite Work Rules," which were provided to all employees at the start of their employment. PECO and Bechtel also established "Nuclear Project Work Rules for Limerick Maintenance," which permitted flexible and productive use of craft labor to perform maintenance during the startup and equipment turnover phase of the project.

Q. WERE THERE NUMEROUS WORK STOPPAGES ON THE LIMERICK PROJECT DURING THE PERIOD OF CONSTRUCTION?

A. TB&A reviewed records on project work stoppages. There were a total of 32 identifiable work stoppages, accounting for 307,685 lost manhours. Most of these were short local disputes; only 5 stoppages amounted to over 10,000 manhours. The total of all work stoppages amounted to approximately two and

one half weeks of lost time (with an average work force of 3000) over the 15-year history of the project. TB&A concludes that the level of work stoppages were not significant.

Q. DID BECHTEL PROVIDE ADEQUATE TRAINING TO ASSURE THAT CRAFT PERSONNEL WERE CAPABLE OF PERFORMING AT A HIGH LEVEL OF EFFECTIVENESS?

A. Bechtel maintained programs for training and qualifying critical crafts, indoctrination programs, general management programs and safety training programs. PECO's oversight activity assured that Bechtel performed this training function adequately.

Interviews of Bechtel staff and a review of existing training program records revealed the extent of Bechtel's training efforts:

- Over 100 superintendents and foremen were used as instructors during the project.
- Formal programs were made available through Bechtel's home office.
- Videotapes were developed onsite for specific needs such as hanger inspection.
- Both staff and line personnel were trained to use management tools (e.g., classes on FOCUS were given to cost and schedule personnel as well as superintendents and foremen).
- Welder training facilities were set up both onsite and in cities where potential recruits were located.

Q. WHAT CRITERIA DOES TB&A USE TO EVALUATE SITE SECURITY AND SAFETY?

A. An effective site security and safety program would include the following: 1) procedures that deal with gate monitoring, authorized access, periodic authorized searches of persons and vehicles entering and leaving the site, and

time card control; 2) policies that deal with violators of security rules; 3) perimeter and storage area patrolling and control; 4) cooperation with local authorities; and 5) project personnel safety performance monitoring for identification of construction hazards.

Q. WHAT WERE THE RESULTS OF TB&A'S INVESTIGATION INTO THE SECURITY PROGRAM AT THE LIMERICK PROJECT?

A. TB&A's review of the security program consisted of a review of theft reports, employee conduct policies and security procedures. While instances of theft were reported by site security throughout the project, we did not identify adverse theft trends. The security program and policies appeared to produce adequate controls at the site to prevent major losses or insurance claims. TB&A found that this area of construction management was not a critical issue at the Limerick Project and did not result in inordinate losses.

Q. WHAT WERE THE RESULTS OF TB&A'S REVIEW OF THE SAFETY PROGRAM AT THE LIMERICK PROJECT?

A. TB&A conducted a review of Bechtel's lost time accident reports, safety and housekeeping procedures and documents regarding construction safety issues. Lost time accidents were tracked by Bechtel and reported regularly to OSHA through the OSHA200 Report. Significant safety related activities were also reported through the Weekly Project Safety Report. Safety meetings were regularly held by superintendents, who in turn reported to Bechtel management. Awards were received for achieving one million consecutive manhours without a lost time accident on four separate occasions, indicating a strong and consistent emphasis on safety throughout the project.

Q. WHAT ARE TB&A'S CONCLUSIONS WITH REGARD TO THE

REASONABLENESS OF PECO'S AND BECHTEL'S PRACTICES RELATIVE TO LABOR MANAGEMENT AT THE LIMERICK PROJECT?

A. PECO and Bechtel employed appropriate tools to effectively manage the extensive labor resources at the Limerick site. From the beginning of the project, management recognized the importance of careful manpower planning and the need for implementing effective systems to measure, control and improve the overall productivity and costs associated with manpower resources.

TB&A found that PECO and Bechtel established an effective manpower planning system, through the FOCUS system, which provided management with the ability to forecast and adjust staffing in a timely fashion in accordance with the resource requirements of the project.

TB&A found that construction management for the Limerick Project properly maintained control over manpower at the jobsite. Appropriate numbers of supervisory personnel were utilized in the construction process by PECO and Bechtel management, who also effectively maintained control over the percentage of non-manual labor used during the project. TB&A found that PECO management most appropriately realized the limited, but costly effects of using high levels of overtime, and properly kept cumulative overtime on the project at approximately 5.5% through fuel load. PECO did use shiftwork periodically at Limerick, but due to cash constraints and labor shortages, this option was not always available to management.

TB&A found that PECO and Bechtel management were aware of the importance of measuring and monitoring craft productivity in controlling overall labor costs at Limerick. TB&A's review indicates that throughout the construction period, management employed appropriate techniques and took

reasonable steps to manage labor effectiveness. The creation of the production engineering group, in 1980, with the specific responsibility of monitoring craft effectiveness; the use of work sampling studies on a regular basis to measure labor utilization by craft; the implementation of several work methods improvements; and the use of quality circles and the employee suggestion program are all strong evidence of the reasonableness of management's actions at Limerick.

TB&A also found that management took appropriate steps relative to manpower training and employee safety at the site. The safety record at Limerick during the construction phase is indeed impressive. In addition, TB&A concludes that site security programs and procedures were comprehensive and diligently enforced at the site.

6. EVALUATION OF MATERIALS AND EQUIPMENT MANAGEMENT

Q. PLEASE DESCRIBE THE SIGNIFICANCE AND OBJECTIVES OF MATERIALS MANAGEMENT ON A NUCLEAR CONSTRUCTION PROJECT.

A. On any construction project, the primary importance of materials management is to ensure that materials are supplied to the job site when and where they are required to support the overall construction effort. A nuclear project imposes the additional requirements of documentation, inspection, physical storage segregation and discrete component traceability in order to satisfy stringent quality assurance standards.

The materials management function is responsible for procuring materials, guarding against stockouts and ensuring that materials are stored properly in order to prevent deterioration. Other objectives include ensuring that material is efficiently transported to the field forces and maintaining

control over inventory carrying costs.

Q. PLEASE DESCRIBE THE CRITERIA TB&A USES TO EVALUATE SITE MATERIALS MANAGEMENT.

A. TB&A has found that materials management activities should begin prior to the start of construction. At that time, site layout studies should be conducted to identify appropriate storage areas, laydown areas and warehouse needs. Attention should also be given to tracking and reporting the needs of the project and to selecting a flexible inventory control system that can be expanded as the project progresses. Our experience is that a proper materials management system serves to minimize material-related delays in the field, in addition to providing better control over material inventory levels.

Specifically, TB&A examined the material management practices at Limerick to ensure the following: 1) the functions and responsibilities of the material management organization were clearly defined; 2) the material storage and warehouse facilities were well planned; 3) a material management, inventory control and tracking system with appropriate interface with purchasing was utilized; and 4) the material management system generated periodic control reports to indicate the status of the material items, including any expected delays.

Q. WHO HAD RESPONSIBILITY FOR MATERIALS PROCUREMENT, RECEIVING, STORING AND DISTRIBUTING MATERIALS ON THE LIMERICK PROJECT AND WHERE DID STORAGE TAKE PLACE?

A. Bechtel, following detailed procedures, was responsible for all material procurement and handling functions at the Limerick Project. Materials were stored in warehouses, at laydown areas on the site, and at a long-term storage

facility owned by PECO and operated by Bechtel.

Q. PLEASE DESCRIBE THE SYSTEM USED FOR TRACKING MATERIALS AT THE LIMERICK PROJECT.

A. The Quantity Tracking System (i.e. QTS), which interfaced with FOCUS, was used for monitoring material and equipment. This system, which was previously described, tracked materials from delivery at the construction site through installation.

Q. WHAT ARE TB&A'S CONCLUSIONS REGARDING MATERIALS MANAGEMENT AT LIMERICK?

A. TB&A concluded, following its examination of the project, that the materials management at Limerick was reasonable and adequate. The materials handling and tracking system functioned as designed, minimizing material shortages and preventing procurement problems. PECO provided adequate storage facilities and inventory control of material prior to issuance to the field for installation. The materials management system provided clear tracking of materials from purchase order through installation and served as an important and appropriate tool in the management of materials at the Limerick site.

Q. HOW DOES TB&A DEFINE THE TERM "CONSTRUCTION EQUIPMENT"?

A. Construction equipment includes <u>all</u> tools and equipment used by the labor force to build the plant. Equipment management encompasses two main objectives: 1) assuring that the construction effort in the field is supported by the proper equipment and tools; and 2) assuring that the equipment and tools are utilized in a cost effective manner.

Q. WHAT CRITERIA DID TB&A USE TO EVALUATE THE REASONABLENESS OF CONSTRUCTION EQUIPMENT MANAGEMENT ON THE LIMERICK PROJECT?

A. TB&A has found that the decisions made regarding the acquisition, utilization, maintenance, repair and replacement of individual tools and pieces of equipment do not usually have a significant impact on the overall project. However, an aggressive effort in maintaining a strong equipment management program typically yields substantial returns in the reduction of construction delays and in direct equipment holding costs.

Our review of construction equipment management focused on the following three areas of inquiry:

(1) Equipment Sourcing - Were plans for obtaining and financing the required quantity and types of construction equipment appropriately developed and executed?

(2) Equipment Utilization - Was equipment dispatch and utilization monitored?

(3) Equipment Maintenance - Was there a formal and comprehensive equipment maintenance management system stressing preventive maintenance and a spare parts program for critical tools and equipment?

Q. PLEASE DESCRIBE THE LIMERICK PROJECT'S CONSTRUCTION EQUIPMENT SOURCING.

A. The equipment sourcing at Limerick was appropriate. Buy versus lease formulas were used to determine the most cost effective approach for each major acquisition decision. PECO's resulting decision to buy most major equipment led to significant project savings.

Q. HOW WAS EQUIPMENT DISPATCHED DURING THE PROJECT?

A. A fully staffed office was responsible for dispatching major equipment as needed throughout the project. Based on both the 12-month and 3-week

schedules, equipment and operating crews were provided to area superintendents as needed. A schedule was maintained that projected the use of each piece of equipment, including scheduled maintenance. When a piece of equipment was not scheduled to be used for a period of time, the crew was either reassigned or laid off and the equipment put in storage until needed. When a determination was made that the unit was no longer needed, it was placed on a surplus equipment list for alternate use or disposal by PECO.

Q. HOW WAS MAINTENANCE SCHEDULED AND CONTROLLED?

A. Maintenance practices were closely adhered to, using manufacturers' recommendations and project experience as guidelines. Complete records were kept of all work done on major pieces of equipment.

Q. PLEASE SUMMARIZE TB&A'S CONCLUSIONS REGARDING THE EQUIPMENT MANAGEMENT FUNCTION ON THE LIMERICK PROJECT.

A. Bechtel utilized its broad construction management experience in implementing a well developed equipment management program.

PECO assumed a major role in the oversight of the equipment management function. PECO closely and aggressively monitored equipment maintenance and utilization in a continued effort to assure equipment reliability and availability at the lowest possible cost. For example, a PECO employee was assigned full time to Bechtel's office to assure optimal utilization of equipment.

In addition, the decision to purchase major equipment was based on a sound analysis and resulted in cost savings. Equipment scheduling methods provided equipment when needed and minimized excess and unneeded crews. Finally, the maintenance planning system was reasonable. Thus, there were no

identifiable negative impacts on the project due to the management of equipment.

7. EVALUATION OF MAJOR CONSTRUCTION ACTIVITIES AND EVENTS

Q. WHAT ASPECT OF CONSTRUCTION SITE MANAGEMENT IS COVERED IN THIS SECTION OF YOUR TESTIMONY?

A. This portion of the testimony examines specific activities and events that occurred during the project construction which might have impacted cost, schedule or quality of the project. The purpose of this analysis is to determine whether the management processes instituted by PECO and Bechtel at the site were effectively utilized. The topics that have been selected include regulatory change effects upon construction, cash constraints, labor unavailability, unit rates and the HVAC subcontract.

a. Regulatory Change Effects Upon Construction

Q. HOW DID REGULATORY CHANGES DURING CONSTRUCTION AFFECT THE COST AND SCHEDULE OF THE LIMERICK PROJECT?

A. Regulatory changes that occurred during the course of construction at the Limerick Project had a major impact on the construction costs and schedule of the plant. New or modified regulations added materials to those originally estimated and designed, or required modification of installed materials, and resulted in more stringent code requirements both in terms of construction procedures and practices that added to the complexities of Limerick's construction. The cumulative effects of the regulations led to increased crowding and congestion as additional equipment and material were added into existing buildings and structures. Previously installed materials required removal and replacement due to changing regulations, which increased both

labor and material costs. These regulatory impacts were not unique to the Limerick Project; they were experienced throughout the industry and were beyond the control of PECO or Bechtel.

Q. WHAT SPECIFIC REGULATORY CHANGES AFFECTED THE LIMERICK PROJECT?

A. The following are examples of changes and additions to regulations and rules that had major impacts on construction of the Limerick Project:

- Changes as a result of the Three Mile Island incident.
- Mark II requirements.
- Fire protection and electrical separation requirements.
- ALARA (As Low As Reasonably Achievable) requirements.
- OSHA requirements for additional lighting, craft protection and safety requirements.
- Environmental qualifications.
- Seismicity requirements.
- Quality Assurance requirements

Q. WERE THE IMPACTS OF THESE REGULATORY CHANGES QUANTIFIABLE RELATIVE TO CHANGES IN COST AND SCHEDULE OF THE LIMERICK PROJECT?

A. Not completely. Although direct costs for design, material, equipment and labor were estimated by PECO and Bechtel, the real costs and schedule impacts due to regulatory changes were not recorded and can only be estimated. The large impact of these regulatory changes were the indirect impacts which were experienced in the deterioration of the project's unit rates in the mid to later stages of construction and the project's inability to sustain production rates at the levels estimated. The combined effects of congestion, modifications to

completed or almost completed systems, and removal and reinstallation of materials led to the dramatic deterioration in unit rates on the Limerick Project, the same as it did for the rest of the nuclear construction industry.

Q. WHAT ACTIONS DID PECO AND BECHTEL TAKE TO MINIMIZE THE IMPACT OF REGULATORY CHANGES?

A. PECO and Bechtel initiated numerous efforts to minimize these impacts, including:

- Aggressive pursuit by PECO of solutions to problems being addressed by regulatory changes in a manner condusive to the project, through use of the BWR Owners' Group and negotiation with the NRC.
- Frequent revisions of schedule logic to take into account changes in work scope and revisions.
- Development of scale models to visually determine the effects of the required design changes.
- Field walkdowns by engineering to minimize field interferences.
- Analysis of least cost installation methods when interferences occurred due to design revisions.

Q. WHAT CONCLUSION DID TB&A REACH RELATIVE TO PECO's AND BECHTEL'S HANDLING OF REGULATORY CHANGES THAT AFFECTED CONSTRUCTION ON THE LIMERICK PROJECT?

A. TB&A concluded that PECO's and Bechtel's actions were reasonable and that they aggressively attempted to minimize cost and schedule impacts due to regulatory changes. The management systems in place had the flexibility to implement these changes in the most effective manner, and PECO closely monitored construction activities to minimize interferences and additional work that resulted from these impacts.

b. Cash Constraints

Q. WHAT IS THE PURPOSE OF THIS PORTION OF THE CONSTRUCTION TESTIMONY?

A. During the 1974-1979 period, PECO management imposed budget constraints on Limerick construction. A detailed discussion of these budget constraints, their effect on schedule completion, and TB&A's findings as to the necessity for the cutbacks is provided elsewhere in this testimony. The purpose of this portion of TB&A's review is to evaluate how PECO's site management responded to the reality of the budget constraints.

Q. WHAT DID PECO AND BECHTEL DO TO MINIMIZE THE EFFECTS OF BUDGET CUTS ON SCHEDULE PROGRESS?

A. TB&A found that PECO and Bechtel took a number of important steps to ameliorate the effects of these budget constraints on schedule progress. First, PECO continued engineering design work despite the construction cutbacks. This was done in order to keep engineering sufficiently ahead of construction and to ensure that when full construction work was resumed the ultimate schedule impact of the cutbacks would be minimized.

Second, PECO closely monitored actual cash flow versus budgeted expenditures to ensure maximum cash allocation to construction within the budget constraints. PECO compared the monthly expenditures and year-to-date expenditures versus budgeted levels and reported the results in the Monthly Cost Report. Based on deviation from the budgeted levels, changes in manual labor levels or requests for additional funds were made.

Third, PECO closely controlled cash flow and postponed many of the non-critical expenditures to a later date. For example, PECO renegotiated the cooling tower erection subcontract with Ragnor-Benson in an effort to minimize cash flow, since this work was not on the critical path. The contract was amended to reflect 1981 and 1982 completion dates for the cooling towers, with Ragnor-Benson not being directed to remobilize its forces until January 1978. Originally, this work was to have been completed in 1973 and 1974.

Fourth, PECO and Bechtel directed the available resources to those activities which management considered necessary to sustain overall schedule progress during the cash constrained periods.

Finally, and related to this last measure, PECO maintained more aggressive construction target schedules than those that were publicly announced through August 1980. During 1980, it became apparent that the overall scope of the project had increased and would not allow for the maintenance of the more ambitious internal working schedule, even with improved financial conditions. A comparison of the publicly announced completion dates and the internal project construction schedules, set forth in Schedule 33, demonstrates the aggressiveness of this effort.

Q. WHAT DID TB&A CONCLUDE AS TO THE REASONABLENESS OF PECO'S IMPLEMENTATION OF CASH CONSTRAINTS UPON THE CONSTRUCTION SITE?

A. TB&A concluded that PECO and Bechtel handled construction-related cash constraints in an appropriate and reasonable manner. When faced with cash constraints, PECO appropriately curtailed construction outlays while maintaining the engineering budget, thereby permitting engineering progress to

PHILADELPHIA ELECTRIC COMPANY

LIMERICK 1 & COMMON SCHEDULE SUMMARY

Date	Construction Target Fuel Load Schedule	Publicly Announced Fuel Load Schedule
Jan-74	Jan-79	Jan-79
Feb-74	Apr-79	Jan-79
Mar-74	Apr-79	Jan-79
Apr-74	Apr-79	Jan-79
May-74	Apr-79	Jan-79
Jun-74	Jun-79	Jan-79
Jul-74	Jun-79	Jan-79
Aug-74	Jun-79	Jan-79
Sep-74	Jun-79	Oct-80
Oct-74	Jun-79	Oct-80
Nov-74	Jun-79	Oct-80
Dec-74	Jun-79	Oct-80
Jan-75	Jun-79	Oct-80
Feb-75	Jun-79	Oct-80
Mar-75	Oct-80	Oct-80
Apr-75	Nov-81	Oct-80
May-75	Aug-80	Oct-80
Jun-75	Aug-80	Oct-80
Jul-75	Aug-80	Oct-80
Aug-75	Aug-80	Oct-80
Sep-75	Aug-80	Oct-80
Oct-75	Aug-80	Oct-80
Nov-75	Aug-80	Oct-80
Dec-75	Aug-80	Oct-80
Jan-76	Aug-80	Oct-80
Feb-76	Aug-80	Oct-80
Mar-76	Aug-80	Oct-80
Apr-76	Aug-80	Oct-80
May-76	Aug-80	Oct-80
Jun-76	Oct-81	Oct-80
Jul-76	Oct-81	Oct-80
Aug-76	Oct-81	Oct-82
Sep-76	Oct-81	Oct-82
Oct-76	Oct-81	Oct-82
Nov-76	Oct-81	Oct-82
Dec-76	Oct-81	Oct-82

PHILADELPHIA ELECTRIC COMPANY

LIMERICK 1 & COMMON SCHEDULE SUMMARY

Date	Construction Target Fuel Load Schedule	Publicly Announced Fuel Load Schedule
Jan-77	Oct-81	Oct-82
Feb-77	Oct-81	Oct-82
Mar-77	Oct-81	Oct-82
Apr-77	Oct-81	Oct-82
May-77	Oct-81	Oct-82
Jun-77	Oct-81	Oct-82
Jul-77	Oct-81	Oct-82
Aug-77	Oct-81	Oct-82
Sep-77	Oct-81	Oct-82
Oct-77	Oct-81	Oct-82
Nov-77	Oct-81	Oct-82
Dec-77	Oct-81	Oct-82
Jan-78	Mar-82	Oct-82
Feb-78	Mar-82	Oct-82
Mar-78	Mar-82	Oct-82
Apr-78	Mar-82	Oct-82
May-78	Mar-82	Oct-82
Jun-78	Oct-82	Oct-84
Jul-78	Oct-82	Oct-84
Aug-78	Oct-82	Oct-84
Sep-78	Oct-82	Oct-84
Oct-78	Oct-82	Oct-84
Nov-78	Oct-82	Oct-84
Dec-78	Oct-82	Oct-84
Jan-79	Oct-82	Oct-84
Feb-79	Oct-82	Oct-84
Mar-79	Oct-82	Oct-84
Apr-79	Oct-82	Oct-84
May-79	Oct-82	Oct-84
Jun-79	Oct-82	Oct-84
Jul-79	Oct-82	Oct-84
Aug-79	Oct-82	Oct-84
Sep-79	Oct-82	Oct-84
Oct-79	Oct-82	Oct-84
Nov-79	Oct-82	Oct-84
Dec-79	Oct-82	Oct-84
Jan-80	Oct-82	Oct-84
Feb-80	Oct-82	Oct-84
Mar-80	Oct-82	Oct-84
Apr-80	Oct-82	Oct-84
May-80	Oct-82	Oct-84
Jun-80	Oct-83	Oct-84
Jul-80	Oct-83	Oct-84
Aug-80	Oct-83	Oct-84
Sep-80	Oct-84	Oct-84
Oct-80	Oct-84	Oct-84
Nov-80	Oct-84	Oct-84
Dec-80	Oct-84	Oct-84

PHILADELPHIA ELECTRIC COMPANY

LIMERICK 1 & COMMON SCHEDULE SUMMARY

Date	Construction Target Fuel Load Schedule	Publicly Announced Fuel Load Schedule
Jan-81	Oct-84	Oct-84
Feb-81	Oct-84	Oct-84
Mar-81	Oct-84	Oct-84
Apr-81	Oct-84	Oct-84
May-81	Oct-84	Oct-84
Jun-81	Oct-84	Oct-84
Jul-81	Oct-84	Oct-84
Aug-81	Oct-84	Oct-84
Sep-81	Oct-84	Oct-84
Oct-81	Oct-84	Oct-84
Nov-81	Oct-84	Oct-84
Dec-81	Oct-84	Oct-84
Jan-82	Oct-84	Oct-84
Feb-82	Oct-84	Oct-84
Mar-82	Oct-84	Oct-84
Apr-82	Oct-84	Oct-84
May-82	Oct-84	Oct-84
Jun-82	Oct-84	Oct-84
Jul-82	Oct-84	Oct-84
Aug-82	Oct-84	Oct-84
Sep-82	Oct-84	Oct-84
Oct-82	Oct-84	Oct-84
Nov-82	Oct-84	Oct-84
Dec-82	Oct-84	Oct-84
Jan-83	Oct-84	Oct-84
Feb-83	Oct-84	Oct-84
Mar-83	Oct-84	Oct-84
Apr-83	Oct-84	Oct-84
May-83	Oct-84	Oct-84
Jun-83	Oct-84	Oct-84
Jul-83	Oct-84	Oct-84
Aug-83	Oct-84	Oct-84
Sep-83	Oct-84	Oct-84
Oct-83	Oct-84	Oct-84
Nov-83	Oct-84	Oct-84
Dec-83	Oct-84	Oct-84
Jan-84	Oct-84	Oct-84
Feb-84	Oct-84	Oct-84
Mar-84	Oct-84	Oct-84
Apr-84	Oct-84	Oct-84
May-84	Oct-84	Oct-84
Jun-84	Oct-84	Oct-84
Jul-84	Oct-84	Oct-84
Aug-84	Oct-84	Oct-84
Sep-84	Oct-84	Oct-84
Oct-84	Oct-84	Oct-84

SOURCE: PHILADELPHIA ELECTRIC COMPANY AND BECHTEL RECORDS

continue ahead of construction. Moreover, PECO selectively maintained funding at appropriate levels for those activities deemed necessary to maintain overall schedule progress. By doing so, PECO Management correctly reasoned that, should financial conditions improve and funding for construction increase, the internal working schedules could be maintained and the more aggressive fuel load dates met. TB&A found that PECO Construction Management took reasonable actions in light of the financial constraints placed upon them, including the maintenance of critical path items and renegotiation of subcontracts that were non-essential to the project's critical path.

c. Labor Unavailability

Q. WAS BECHTEL ABLE TO HIRE ALL THE CRAFTSMEN IT NEEDED AT ALL TIMES DURING THE PROJECT?

A. No, there were serious shortages of pipe welders, and sheetmetal welders both locally and nationally during the period 1978-1980. During this period, demand for these crafts was high due to other nuclear, petrochemical, refinery and casino construction projects that were also ongoing. These shortages were reported regularly in the monthly progress meetings and PECO Schedule Analysis Reports.

Q. WHEN FACED WITH LABOR UNAVAILABILITY, WHAT ARE THE TYPICAL ACTIONS TAKEN BY A UTILITY?

A. A utility can attempt to mitigate the effects of labor unavailability in a number of ways, including hiring labor from outside the immediate area, hiring locally by offering incentives, instituting training programs to upgrade the local labor pool, increasing/adding overtime, or increasing the productivity of the existing workforce. Each of these actions will result in some relief of the

problems associated with labor unavailability, but these solutions are not always available as an option to management. Particularly, as in the case of PECO, during the periods of construction cash constraints, a utility's best option is generally to maximize the effectiveness of its existing labor resources.

Q. WHAT EFFORTS WERE MADE BY BECHTEL AND PECO TO RESOLVE THESE MANPOWER SHORTAGES?

A. Bechtel attempted to recruit throughout the Pennsylvania and New Jersey region and nationwide as well. They also hired trained nonunion and subjourneymen welders to the fullest extent possible and trained and upgraded existing welders so that they qualified for the specific welding techniques employed at Limerick. However, increased labor requirements continued to result in shortages.

In its review of PECO's Schedule Analysis Reports, TB&A found numerous examples of these labor unavailability problems and the diligent efforts of PECO and Bechtel to resolve them. For instance, when HVAC work progress was seriously impeded by a shortage of heavy sheetmetal welders, Bechtel instituted an on-site welder test program. In addition, a voluntary training program was instituted to recruit and develop pipefitter welders. Finally, arrangements were made with PSE&G to train prospective welders at Hope Creek for assignment to Limerick.

Q. WHAT OTHER METHODS ARE AVAILABLE FOR RECRUITING SKILLED CRAFT MANPOWER AND TO WHAT EXTENT DID PECO USE THEM?

A. Two methods sometimes used for attracting manpower to projects like Limerick are to provide guaranteed overtime and travel allowances. However,

the constrained construction budgets confronting PECO made these overtime expenditures unattractive. Furthermore, PECO believed that productivity decreases that result from long periods of overtime can actually impede schedule progress. PECO did implement an increase in the travel allowances for out-of-town pipefitters and welders in April 1980, in an effort to attract additional manpower.

Q. WHAT CONCLUSION DID TB&A REACH RELATIVE TO MANPOWER SHORTAGES AND PECO's AND BECHTEL's EFFORTS TO RESOLVE THEM?

A. The shortage of certain craft labor was a serious problem during the 1978-1980 period. Numerous references in PECO's monthly schedule analyses identified the effects of these shortages on construction progress, as well as PECO and Bechtel efforts to minimize the impact of these shortages. TB&A's review of PECO's efforts to overcome these shortages led to the conclusion that the Company effectively analyzed the best available options for recruiting manpower, calculated the associated costs and benefits of each option and acted aggressively in implementing the chosen solution. PECO decided not to utilize high cost methods of recruiting, such as guaranteed overtime, because of limited availability of cash and the reasonable belief that excessive use of overtime over extended periods generally leads to a deterioration in labor productivity. Instead, PECO advertised for and trained welders, negotiated the use of non-union and subjourneymen, and maximized the use of existing personnel on critical path activities. TB&A believes that PECO's and Bechtel's management actions were reasonable under the circumstances and minimized adverse effects to the overall project cost due to manpower shortages.

d. Unit Rates

Q. PLEASE PROVIDE TB&A's PERSPECTIVE ON LABOR EFFICIENCY.

A. Labor efficiency is one of the most commonly used vehicles by managers and regulators alike in assessing the effectiveness of construction management. However, TB&A believes that the maximization of such efficiency should be but one objective, and it often is in conflict with other construction management objectives. Construction managers are charged with simultaneously controlling at least five separate variables in the construction effort.

- Labor unit rates
- Production rates
- Labor dollar rates
- Quality rates
- Construction safety rates

Labor unit rates define craft productivity by indicating the number of manhours required to install a measure of material. Production rates address the quantities of material installed during a defined period of time. Labor dollar rates describe the cost of a craft manhour, and reflect the extent to which more costly or non-productive manhours are incurred. Quality rates are concerned with the amount of rework or failed inspections attributable to poor workmanship. Safety rates indicate the injuries or manhours lost on a project due to accidents.

Depending upon specific circumstances, project owners and construction managers may choose to place differing emphasis or priorities on these objectives. Trade-offs must often be made among the five objectives. The

most common trade-off occurs between labor unit rates and production rates. For example, attempts to increase production rates (and thereby shorten schedule durations) by adding more craftsmen or working overtime can and will, after a point, result in higher labor unit rates and also increased labor dollar rates. The achievement of quality often necessitates numerous work hold points and subsequent inspections. While quality levels are thus promoted, production and unit rates can suffer due to the time consumed. Job safety enforcement may dictate additional flagmen, firewatch, clean-up and other non-production labor, which can also inflate labor unit rates.

Thus, construction managers operate in an environment of often conflicting objectives in their efforts to attain the broad goal of low overall project costs within the schedule and quality constraints. Extreme emphasis on any one objective is likely to produce penalties in one or more of the other objectives.

Q. PLEASE DEFINE UNIT RATES, AND EXPLAIN THEIR SIGNIFICANCE.

A. Unit rates are defined as the number of manhours required to install one unit of material -- in this case the installation of construction materials for the building of a nuclear power plant. The unit rate provides the owner and/or the construction manager with a method for tracking the efficiency of construction labor. Unit rates can be measured cumulatively over the entire construction effort to date, or incrementally for set periods of time (monthly, quarterly, yearly, etc.).

Changes in unit rates do not by themselves identify causes of problems; rather they serve as a necessary warning signal to management that changes have developed in a particular area of construction. It is at this point that

further analysis is required by the construction manager and owner to pinpoint the cause of the change in unit rate, and to then take corrective action if needed.

Q. DID UNIT RATES MEET THE FORECASTED AND BUDGETED LEVELS AT ALL TIMES DURING THE PROJECT?

A. No. Due to many factors, unit rates were above the levels desired for some commodities. This was a universal problem during the 1970s and 1980s at nuclear plant construction projects.

Q. DID PECO LOOK AT THE UNIT RATE PERFORMANCE OF OTHER PLANTS WITHIN THE NUCLEAR INDUSTRY TO DETERMINE WHETHER THEIR PERFORMANCE WAS IN LINE?

A. Yes. Periodically PECO compared the unit rates of Limerick with those experienced throughout the industry. More importantly, PECO maintained close communications with personnel at Pennsylvania Power & Light's Susquehanna Project and other Bechtel projects that used the same tracking systems. This enabled PECO to stay abreast of the unit rate performance on other projects in which their construction manager, Bechtel, was involved.

Q. WHAT SPECIFIC DEVELOPMENTS DURING CONSTRUCTION HAD A MAJOR IMPACT ON THE FINAL UNIT RATES AT LIMERICK?

A. TB&A determined that a number of major factors caused negative impacts to the unit rates originally estimated for the Limerick Project. Other contemporaneous projects were also affected by these factors.

The Limerick Project was impacted by the increased regulatory requirements that were imposed during the course of construction. New regulations led to unanticipated difficulties during installation of some bulk

commodities and the actual removal and reinstallation of others. This process dramatically increased unit rates because the manhours expended for revisions to already installed materials was included in the calculation of unit rates but did not impact the overall quantity of material since no additional material had been added. Another factor caused by increased regulation was congestion. The original design of Limerick took into account the anticipated space needed for installation of commodities. However, major changes in project scope requirements due to Mark II design criteria, fire protection requirements and new seismic requirements, as well as AEC and ACRS requirements developed during the construction permit review led to congested work spaces. These latter requirements involved vertical direction seismic analysis for all safety related structures and a 25% increase in maximum ground acceleration for the design basis earthquake. This in turn led to slower and less efficient commodity installation. In the area of piping and cable tray supports, the unit rates were severely impacted by the seismic criteria imposed by Regulatory Guide 1.29 which forced PECO to reclassify non-seismic hangers to seismic, which due to their complexity have a much higher unit rate associated with them. Quality assurance requirements also impacted unit rates by imposing increased documentation and more stringent acceptance requirements for safety-related items or systems.

Q. DID TB&A PERFORM A DETAILED REVIEW OF UNIT RATES ON THE LIMERICK PROJECT?

A. Yes. TB&A conducted a detailed review of unit rates for the major bulk commodities including concrete placement, structural steel, large bore pipe, large bore pipehangers, small bore pipe and hangers, cable and wire, and cable

tray. In addition, a comparison with Susquehanna of final unit rates was made for these commodities along with rebar, formwork, large pipe welds, electrical connections, and metallic conduit. The results of TB&A's review of unit rates are summarized below.

Concrete Placement - Performance on this commodity was reasonably close to that originally estimated and reflects the fact that concrete design was not affected significantly by changes such as TMI, Mark II or other regulatory factors.

Structural Steel - This increase is attributable to the cumulative effects of design changes that occurred late in the project and as a result of seismic requirements for pipe restraints of a type not anticipated at the time of Forecast 1.

Large Bore Pipe - A major discrepancy was caused by the use of estimation curves at the time of Forecast 1 which projected a lower than realistic unit rate. PECO's studies on unit rates revealed that Limerick's final cumulative unit rate was comparable to other Bechtel-managed contemporaneous nuclear projects.

Hanger Installation - The significant increase in the final unit rate over the definitive estimate was due to a number of factors. These included an original estimate that neglected to add a premium for seismic hangers, changes due to Mark II revisions, interferences with other seismically installed materials and increased design complexity.

Small Bore Pipe - The increases in unit rates resulted from unexpected impacts of Mark II, the increased number of seismic hangers due to the requirements in Reg. Guide 1.29, and interferences with other commodities during construction.

Cable Tray - The actual unit rate was much higher than original estimates due to the increased requirements for additional seismic hangers as a result of Reg. Guide 1.29.

Wire and Cable - The actual performance was reasonably close to the projected unit rates at the time of Forecast 1.

Q. MANY OF THE COMMODITIES SHOWED SIGNIFICANT INCREASES IN THE ACTUAL UNIT RATES. WAS THIS A COMMON OCCURRENCE ON OTHER CONTEMPORANEOUS PLANTS?

A. Yes. The significant changes that took place when constructing nuclear plants, especially during the post-TMI era, affected many other plants as well. For example, TB&A reviewed the unit rate data for PP&L's Susquehanna plant which was often used for comparisons during the project by PECO and Bechtel. Schedule 34 summarizes this data and shows that for 8 out of the 12 key commodities Limerick achieved better unit rates than Susquehanna Unit 1. The four commodities for which Limerick had higher unit rates were directly impacted by seismic requirements which were much more stringent at Limerick than at Susquehanna.

Q. WHAT SPECIFIC EFFORTS WERE MADE BY PECO AND BECHTEL TO IMPROVE THE UNIT RATES ON THE LIMERICK PROJECT?

A. PECO and Bechtel took a number of actions to improve unit rates. Some of these were:

- Monitored and reported earned manhours using the FOCUS system.
- Developed the ICS schedule to better schedule and track performance.
- Instituted the Production Engineering Group, work sampling, and other methods improvement programs.

PHILADELPHIA ELECTRIC COMPANY

LIMERICK - SUSQUEHANNA PRODUCTIVITY COMPARISON

	MANHOURS PER UNIT COMMODITY	
COMMODITY	LIMERICK UNIT 1 & C	SUSQUEHANNA UNIT 1 & C
Concrete (Cu. Yd.)	2.99	4.66
Structural Steel (Tons)	39.16	46.55
Rebar (Tons)	32.04	52.28
Formwork (Sq. Ft.)	0.48	1.00
Large Pipe Welds (Ea.)	14.15	16.35
Large Pipe (LF)	4.21	6.79
Large Pipe Hangers (Ea.)	144.00	129.56
Small Pipe (LF)	9.24	7.60
Cable Tray (LF)	3.80	3.37
Conduit (LF)	3.07	1.51
Wire & Cable (LF)	0.09	0.12
Connections (Ea.)	0.93	1.72

SOURCE: BECHTEL RECORDS

- Instituted studies of specific problems and compared results with other contemporaneous projects.

Q. WHAT HAS TB&A CONCLUDED ABOUT THE UNIT RATES ON THE LIMERICK PROJECT AND PECO's EFFORTS TO EFFECTIVELY CONTROL UNIT RATES?

A. TB&A has concluded that the unit rates achieved at the Limerick Project were reasonable given the significant changes that took place on the project specifically and throughout the nuclear industry generally during this time frame. The rates that were used in Forecast 1 in 1975 were optimistic and were based on expected improvements over Peach Bottom, a plant constructed in a different regulatory environment. The effects of increased seismic requirements, evolving regulation, Mark II, TMI and other factors were not anticipated at the time of Forecast 1. The final unit rates clearly show that commodities not affected by seismic constraints, such as concrete and cable pulling, did not increase appreciably from early estimates.

TB&A has also concluded that the efforts by PECO and Bechtel to improve unit rates were reasonable. The close monitoring and reporting of unit rates by PECO from the early stages of construction through completion of construction was most appropriate. Through its use of numerous studies on labor productivity which were included in PECO's Monthly Cost Reports and its implementation of the work sampling programs, PECO management actively strove to maintain a high level of craft labor productivity at the Limerick Project. This active involvement allowed PECO management to take action which precluded increases greater than those that eventually occurred.

e. HVAC

Q. WHY WAS THE HEATING, VENTILATING AND AIR CONDITIONING (HVAC) SUBCONTRACT REVIEWED?

A. The HVAC subcontract had a high number of design and scope changes, problems with manpower availability, possible bankruptcy of the subcontractor, two renegotiations of the subcontract and a large increase in the ultimate cost of the system. This, therefore, seemed an appropriate subcontract for detailed analysis in order to evaluate PECO and Bechtel's subcontract management.

Q. WHAT TYPE OF CONTRACT WAS THIS ORIGINALLY AND WHY WAS THAT TYPE OF CONTRACT USED?

A. This contract was originally awarded as a lump sum/unit price contract in July 1977 to Schneider Sheet Metal, Inc. (SSM). Under this contract, SSM was to fabricate and install the HVAC system for Limerick Units 1 and 2. Subsequently, this contract was renegotiated on two different occasions. On January 14, 1980, it was changed to a cost plus contract with target incentives, and in 1981 it was renegotiated once again to take into account delays in the Unit 2 completion schedule.

Originally, PECO believed that a lump sum contract would provide the lowest cost for installation of this system, and assure that the contractor would make every attempt to work efficiently to avoid losses. At the time this type of contract was chosen, Bechtel believed that 95% of the engineering was complete for HVAC and that scheduling could be accomplished in a manner that would minimize conflicts. Under these conditions, a lump sum/unit price contract afforded the contractor the opportunity to accurately bid the job, and the owner an opportunity to reduce cost exposure risks.

Q. WHEN DID THE ISSUE OF CONTRACT RENEGOTIATION FIRST ARISE?

A. In September 1978, after a series of unsuccessful meetings with Bechtel and PECO, Schneider Sheetmetal Inc. filed a lawsuit involving price adjustments and the volume of changes experienced on the job. This was followed by meetings and studies by all parties in order to resolve the dispute with minimal effect on the project. During this period, renegotiation of the contract was one of the options considered.

Q. WHAT TYPE OF ANALYSIS WAS DONE BY PECO TO DETERMINE WHETHER RENEGOTIATION WAS APPROPRIATE?

A. The following actions were taken to evaluate this question:

- Coopers & Lybrand business review (January 1979) of SSM's accounting records to determine whether negative cash flow actually was a problem, this being the source of the need asserted by Schneider for renegotiation.

- PECO Cost Group analysis (January 1979) of SSM Balance Sheet, indicating that SSM had about $1 million negative cash position.

- PECO Schedule Group analysis (April 1979) of impact to schedule of various options, including the cancellation of the SSM subcontract and its impact to the project schedule.

- Bechtel - Cost Overrun Analysis and Recommendation (April 1979) recommended renegotiation as best alternative.

- Gilbert/Commonwealth Independent Study (June 1979) of HVAC subcontract at Limerick also recommended renegotiation of contract.

Q. WERE THERE SIGNIFICANT DESIGN DIFFERENCES INVOLVED IN LIMERICK'S HVAC COMPARED TO PECO'S PEACH BOTTOM UNIT AND OTHER UNITS BEING BUILT DURING THAT TIME FRAME?

A. There were two significant aspects of the HVAC design that impacted both the difficulty of installation and ultimately the cost. The first was the seismic requirement of .15g ground acceleration for the Limerick plant site, which was

significantly higher than Peach Bottom and other plants such as Susquehanna. This design constraint resulted in a much heavier material being used for ductwork, and more hangers than had been anticipated when the project began. The second design difference was the requirement that the reactor enclosure HVAC system have a closed loop, filtered, air recirculation mode to minimize radiological releases during a loss-of-coolant-type accident. The result was that the HVAC system at the Limerick Project was more congested, more complex and more costly than originally anticipated.

Q. PLEASE DESCRIBE THE PROBLEMS WITH MANPOWER UNAVAILABILITY ON THIS SUBCONTRACT AND EFFORTS BY ALL PARTIES TO RESOLVE THESE PROBLEMS.

A. The primary problem was a shortage of qualified sheetmetal welders available to SSM from the local union. TB&A's review of PECO's monthly schedule analyses showed that the Company and Bechtel made every effort to resolve this problem and that sufficient staffing levels were ultimately achieved.

Q. WHAT LEVELS OF PRODUCTION RATES WAS SSM ABLE TO SUSTAIN DURING 1978 AND 1979?

A. Due to the shortages of sheetmetal welders, and unit rates that were higher than anticipated, production never achieved the scheduled levels during 1979 and 1980. In fact, during this period production rates were 50%-70% of the scheduled level. The result of this shortfall in production was concern over possible impacts on other commodities and on the overall schedule.

Q. WHAT EFFORTS WERE MADE ON THE PART OF SCHNEIDER, BECHTEL AND PECO TO MINIMIZE POTENTIAL CONFLICTS WITH OTHER CRAFTS AND TO IMPROVE PRODUCTION RATES?

A. A number of different actions were taken to minimize conflicts, improve schedule progress and minimize the effects of HVAC problems on overall project costs. These included:

- Administrative changes such as the parent company of SSM, Schneider, Inc. taking over administration of the work from their subsidiary.
- Addition by Bechtel of another civil project engineering representative to HVAC.
- Approval of all HVAC drawings in the field so as to speed up implementation of design changes.
- Increased responsiveness by SSM in shifting manpower to critical path areas.
- Computerization of progress status reports for high priority work areas.
- Agreement with Local 19 Union to use non-union and subjourneyman mechanics and welders.
- Establishment of second shift in critical areas.
- Implementations of training programs for craft labor.

Q. WHEN DID PROGRESS BEGIN TO IMPROVE?

A. During 1980, as manpower increased, improvements occurred. Throughout 1980 and 1981, PECO closely monitored HVAC progress. By February 1982, however, HVAC was 79% complete for Unit 1 and Common, with only drywell and reactor work slightly behind schedules. Second shifts were being used to recover that slippage. In addition, close coordination with Bechtel and rapid engineering responses to interferences and engineering problems were minimizing the impacts of new problems.

Q. WAS PECO'S INVOLVEMENT IN HVAC INSTALLATION DURING THE COURSE OF LIMERICK APPROPRIATE?

A. Yes. Initially, PECO provided a Field Engineer full-time to monitor Schneider's

HVAC contract. Responsibilities included weekly meetings with Bechtel and Schneider, analysis of progress, and review of Change Work Orders (CWO's) and Extra Work Orders (EWO's). When renegotiation began, PECO's Construction Manager was actively involved in both evaluation of options and negotiation of contract details.

Both PECO and Bechtel made major efforts and were extensively involved in resolving difficulties encountered with the HVAC subcontract. PECO initiated a number of studies in 1978-79 to determine a solution to the HVAC subcontract problem in a manner that was in the best interests of the project. PECO renegotiated the subcontract in January, 1980, which permitted work on the HVAC system to continue and avoided the major delays that most certainly would have occurred had a new subcontractor been retained. TB&A found that this management action was most appropriate given the adverse schedule impact that was avoided.

Through its review of the HVAC subcontract, TB&A determined that both PECO and Bechtel took actions to resolve, and did successfully resolve, shortages of qualified sheetmetal welders that existed early in the construction of the HVAC system. PECO management was aggressive in becoming actively involved in resolution of problems with the HVAC subcontract and subcontractor. PECO closely monitored HVAC subcontract performance, taking actions that were reasonable in light of the possible detrimental impact to the project in terms of schedule delay and its associated cost. As the result of such PECO and Bechtel actions, significant schedule delays were avoided.

B. EVALUATION OF STARTUP TESTING MANAGEMENT

Q. WHAT IS THE PURPOSE OF THIS SECTION OF YOUR TESTIMONY?

A. This section of testimony examines PECO's management practices concerning the startup phase of the Limerick Project. This section is organized in four parts: 1) startup organization and staffing; 2) scheduling and monitoring of startup activities; 3) specific PECO management actions; and 4) TB&A's evaluation.

Q. PLEASE DESCRIBE WHAT TB&A DEFINES AS STARTUP MANAGEMENT.

A. Startup generally refers to the period of time when constructed components and systems are initially operated and tested to ensure as-built compliance with, and verification of, design criteria. As component and system construction is completed, the construction group "turns over" these items to a startup group for initial operation and testing. Upon successful completion of testing and initial operation, the components and systems are turned over to the utility's Electric Production Department, which is responsible for actual operation of the plant. The Nuclear Regulatory Commission requires that startup testing be performed prior to the issuance of a low power license.

Startup management consists of organizing and staffing project resources and implementing management control tools in order to ensure successful system turnover and plant testing.

Q. WHAT DID TB&A REVIEW TO EVALUATE PECO'S STARTUP MANAGEMENT?

A. TB&A reviewed how the startup organization was structured, whether the structure contained proper channels of communication both within startup and vis-a-vis other groups on the project, and whether there was integration of personnel from both construction and operations. In addition, TB&A reviewed

whether staffing levels were reasonable given the demands of schedule, and whether the staff was effectively utilized in the startup effort.

TB&A evaluated startup schedules and controls to determine whether they were reasonable, how often they were revised, and what actions were taken by management to control the startup schedule. Moreover, TB&A analyzed whether PECO management maintained and utilized proper scheduling and reporting tools.

The final area in which TB&A reviewed PECO's startup management was the processes relative to problem identification and resolution. Management must be able to identify and resolve a problem in a timely fashion, before the schedule is impacted.

1. ORGANIZATIONAL STRUCTURE AND STAFFING

Q. PLEASE DESCRIBE THE STARTUP ORGANIZATIONAL STRUCTURE AT THE LIMERICK PROJECT.

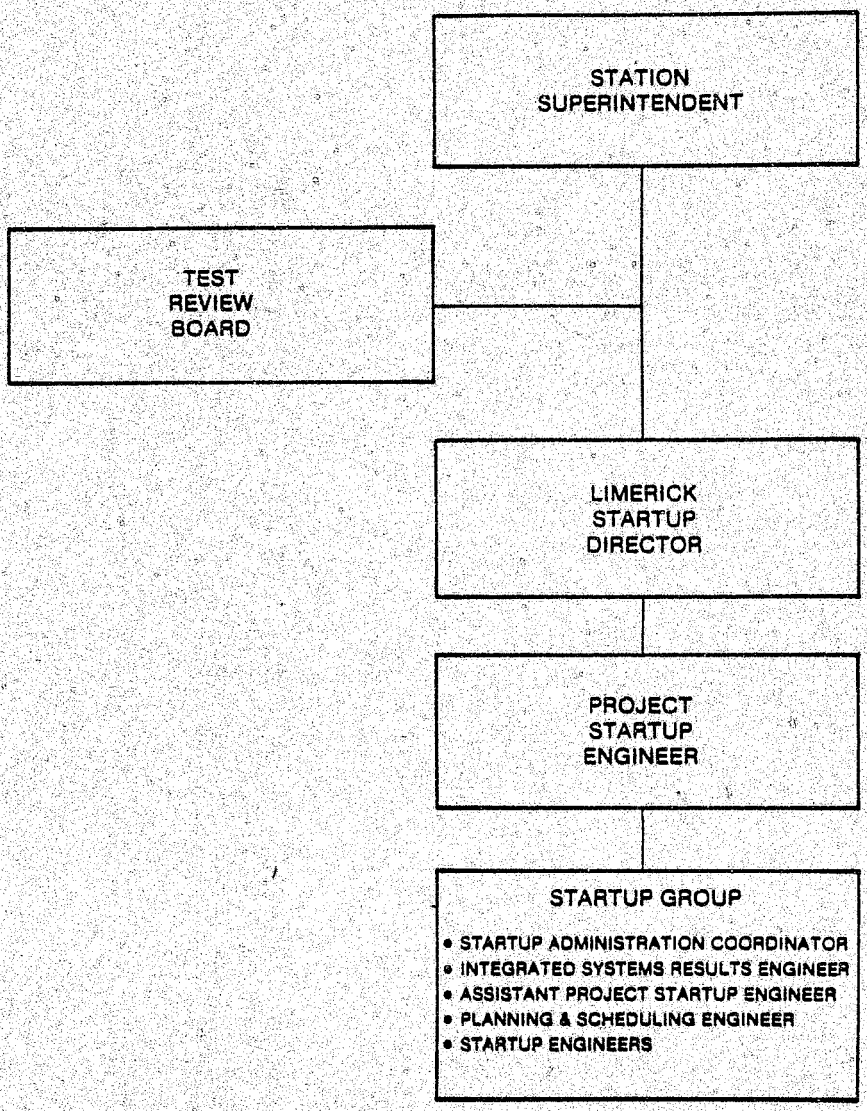
A. Schedule 35 illustrates the startup organization. Startup activities were conducted primarily by Bechtel under the direct management of PECO's Electric Production Department, which had the responsibility for operating the plant following successful turnover from startup. PECO's Limerick Station Superintendent had the overall responsibility for all startup activities. PECO's Startup Director, who reported to the Limerick Station Superintendent, had direct responsibility for coordinating all activities. The following key personnel reported to the Startup Director:

- Startup Administrative Coordinator (Bechtel)
- Integrated System Results Engineer (PECO)
- Project Startup Engineer (Bechtel)

PHILADELPHIA ELECTRIC COMPANY

PHILADELPHIA ELECTRIC COMPANY — LIMERICK STARTUP ORGANIZATION

1984



SOURCE: PHILADELPHIA ELECTRIC COMPANY RECORDS

- Planning and Scheduling Engineer (Bechtel)

The Startup Administrative Coordinator was charged with the tasks of monitoring the startup work list, release status, turnover package approval, and plant scoping status, and coordinating all Preoperational Test Program procedure activities. The Integrated System Results Engineer had the primary responsibility for the development and direction of integrated system tests as well as the supervision of his startup engineers.

The Project Startup Engineer (PSUE) was responsible for managing daily startup activities, providing manpower planning and Bechtel startup personnel administration, providing overall project startup coordination and problem resolution, ensuring proper startup program implementation, supervising assistant PSUE's and others, and acting as the back-up to the Startup Director.

The PSUE was also responsible for coordinating the efforts of the shift operations coordinator, electrical group supervisor, the Research and Testing Division Lead Site Engineer and the Instrument Controls Engineer. The startup groups under the Assistant PSUE(s) were initially organized by major area such as HVAC, NSSS and Balance-of-Plant (BOP), but later the organizational structure changed to mixed functions in order to more effectively utilize the startup personnel. The startup engineers themselves were assigned by system responsibilities within an area.

The Planning and Scheduling Engineer maintained the startup schedules. He was responsible for interfacing with the other project groups and startup supervisors, providing status on overall system testing, and maintaining the startup/cost progress monitoring system.

The Test Review Board (TRB) was responsible for the review and

approval of preoperational test procedures prior to testing and, later on, review and approval of test results. The TRB was headed by PECO, and included representation by Bechtel and General Electric as appropriate.

Q. WHAT WAS THE DIVISION OF RESPONSIBILITY BETWEEN BECHTEL AND PECO?

A. The Limerick Startup Organization was an integrated PECO and Bechtel team, with PECO retaining management responsibility for startup. PECO's primary role was to direct, coordinate and retain overall management responsibility for the startup program. Bechtel's role was to staff and perform the required testing.

Q. HOW WERE THE WORK RESPONSIBILITIES DIVIDED BETWEEN THE STARTUP AND CONSTRUCTION ORGANIZATIONS, AND WHAT INTERFACE EXISTED BETWEEN THE TWO ORGANIZATIONS?

A. Bechtel Construction generally finished installation and performed static testing on components/systems/subsystems. Bechtel Construction then released the components to PECO's Engineering and Research Department for electrical and instrument component calibration. Upon completion of Bechtel Construction and Engineering and Research Department activities, systems and subsystems were then turned over to the startup organization for initial operation, flushing and system testing. The transition from construction of a system to startup of the system on the Limerick Project was similar to that found on other nuclear projects reviewed by TB&A.

Q. HOW DID THE LIMERICK STARTUP ORGANIZATION INTERFACE WITH THE REST OF THE PROJECT?

The Limerick Startup Director coordinated with the Bechtel Project Manager

and PECO Construction Manager concerning project matters, and with the PECO Station Superintendent for operational support during the startup process. The PSUE worked with the Bechtel Field Construction Manager and the Bechtel Project Engineer on construction and engineering startup support issues. At a lower level, the Assistant PSUE(s) interacted with the Construction Startup Superintendent and the Construction System Completion Superintendent. The Construction Startup Superintendent, who worked for Bechtel Construction, was responsible for coordination of construction support during startup. The Construction System Completion Superintendent, who also worked for Bechtel Construction, coordinated the construction completion of systems in order to support the startup program.

Q. PLEASE DISCUSS THE COMMUNICATION CHANNELS UTILIZED BY THE LIMERICK STARTUP ORGANIZATION.

A. The Limerick Startup Organization utilized meetings, reports and daily verbal contacts to communicate with project management and other project departments. The Startup organization also attended the Monthly Project Status Review Meeting, at which time questions from the rest of the project management team concerning startup status and other pertinent topics were answered. A startup status summary and addendum report was contained in the Project Status Review Meeting handouts. In addition to the Monthly Project Status Review Meeting, the startup organization attended or conducted other meetings to communicate and receive information. The Assistant PSUE conducted a daily "3-day plan of the day" meeting to plan and coordinate the working level activities. This meeting was attended by personnel from both Construction and Engineering, as well as the startup organization. The startup

organization also conducted daily meetings with the Construction organization and with the System Completion Group.

The startup organization communicated internally in a similar manner. The Startup Director was briefed at least daily on startup status by the Assistant PSUE, who in turn met daily with the startup group supervisors on startup status and problem resolution. Phone conversations, ad hoc meetings, and daily face-to-face interaction served to keep startup management informed.

The startup organization utilized three types of reporting: 1) the Monthly Project Status Review Meeting Report; 2) the startup schedule; and 3) the Startup Cost Report from the PICOM computer tracking program. These reports were used by the startup group to monitor the status of startup activities for both the startup organization and for project and PECO corporate management. In addition, a number of special schedules were used for startup of certain systems within the plant.

Q. DESCRIBE THE STAFFING LEVELS WITHIN THE LIMERICK STARTUP ORGANIZATION.

A. Startup personnel were provided primarily by Bechtel, with PECO providing key startup management staff, including the Limerick Startup Director, TRB Chairman, Engineering and Research Department personnel, as well as several startup engineers. PECO staff was also responsible for electrical and instrument component calibration ("Blue Tag testing"). Other contractors, such as GE, also provided startup support in selected areas or systems in the plant.

Bechtel's non-manual startup field staff rose from approximately 35 people at the beginning of 1983 to a peak of approximately 150 people eight

months prior to fuel load. Effective staffing also peaked eight months prior to fuel load at the 200-person level. Bechtel's startup manual staffing rose from approximately 30 at the end of 1982 to a peak in August 1984 of approximately 400.

2. SCHEDULING AND MONITORING OF STARTUP ACTIVITIES

Q. WHAT TOOLS DID PECO AND BECHTEL EMPLOY FOR THE SCHEDULING AND COST MONITORING OF THE STARTUP OF LIMERICK?

A. Prior to mid-1981, PECO employed a manually generated Critical Path Method schedule (based upon Peach Bottom Unit 3 experience) for the Limerick Startup schedule. In 1980 PECO, together with PSE&G and Bechtel, undertook an effort to develop computerized startup schedules utilizing the Project Resource Evaluation Management Information System (PREMIS) program. From this effort, computerized startup schedules for both the Limerick and Hope Creek projects were produced.

Individual startup schedules were prepared for each operational test. These schedules illustrated prerequisites, restraints, and test logic that influenced preoperational/acceptance tests. Special schedules were also prepared for all major startup tests or plant operations, such as code hydrostatic tests, integrated leak rate tests, loss of air tests, and operational hydrostatic tests, i.e. activities that require close coordination between startup, construction and engineering. These schedules provided details of each milestone to be accomplished from acceptance of a system by the startup group, through acceptance of the startup test procedure, to completion of preoperational/acceptance tests and review of the test results package. Revision 5 of the Limerick Startup Schedule, issued July 31, 1981 and all

subsequent issues were generated utilizing PREMIS.

PECO also utilized the Project Information and Cost Management Program (PICOM), a progress monitoring computerized system that was incorporated into the PREMIS-generated startup schedules. This progress monitoring system was based on work units to be performed during startup. Work unit weighting was assigned based on Peach Bottom and industry data. As work units were completed, progress was recorded and tallied.

Q. PLEASE DESCRIBE IN MORE DETAIL THE PREMIS AND PICOM PROGRAMS.

A. PREMIS and PICOM together form an integrated cost and scheduling system. PREMIS, the scheduling program, provides CPM-type schedules, Gantt Charts, and Major Milestone Charts. PREMIS is flexible in its ability to rapidly analyze and generate new schedules for both the actual Startup schedule or for any sensitivity analysis involving changing variables within the schedule, such as manpower loading or task duration.

PICOM, the cost program, provides reports on the status of individual startup tasks, the time and money expended to date or over a set period, the number of manhours or costs to-go, and overall budgeted manpower and cost for a particular startup task. The PICOM program is capable of interacting directly with PREMIS, and as such provided a true cost/scheduling tool for the startup organization.

Q. PLEASE DESCRIBE THE MONITORING EFFORTS OF PECO STARTUP MANAGEMENT.

A. PECO closely monitored the progress of startup activities through PREMIS and PICOM. As both of these computer programs are dynamic in their ability to quickly generate reports for management, PECO startup management was able

to identify and resolve issues before they impacted the startup schedule and fuel load. Through the interaction between the Project Startup Engineer and the Limerick Startup Director, PECO adequately monitored the progress of startup activities.

3. SPECIFIC STARTUP MANAGEMENT ACTIONS

Q. WHAT WERE THE IMPORTANT DECISIONS MADE BY PECO STARTUP MANAGEMENT DURING THE STARTUP PHASE OF THE PROJECT?

A. TB&A identified a number of key actions taken by PECO startup management during the startup phase of the project.

In June 1983, in response to a number of late system turnovers to PECO for "Blue Tag" testing, PECO startup management involved Bechtel electrical field engineering in an effort to improve the "Blue Tag" releases to PECO. This involvement by Bechtel led to greatly improved efficiency in the release of equipment and systems to the "Blue Tag" testing program.

In the following month, PECO startup management instituted the formation of the Code Hydro Group to ensure attainment of the important Code Hydro startup milestone. As a result of this effort, the Code Hydro milestone was achieved 22 days ahead of schedule.

Another significant management action taken by PECO was the decision in March 1984 to develop a schedule recovery plan which deferred until after fuel load the completion of those systems not specifically required by the NRC prior to fuel load. This action permitted PECO to defer 6% of the scheduled work load for fuel load, providing the startup organization with a more manageable rate of required progress.

Q. WHAT WAS THE LEVEL OF PECO AND BECHTEL SENIOR MANAGEMENT INVOLVEMENT IN THE STARTUP PHASE OF THE PROJECT?

A. PECO senior management had a substantial involvement in startup. In the summer of 1984, in an effort to ensure achievement of scheduled fuel load, PECO established a full-time jobsite presence of a number of senior managers including PECO's Vice-President of Engineering and Research, PECO's Superintendent of Nuclear Power, and Bechtel's Limerick Project Manager. This senior management team, by their involvement and authority, facilitated the effective completion of activities required for fuel load. The NRC commended this senior management involvement in the 1985 SALP report:

> "The involvement of senior PECO corporate and site management continued to be evident. In fact, the involvement of corporate management increased during the latter part of the period with the full-time presence of the Vice President of Engineering and Research at the site to lead a project completion team composed of himself, the Superintendent of Nuclear Generation, and the Bechtel Project Manager. This team, along with PECO Project Construction and Field Quality Assurance organizations, greatly enhanced the performance of the licensee especially regarding completion of licensee punch-list items and preoperational test activities."

4. TB&A EVALUATION OF STARTUP MANAGEMENT

Q. WHAT IS TB&A'S OVERALL ASSESSMENT OF PECO'S MANAGEMENT OF STARTUP ACTIVITIES AT LIMERICK?

A. After a detailed analysis of PECO's management actions during the startup phase of Limerick Unit 1, TB&A concludes that PECO management maintained extensive and commendable involvement in the startup effort. PECO's concern for meeting the October 1984 fuel load target is exemplified by the assignment of senior management to the jobsite on a full-time basis. TB&A found that this assignment of key senior management directly contributed to the

accomplishment of fuel load in October 1984 as scheduled.

TB&A also found that PECO management utilized the results of outside technical reviews to implement changes to improve the overall startup phase of the project. The actions taken by PECO management were effective in improving the performance of startup tasks.

PECO management properly structured the startup organization to most effectively monitor and manage progress in startup activities through their use of an integrated startup team. Representation on that team by both the Electrical Production Department of PECO and Bechtel Construction led to an orderly transition from constructor to operator.

The organizational structure that PECO and Bechtel implemented for the startup functions facilitated the organizational interfaces necessary during startup. The organizational structure provided multiple interfaces between Startup and Bechtel Construction and Engineering. Interfacing and communication between the Startup organization and Construction and other project entities were appropriate to achieve the needed level of coordination.

PECO Startup Management was properly organized to take full advantage of interfaces between Bechtel Construction and Engineering, PECO Construction and Engineering and PECO's Electric Production Department. This interface is critical to a startup effort, where changing conditions require that key management decisions be made in a timely fashion. The proper organizational structure and aggressive management involvement by PECO allowed for timely resolution of problems as they arose.

TB&A found that PECO was aggressive in terms of the scheduling of startup activities. PECO staffing adequately supported the October 1984 fuel

load, and was effective in accomplishing the required startup tasks in line with the overall project schedule. TB&A found that PECO Startup utilized flexible scheduling and management control tools. Schedules were often revised to more accurately reflect changing conditions as problems arose. PECO, through the pooling of resources with PSE&G and Bechtel, improved the quality of these management tools in the most cost-effective manner. PECO startup scheduling tools were both reasonable and adequate in supporting the October 1984 fuel load. As opportunities for schedule improvement arose, the Limerick Startup organization modified the schedule to take advantage of these opportunities.

The overall schedule for the project was geared toward meeting an October 1984 fuel load. Because of the effective startup organizational structure, careful PECO management and monitoring of startup activities, and the extensive involvement of senior management personnel, PECO Startup management was successful in attaining the scheduled fuel load date.

V. PROJECT DEFERRAL ANNOUNCEMENTS AND CONTINUED JUSTIFICATION ANALYSES

Q. WHY DID TB&A EXAMINE THIS ASPECT OF THE LIMERICK PROJECT?

A. In its Order of May 7, 1982, the Pennsylvania Public Utility Commission questioned the reasonableness of certain Limerick Project deferral announcements and related actions. For TB&A to adequately assess whether the management processes underlying these announcements were reasonable and appropriate, it was necessary to perform a retrospective review of this aspect of project management.

The objective of TB&A's examination was two-fold: 1) to review the internal and external financial environment at the time the decisions were

made; and 2) after examining the environment, to determine whether the management processes employed and consequent decisions made were reasonable management actions.

Q. HOW DID TB&A PERFORM ITS ANALYSIS OF PECO MANAGEMENT ACTIONS REGARDING THE DEFERRAL ANNOUNCEMENTS?

A. Decisions to defer construction of large nuclear power plant projects result from many interrelated factors. A utility's ability to finance construction, the anticipated need for its capacity, regulatory issues, project scope changes, etc., may all have varying degrees of influence on a decision to slow-down construction activities. In the case of Limerick, TB&A's approach to examining this issue was to:

1. Review the mechanics of PECO's management process as applied to the financial planning of major capital intensive projects.
2. Collect, analyze and compare key financial statistics of PECO with those of the utility industry in general.
3. Review PECO's generation planning process and their efforts to perform continuing justification analyses of the Limerick Project.

This form of analysis allowed TB&A to address the relevant contemporaneous events and conditions impacting the Limerick deferral decisions of 1974, 1976 and 1978.

A. EVALUATION OF PECO FINANCIAL PLANNING PROCESS

Q. PLEASE EXPLAIN WHAT YOU MEAN BY FINANCIAL PLANNING?

A. Financial planning is not just one discrete activity but a process encompassing varied activities. What comprises the process is perhaps best described by Richard Brealey and Stewart Meyers. In their book, "Principles of Corporate

Finance", they describe financial planning as a process of:

"1. Analyzing the interactions of the financing and investment choices open to the firm.

2. Projecting the future consequences of present decisions, in order to avoid surprises and understand the links between present and future decisions.

3. Deciding which alternatives to undertake (these decisions are embodied in the final financial plan)

4. Measuring the subsequent performance against the goals set in the financial plan."

Additionally, it is important to keep in mind the horizon within which financial managers must plan. There are not only short-term plans, usually 12 months or less but, as in the case of utilities, long-term plans extending out for 10 years or more due to the nature of their business and the service they provide.

Q. WHAT IS TYPICALLY INCLUDED IN A FINANCIAL PLAN?

A. Financial plans will usually include pro-forma (forecasted) financial statements, i.e. balance sheets, income statements and sources and uses of funds, as well as projected capital expenditures and planned financing scenarios. With regard to financing scenarios, Brealey and Meyers explain:

> "The complexity and importance of financial plans varies tremendously from firm to firm. A firm with limited investment opportunities, ample operating cash flow, and a moderate dividend payout accumulates considerable 'financial slack' in the form of liquid assets and unused borrowing power. Life is relatively easy for the managers of such firms, and their financial plans are routine. Whether that easy life is in the interest of their stockholders is another matter.
>
> Other firms have to raise capital in large amounts by selling securities. Naturally, they give careful attention to planning what kinds of securities are to be sold, and when. Such firms may also find their financing plans complicated by covenants of their existing debt. For

example, electric utility bonds usually prohibit the firm from issuing more bonds if interest coverage drops below a certain level. Typically, the minimum level is two times earnings."

Financial planning at utilities was assuming greater significance, as well as becoming increasingly complex, during the mid-1970s.

Q. WHAT WAS THE STRUCTURE OF PECO'S FINANCIAL PLANNING PROCESS DURING THE DEFERRAL DECISION PERIODS?

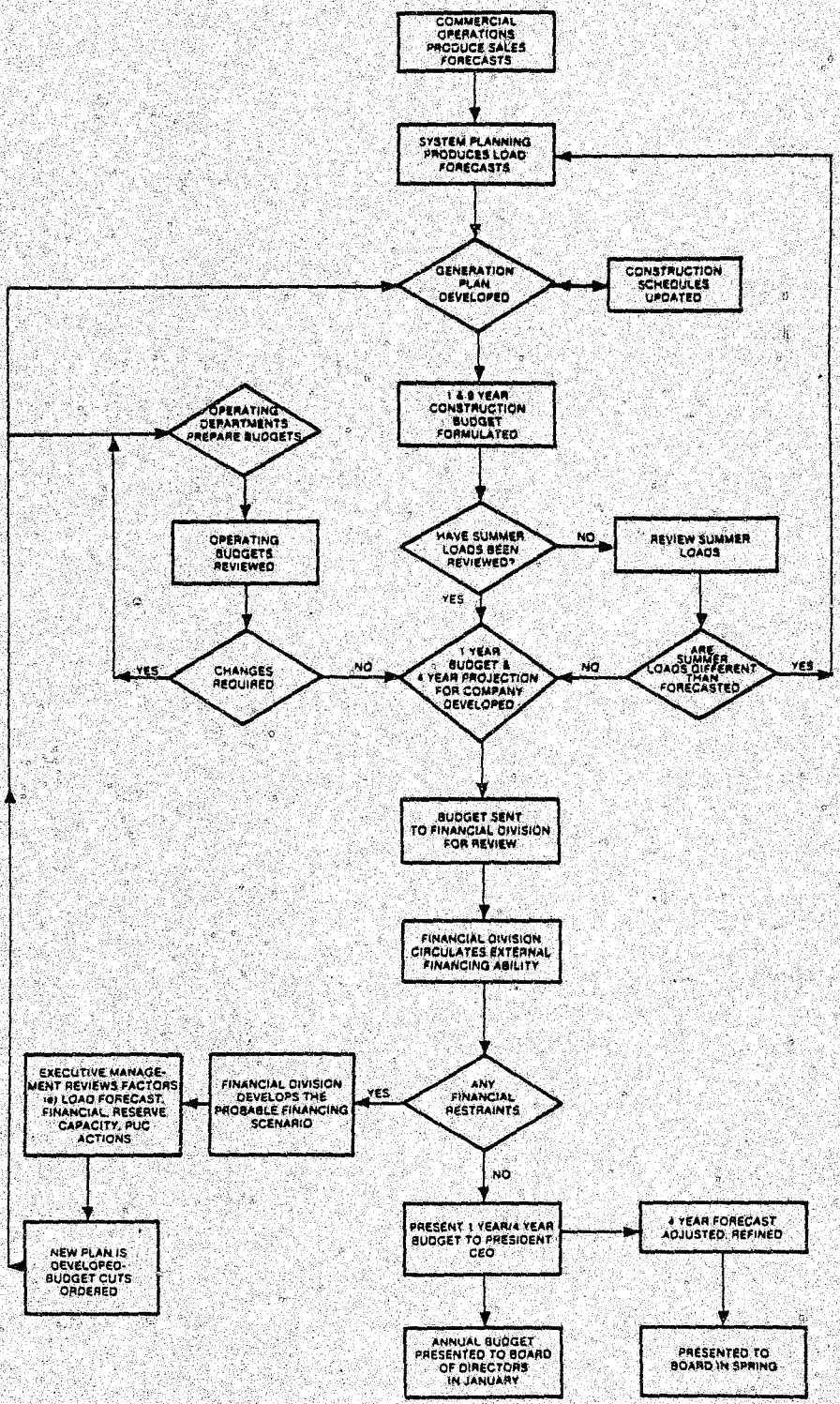
A. Schedule 36 presents an overview of PECO's financial planning process during the 1970s. This exhibit graphically demonstrates the flow of information during a typical budgeting year and illustrates the overall interrelationships of key departmental groups. The process, as shown, included the development of sales forecasts, peak load projections, generation plans, capital budgets, operating budgets, financial scenarios and pro-formas. The planning process was substantially the same throughout the 1970s.

Q. IS PECO's FINANCIAL PLANNING PROCESS DEPICTED IN SCHEDULE 36 UNIQUE TO PECO OR IS IT COMPARABLE TO OTHER UTILITIES?

A. The mechanics of PECO's planning process are similar to those utilized by other large utilities for which TB&A has performed management audits. TB&A found that the interdepartmental relationships depicted in Schedule 36 facilitated information flow and decision-making while still permitting flexibility when unusual circumstances dictated. The planning process also made allowance for inclusion of major budgetary changes on a timely basis, as well as proper review and evaluation of the impact of those changes.

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PHILADELPHIA ELECTRIC COMPANY FINANCIAL PLANNING PROCESS



SOURCE: TB&A ANALYSIS

Q. YOU MENTIONED THAT PECO'S PLANNING PROCESS PERMITTED "FLEXIBILITY WHEN UNUSUAL CIRCUMSTANCES DICTATED." PLEASE EXPLAIN WHAT IS MEANT BY THAT?

A. The period throughout the mid to late 1970s was a financially troubling one for many utilities, including PECO. As conditions worsened, it became imperative for PECO's financial managers to adapt to the changing environment. "Flexibility" was required in developing alternative financing scenarios. PECO achieved this flexibility by considering numerous variations to its base case forecast of projected financial performance. When it became evident, in any given year, that PECO could not support originally projected funding levels, it was forced to go back and re-evaluate its initial financing plan. This entailed varying key input factors, e.g., capital structure, timing of security offerings, projected operating and capital budget expenditures, etc., and then analyzing the impact of these changes on financial indicators such as coverage ratios, earnings and dividends. Often, numerous iterations were required before a recommended course of action would be presented to PECO Senior Management along with explanations of possible limitations, e.g. the dependence of projected results on the amount and timing of anticipated rate relief.

Q. WHAT ARE TB&A'S CONCLUSIONS REGARDING THE FINANCIAL PLANNING PROCESS EMPLOYED BY PECO DURING THE 1970s?

A. TB&A concludes that PECO's financial planning process during the 1970s was representative of sound management procedures, addressed the relevant aspects of financial planning and practices, and allowed for reasoned and informed decision-making.

B. ANALYSES OF PECO FINANCIAL CONDITION

Q. WHAT WAS THE FINANCIAL CONDITION OF THE UTILITY INDUSTRY DURING THE 1970s?

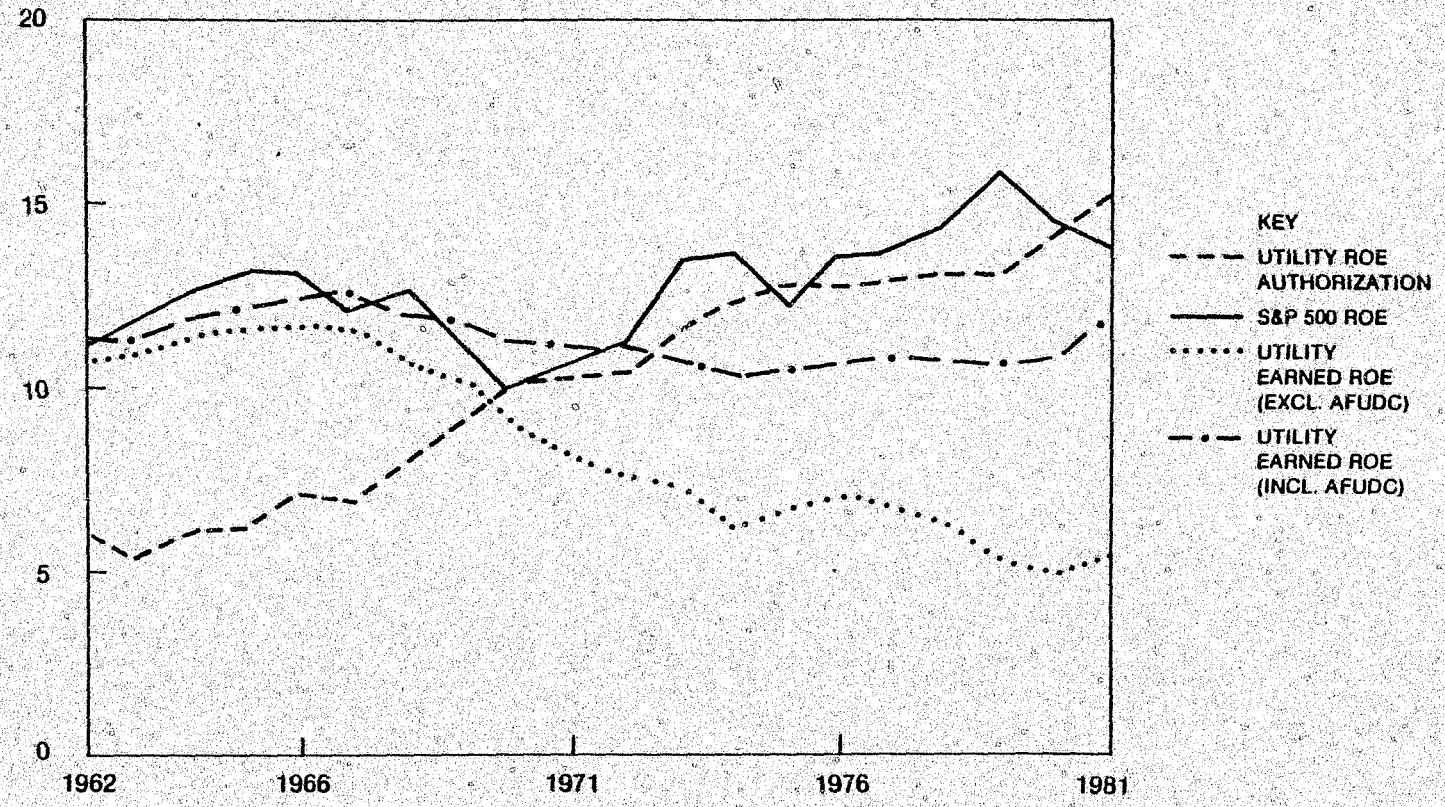
A. The period spanning the 1970s was very turbulent for electric utilities in general and for those with nuclear construction programs in particular. Many factors caused this upheaval, including the oil embargo and resultant rising energy costs, declining sales and load growth, construction cost spirals, restrictive Public Utility Commissions, and a financial community that re-evaluated the risk of utility industry investments.

The oil embargo and its effect on energy sales had a major impact on the financial condition of an industry that was already showing signs of deterioration. Schedule 37 illustrates the lower appeal of utilities as a potential investment compared to the S&P 500, as seen by the diverging return on equities (ROE) achieved during the 1970s. Utility earned ROE, excluding Allowance for Funds Used During Construction (AFUDC), is particularly relevant because it highlights the reduced cash flow that the industry was experiencing.

This anemic financial condition was further exacerbated by the reluctance of state Public Utility Commissions to give rate relief at the levels requested. Schedule 38 shows the significant difference between what utilities were requesting in the form of rate relief and what the commissions were awarding. The resulting effect on cash flow was to reduce the level of internally generated funds which, in turn, forced utilities to finance larger percentages of capital projects from externally acquired funds. This led to a drop in utility bond ratings and stock price deterioration. Also, the

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ELECTRIC UTILITY AVERAGE RETURN ON EQUITY

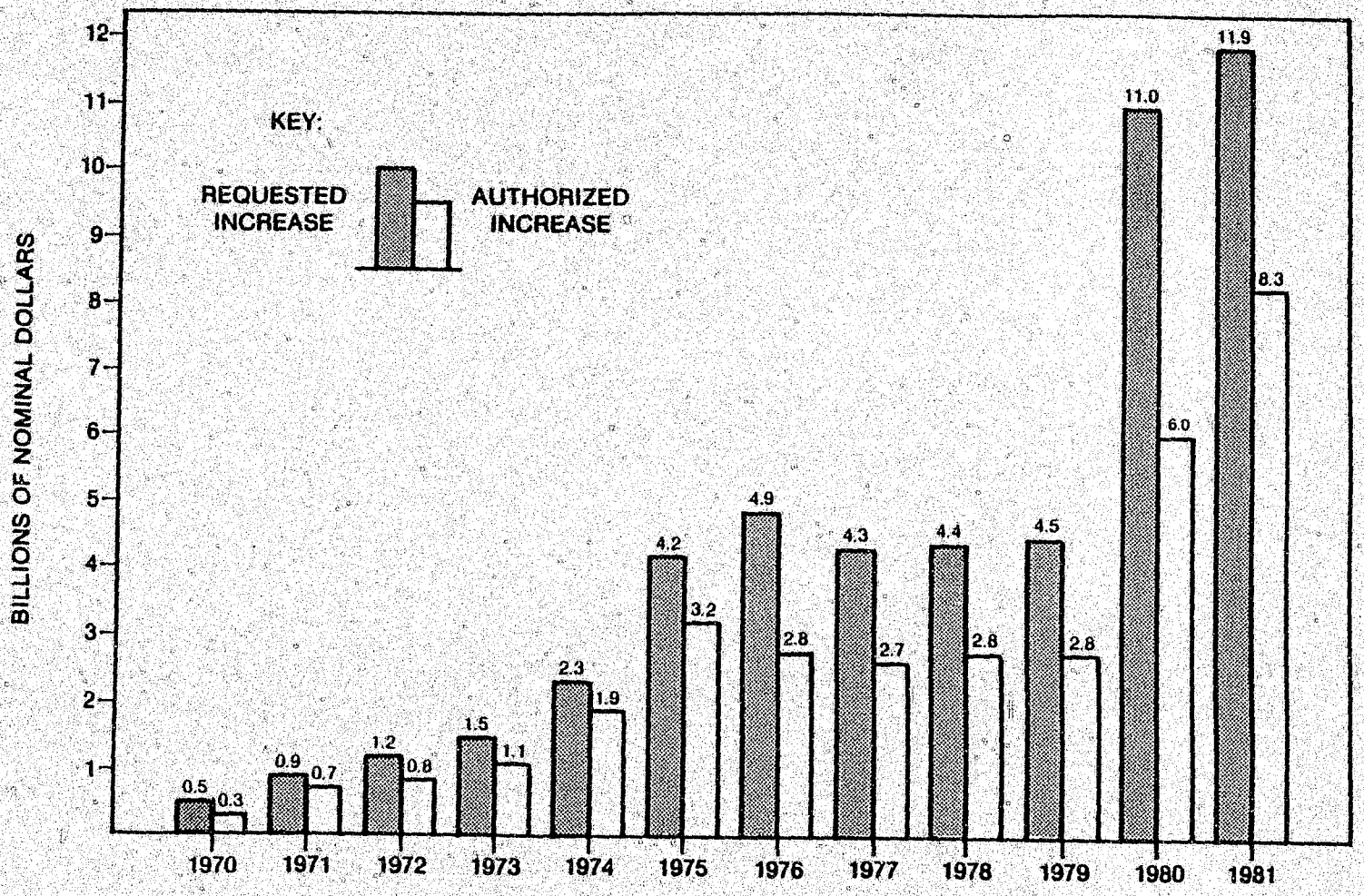


SOURCE: U.S. DEPARTMENT OF ENERGY, *THE FINANCIAL HEALTH OF THE ELECTRICAL UTILITY INDUSTRY*, 1982, p. III-7

SCHEDULE 37

PHILADELPHIA ELECTRIC COMPANY

BASE RATE INCREASE REQUESTS AND AUTHORIZATIONS



NOTE: EXCLUDES FUEL ADJUSTMENT

SOURCE: U.S. DEPARTMENT OF ENERGY, *THE FINANCIAL HEALTH OF THE ELECTRIC UTILITY INDUSTRY*, 1982, p. III-9

SCHEDULE 38

market/book ratio of most utility stocks dropped below 1.0, leading to dilution of common stock earnings.

A low point for the industry was reached in 1974 when Consolidated Edison omitted its common stock dividend payment, and many utility stock prices dropped precipitously. During 1974, numerous companies deferred construction on large nuclear power plants specifically as the result of financing difficulties. While financial and load growth problems were worsening, the cost of constructing nuclear plants was increasing. New regulations, changes in scope, high interest rates, high labor costs, increasing material and equipment costs and a host of other factors all contributed to costs of nuclear plants well above what was originally projected.

Q. WHAT WAS THE FINANCIAL CONDITION OF PECO DURING THE 1970s?

A. During the 1970s, PECO experienced poor financial performance relative to its own past history and to the utility industry in general. This financial performance was due to factors such as: 1) limited cash flow, which resulted from lower than anticipated sales revenue; 2) poor quality of earnings, which reflected the high component of non-cash earnings due to AFUDC; 3) a high dividend payout ratio, which resulted in reduced levels of retained earnings; and 4) returns on equity which fell well below the allowed returns and those of the industry in general.

The contemporaneous financial condition of PECO and the utility industry in general had a significant bearing on the options available to, and the decisions made by, PECO during the 1970s. In particular, it affected the sources and cost of capital available, the risks for PECO, and the financial constraints imposed upon it.

Q. DID TB&A PERFORM ANY ANALYSIS TO DETERMINE THE FINANCIAL PERFORMANCE OF PECO RELATIVE TO THAT OF THE UTILITY INDUSTRY IN GENERAL DURING THE 1970s?

A. Yes. TB&A selected a group of financial indicators to compare PECO's financial performance with that of the industry.

Q. WHAT WERE THESE CRITERIA AND WHY WERE THEY SELECTED?

A. Many indicators may be evaluated in determining the relative financial condition of a utility with a large construction program. The criteria reviewed vis-a-vis the industry and PECO were Yield, Return on Equity (ROE), Allowance for Funds Used During Construction (AFUDC) as a % of Earnings, Market to Book Ratio, Interest Coverage Ratio and Bond Ratings. These indicators were selected because they provide an overall perspective with regard to a company's financial condition and its level of acceptance in the market.

Q. WHAT WERE THE RESULTS OF YOUR ANALYSIS?

A. In evaluating PECO's performance against the utility industry in general using the above noted criteria, TB&A obtained the following results:

Yield is a ratio (expressed as a percentage) of the return on common stock, in the form of yearly dividend payments, to the stock's market price. Based upon this criterion, PECO had between the fourth and eighth highest yields (compared to the 50 largest eletric utilities) on their common stock for the years 1974 to 1979. In this ranking, the highest yield would indicate the stock that carried the greatest perceived risk.

Return on Equity (ROE) - The earned return on book common equity is indicative of the return on investment that the utility earns for its common

shareholders. The allowed return is set by the PUC through rate setting mechanisms and is intended to allow a utility to raise equity funds at a cost adequate to ensure reasonable financial health of the company. PECO's earned ROE ranged from 8.9% to 9.9% between 1974 and 1979, which led it to be ranked from 73rd to 82nd of 89 of the utilities evaluated in Standard & Poors Current Analysis, with lowest earned ROE ranked last.

AFUDC as a % of Earnings, or quality of earnings, indicates the strength of a company's cash flow and the impact on ROE that will occur when AFUDC is removed from earnings calculations. Between 1974 and 1979, PECO's quality of earnings ranked from 76th to 85th of 89 of the utilities evaluated in Standard & Poor's Current Analysis, with a higher percent indicating a weaker performance.

Market to Book ratio measures the market's perceived economic value of a firm versus its accounting book value. PECO's performance rank from 1974 to 1979 paralleled that of the industry average, but was usually well below 1.0.

Interest Coverage Ratio - PECO's mortgage interest coverage ratio during the 1970s fluctuated from 2.1 to 2.5. This precarious position constrained PECO from utilizing long-term debt for capital acquisition. The interest coverage ratio is also one of the key indicators examined by rating agencies and undoubtedly contributed to the periodic downgradings of PECO bonds. PECO had worse coverage ratios than the industry in general during the analysis period (1974-1979).

Bond ratings - Standard & Poor's rating of PECO's mortgage bonds deteriorated from AA in 1974 to BBB- in 1982. Downgradings took place at the following dates:

DATE	FROM	TO
10/74	AA	A
2/76	A	A-
4/80	A-	BBB+
6/81	BBB+	BBB
9/82	BBB	BBB-

Bond downgradings were also typical of other utilities and partially reflected the growing risk and uncertainty of investments in companies with nuclear construction programs. PECO's present BBB- rating places it at the lowest "investment grade" rating level.

Q. IN TB&A'S ANALYSIS OF PECO'S FINANCIAL CONDITION, DID YOU COMPARE PECO SPECIFICALLY WITH OTHER UTILITIES WHO DEFERRED CONSTRUCTION OF NUCLEAR POWER PLANTS FOR FINANCIAL REASONS?

A. Yes. TB&A's analysis also encompassed a review of other utilities with nuclear construction programs that faced similar financial problems during the period from 1974 through 1979. The sample was selected using NUREG-0300 (Yellow Book), as well as TB&A experience, and includes companies that deferred construction for financial reasons after 1974. Many utilities, not included in TB&A's sample, deferred construction for financial reasons during 1974, however, only those utilities that also experienced financially related deferrals in later periods, similar to PECO's, were included. It should be noted that this group is not exhaustive because it is quite likely that other utilities have taken similar action, i.e. reducing construction expenditures and extending the project schedule, but without publicly announcing this fact. TB&A's sample included:

Utility	Plant
Carolina Power & Light	Harris 1
Detroit Edison	Fermi 2
Duquesne Power	Beaver Valley 2
Consumers Power	Midland 1,2
Illinois Power	Clinton 2
Niagara Mohawk	Nine Mile Point 2

Also included in the list was Pennsylvania Power and Light's Susquehanna Units 1 & 2, which were not deferred due to financial constraints, but which for many reasons (proximity, similar reactor types and A/E's, etc.) is included in the sample. Again, a compilation of key financial indicators (Yield, ROE, AFUDC as a % of earnings and Market to Book ratio) was developed. The results of TB&A's analysis are presented in Schedule 39, and are summarized below.

Yield - In every year PECO's yield was above the group average, which implies a higher perceived risk by the market for PECO stock.

Return on Equity (ROE) - Overall, PECO had consistently low returns that were below not only the industry average, but most of these other financially constrained utilities.

AFUDC as a % of Earnings - Relative to the other seven companies, PECO tended to have consistently high AFUDC, indicating relatively poor quality of earnings.

Market to Book ratio - PECO's market to book ratio for its common stock paralleled the sample group's average ratio, but was usually well below 1.0.

Q. DID PECO'S FINANCIAL CONDITION HAVE AN IMPACT ON ITS ABILITY TO RAISE EXTERNAL SOURCES OF CAPITAL?

A. Yes, it did. It is obvious that their high cost of capital, low coverage ratios and

FINANCIAL STATISTICS - UTILITY COMPARISON

COMMON STOCK YIELD (%)
YEAR END

UTILITY	1974	1975	1976	1977	1978	1979
Carolina Power & Light Co.	13.3	8.0	7.2	7.7	8.9	10.9
Consumers Power Co.	20.2	10.5	9.1	8.8	10.2	12.4
Detroit Edison Co.	18.1	11.2	9.7	8.9	10.9	12.3
Duquesne Light Co.	15.6	10.1	8.6	9.1	11.5	12.9
Illinois Power Co.	14.7	8.5	7.9	8.4	9.9	12.0
Niagara Mohawk Power Corp.	14.8	9.5	8.9	8.9	10.3	11.1
Pennsylvania Power & Light Co.	12.0	9.5	8.2	8.3	10.1	11.3
Philadelphia Electric Co.	16.4	10.9	9.1	9.0	11.3	12.9

SOURCE: Argus Utility Scope Regulatory Service (1974-1980)

FINANCIAL STATISTICS - UTILITY COMPARISON

RETURN ON AVERAGE COMMON EQUITY (%)

UTILITY	1974	1975	1976	1977	1978	1979
Carolina Power & Light	9.6	11.9	11.9	11.3	12.6	12.3
Consumers Power Co.	4.7	8.8	12.1	10.5	10.9	11.2
Detroit Edison Co.	7.5	7.5	8.0	9.3	8.2	9.1
Duquesne Light Co.	10.3	10.8	8.4	7.6	6.4	6.8
Illinois Power Co.	11.3	13.2	11.3	12.7	12.8	12.4
Niagara Mohawk Power Corp.	10.3	12.2	9.7	10.4	11.1	11.4
Pennsylvania Power & Light Co.	12.7	12.7	11.8	14.3	11.7	12.7
Philadelphia Electric Co.	8.9	9.4	9.9	9.6	9.7	9.8

SOURCE: Standard & Poor's Industry Surveys - Current Analysis of Electric Utilities (1974-1980)

FINANCIAL STATISTICS - UTILITY COMPARISON

AFUDC AS % OF COMMON EARNINGS

UTILITY	1974	1975	1976	1977	1978	1979
Carolina Power & Light Co.	106	79	53	57	57	80
Consumers Power Co.	62	35	30	45	55	74
Detroit Edison Co.	57	60	59	45	60	81
Duquesne Light Co.	44	43	46	35	45	49
Illinois Power Co.	21	15	21	33	43	51
Niagara Mohawk Power Corp.	31	31	24	35	40	45
Pennsylvania Power & Light Co.	33	50	57	44	68	79
Philadelphia Electric Co.	72	62	62	65	65	76

SOURCE: Standard & Poor's Industry Surveys - Current Analysis of Electric Utilities (1974-1980)

FINANCIAL STATISTICS - UTILITY COMPARISON

MARKET TO BOOK RATIO
YEAR END

UTILITY	1974	1975	1976	1977	1978	1979
Carolina Power & Light Co.	0.51	0.90	1.04	1.03	0.91	0.75
Consumers Power Co.	0.32	0.63	0.73	0.87	0.79	0.68
Detroit Edison Co.	0.40	0.69	0.81	0.90	0.74	0.69
Duquesne Light Co.	0.61	0.92	1.08	1.02	0.82	0.79
Illinois Power Co.	0.77	1.29	1.35	1.26	1.05	0.85
Niagara Mohawk Power Corp.	0.48	0.79	0.85	0.88	0.82	0.75
Pennsylvania Power & Light Co.	0.66	0.82	0.94	0.93	0.76	0.70
Philadelphia Electric Co.	0.50	0.79	0.95	1.04	0.83	0.73

SOURCE: Argus Utility Scope Regulatory Service (1974-1980)

greater risk as perceived by the market would certainly have hindered their ability to fully utilize external financing sources.

Q. IS TB&A IMPLYING THAT PECO COULD NOT HAVE RAISED ANY ADDITIONAL CAPITAL, DURING THE CRITICAL DEFERRAL DECISION PERIODS, TO FURTHER SUPPLEMENT THE LIMERICK CONSTRUCTION BUDGET?

A. No. Obviously, since PECO's coverage ratio was not at 2.0 or below, additional mortgage bonds could conceivably have been placed. Also, additional preferred and common stock could have been issued. However, the germane issue is not whether PECO could have secured greater levels of external funding but whether the amounts that were secured represented reasonable financial management. It is certainly not good financial planning to drive your interest coverage ratio below 2.0, thereby effectively eliminating your ability to issue additional mortgage bonds in the event of an emergency. Nor is it especially wise to continually issue common stock at market values substantially below book value unless severe capital restraints dictate such a financially debilitating measure.

Q. WERE THERE ANY OTHER ASPECTS OF TB&A'S REVIEW OF THE FINANCIAL CONDITION OF PECO DURING THE 1970s?

A. Yes. TB&A examined the Pennsylvania Public Utility Commission's treatment of PECO electric base rate requests with regard to the percentage received of the dollar amount requested and the length of time between the date the request was filed and the date of the final order. Further analysis addressed the impact of the Commission's actions on the investment community's perception of PECO's financial prospects. Key findings of this review are listed

below.

- Between 1975 and 1979 the Commission granted approximately 71% of PECO's requested electric base rate increases while taking an average of approximately 14 months to issue the final order.

- PECO's February 25, 1976, $100 million mortgage bond offering was downgraded (from A to A-) by Standard and Poor's subsequent to a February 6, 1976 PUC decision to pare PECO's interim rate request.

- An evaluation of the Pennsylvania Public Utility Commission performed by Argus Utility Scope Regulatory Service in March, 1978, expressed the opinion that "Utility regulation in Pennsylvania was relatively satisfactory until the early 1970s. Since that time, however, utility rate making in Pennsylvania has become increasingly politicized and there was a perceptible change during the years 1974-75 in the PUC's responsiveness to the rate requests of the state's utilities. The Commission's record for timeliness slipped since the early 1970s and so too has the financial health of the utility industry in Pennsylvania. There has been much uncertainty in the past few years about the direction of utility regulation in Pennsylvania, mainly because there has been little consistency in the PUC's actions. We continue to rate the regulatory climate in Pennsylvania as below average." (emphasis added)

- Additionally, the Pennsylvania PUC, relative to other state Commissions, was ranked by Argus "below average" in 1979 and 1980 and "average" in 1981, 1982 and 1983. Argus' rating system, which started in 1976, attempts to evaluate the "constructiveness from an investor viewpoint, of the actions and decisions of these regulatory authorities...."

Q. WHAT DOES TB&A CONCLUDE REGARDING THE IMPACT OF THE PENNSYLVANIA PUBLIC UTILITY COMMISSION ON THE ABILITY OF PECO TO UTILIZE EXTERNAL FINANCING?

A. TB&A concludes that the regulatory climate in Pennsylvania during the 1970s changed in such a manner that PECO and the financial community could not expect consistent or timely responses to PECO rate requests. This was manifested by the PUC granting reduced percentages of rate increases requested and the delays experienced in issuing final orders. This added

significantly to PECO's difficulties in effective financial planning.

Q. WHAT OVERALL CONCLUSIONS DID TB&A ARRIVE AT REGARDING PECO'S FINANCIAL CONDITION DURING THE 1970s?

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

C. EVALUATION OF PECO'S CONTINUING JUSTIFICATION ANALYSES

Q. WHY WAS AN ANALYSIS OF PECO'S EFFORTS TO CONTINUALLY JUSTIFY THE LIMERICK PROJECT IMPORTANT?

A. One of the more important functions of utility management is to review on a timely basis various key aspects of major generation projects, especially projects of extended duration and significant cost, such as Limerick, that will have significant shareholder and ratepayer impact. Some of the key factors that should be examined regularly are:

1. The ultimate need for the plant
   - Has the projected load demand changed to such a degree that the plant's capacity will no longer be required in the foreseeable future?
2. The ultimate cost of the plant
   - If the capacity is required, have the economics of completing the project changed in such a way that conversion/cancellation and replacement by some alternative

energy source is more cost effective?

3. The possibilities of sharing energy output with other utilities

- If the need for capacity and cost effectiveness of the current project are demonstrated, but endogenous factors such as financial constraints are hindering completion of the project, has the utility analyzed the advantages and disadvantages of sharing ownership in the plant?

4. The optimal service dates of the plants

- Has the utility reviewed the effects on both stockholders and ratepayers, the reserve capacity implications and overall financial considerations of various possible commercial operation dates for the units.

Q. WHAT SPECIFIC AREAS OF INQUIRY WERE ADDRESSED IN TB&A'S ANALYSIS OF PECO EFFORTS AT CONTINUALLY JUSTIFYING THE LIMERICK PROJECT?

A. TB&A was concerned with reviewing distinct, but interrelated areas. The first area reviewed was PECO's load forecasting efforts throughout the mid to late 1970s. Since load projections form the foundation for ultimate capacity requirements, TB&A examined the methods and procedures PECO utilized to forecast load increases as well as the relative accuracy of the results obtained. This allowed TB&A to determine whether these forecasts provided a contemporaneously sound basis for the decision to continue construction of Limerick. Second, TB&A examined the types and timeliness of studies utilized by PECO to evaluate the cost-effectiveness of Limerick versus viable alternatives, such as coal or oil-fired generation or even outright cancellation.

Also examined were PECO's efforts to sell/share portions of Limerick's output as well as the Company's efforts at determining optimal service dates for the project.

Q. WITH REGARD TO LOAD FORECASTS, WOULD YOU PLEASE DESCRIBE THE EVOLUTION OF UTILITY LOAD FORECASTING METHODOLOGIES DURING THE 1970s?

A. In 1979, TB&A conducted a proprietary survey of utility industry management practices which included a comprehensive review of the load forecasting aspects of system planning. At that time, three primary load forecasting methodologies were being used by the thirty plus utilities that participated in the survey:

- Time-series methods
- Econometric methods
- End-use methods

Time-series techniques analyze the behavior of variables over time and attempt to predict a variable's future based on its past behavior. Econometric techniques are "causal-oriented" -- that is, they specify the behavioral and technological structure of energy demand and relate these to changes in other economic and social variables. End-use techniques approximate actual energy uses by categories of energy consumption devices to arrive at estimates of load requirements.

Time-series methods have traditionally been the most common forecasting technique used in the industry. These vary from simple graphical projections to more complex statistical routines. Much of the utility research devoted to forecasting methodology in the early 1970s was undertaken to

improve time-series based forecasts. In the previously mentioned TB&A survey, 30% of the companies were using time-series based load forecasts. Both economic and end-use techniques have unique characteristics which are perceived as advantageous over purely historically based time-series projections for long-term forecasts. Econometric forecasts relate the impact of changes in prices and other economic factors with energy consumption. End-use analysis allows the examination of factors such as load management or conservation on energy consumption. In the 1979 TB&A study, approximately 50% of the firms surveyed used econometric based forecasts, while 20% utilized end-use based forecasts.

Q. WHAT METHODS WAS PECO USING TO PRODUCE THEIR LOAD GROWTH PROJECTIONS DURING THE 1970s?

A. PECO's load forecasts during the mid-1970s used a combination of the above noted methods. In varying degrees, PECO utilized trend analyses, correlation analyses with regressions, economic projections, and end-use techniques. The forecasts were composed of a band of values consisting of a high, low and most probable sales levels based on variations of underlying assumptions. The total company forecast values were an aggregate of the Residential, Commercial and Industrial classes of customer forecasts. A review of PECO documents indicates the residential energy sales forecasts were based on two main determinants: 1) the number of customers; and 2) the average use per customer. Correlations between various demographic factors, historical population data, the effects of new construction, space and water heating, air-conditioning and other appliances were among the many factors that were addressed in preparing these forecasts. The small commercial and industrial

sales projections were performed in essentially the same fashion as residential sales, using thirty years of historical data plus monthly reports on plans for adjustment of application loads. The large commercial and industrial sales forecasts were based on projections, supplied by Wharton Econometric Forecasting Associates (WEFA), of the regional economy, supplemented by interviews with major customers concerning future plans.

Additionally, in the late 1970s and early 1980s, PECO contracted with WEFA to provide an independent, econometric based forecast of energy growth which they used to compare with their in-house developed projections.

Q. WERE THE RESULTS PECO OBTAINED FROM THEIR LOAD FORECASTING EFFORTS REASONABLY ACCURATE FROM A CONTEMPORANEOUS CONTEXT?

A. PECO, along with most other utilities, consistently over-estimated the need for power throughout the 1970s. PECO's projected ten year compounded growth rates for electric sales dropped from 6.7% per year in 1972 to 2.5% per year in 1980. This reduction was a reflection of many factors, including conservation, demographics, greater use of energy efficient appliances, and overall diminishing economic activity. These same factors impacted other utilities' forecasts as well causing overall electric utility industry projections for sales growth to drop from 7.4% per year in 1972 to 3.6% per year in 1980. It is important to note that PECO's electric sales projections, on an annual basis, were reduced by 63% from 1972 to 1980, while overall electric utility industry forecasts dropped 51%. This comparison serves to indicate that PECO's forecasts were certainly representative from an accuracy standpoint with results obtained by the utility industry in general. Further, PECO forecasts

produced during this period were at least somewhat reflective, as noted previously, of PUC pressure in the late 1960s and early 1970s to increase system capacities to avoid a recurrence of load interruptions. PECO was, thus, acutely aware of the need to not underestimate energy growth for the future.

Q. WHAT DOES TB&A CONCLUDE FROM ITS REVIEW OF PECO'S LOAD FORECASTING EFFORTS DURING THE 1970s?

A. TB&A considers PECO's load forecasts, produced during the 1970s, to have been the product of a reasonable and sound process and their resultant overall accuracy to have been comparable to the utility industry in general. Further, TB&A concludes that PECO's projected system loads were a reliable and reasonable basis from which to plan for additional capacity to meet the anticipated energy demand.

Q. YOU MENTIONED PREVIOUSLY THAT YOU EXAMINED PECO'S EFFORTS AT REVIEWING THE ECONOMICS OF LIMERICK VIS-A-VIS ALTERNATIVE SCENARIOS, I.E. REPLACEMENT WITH FOSSIL UNITS, OUTRIGHT CANCELLATION, AND IMPACTS OF VARIOUS SERVICE DATES. WHAT DID YOUR ANALYSIS INDICATE?

A. A wide variety of issues were examined by the Company relating to, among others, the economics of nuclear versus fossil generation, the financial implications of moving the service dates of Limerick up or back, joint ownership aspects, the financial consequences of alternative rates of load growth, and ratepayer impacts of various commercial operation dates for Limerick. TB&A found that:

1. PECO internally evaluated the issue of the economic advantage of nuclear powered generation versus fossil-fired generation on a

regular and continuous basis.

2. PECO continuously studied the impacts of adjusting the Limerick service dates.

3. Joint ownership of Limerick was examined thoroughly but generally found, due to financial as well as managerial reasons, to be adverse to the Company's interests.

Q. HOW DID TB&A'S ANALYSIS ADDRESS THE ISSUE OF WHETHER PECO SHOULD HAVE CONSIDERED OUTRIGHT CANCELLATION OF THE LIMERICK PROJECT?

A. TB&A's analysis included a chronological review, using information obtained from PECO's Annual Capital Construction Budget and Nine Year Forecast, to determine the changes that took place in the type and amount of major generation projects planned, from the early 1970s to the present. Schedule 40 demonstrates the significant changes that were taking place from year to year with regard to generation planning. One of the more important points to be gleaned from this schedule is that throughout the 1970s and into the early 1980s there were <u>always</u> major generation projects planned to follow Limerick. PECO's load growth projections during this period, as we have seen, constantly projected the need for additional capacity. Thus, the outright cancellation of Limerick was never really questioned since there were always projects less advanced, from an engineering and construction viewpoint, that would be deleted prior to considering Limerick's cancellation. And, in point of fact, Schedule 40 demonstrates that many of those projects, representing thousands of MW's, were eventually canceled by PECO.

GENERATION PLANS

YEAR	MAJOR NEW GENERATION PROJECTS PLANNED	MW PLANNED	CHANGES IN GENERATION PLAN FROM PREVIOUS YEAR
1973	Chester: 1-600MW (Oil) - 1978 Croydon: 400MW (CT) - 1974 Croydon: 400MW (CT) -.1977 Eddystone: 2-400MW (Oil) - 1974, 1975 Limerick: 2-1055MW (NUC) - 1978, 1980 Peach Bottom: 2-453MW* (NUC) 1973, 1974 Richmond: 173MW (CT) - 1973 Salem: 1-464MW* (NUC) - 1974 Salem: 1-474MW* (NUC) - 1975 Unassigned: 1-1500MW (NUC) - 1989 Unassigned: 2-1160MW (HTGR) - 1980, 1982 Unassigned: 2-1500MW (NUC) - 1985, 1987 Unassigned: 2-115MW (NUC) - PECo Share of DP&L Units - 1980, 1981 * - PECo Share	13,377	DEFERRED: 2110MW Limerick: 2-1055MW (NUC) deferred from 1976-77 to 1978-80 ADDED: 1673MW Chester: 1-600MW (Oil) Croydon: 400MW (CT) Croydon: 400MW (CT) Richmond: 173MW (CT) Unassigned: 6-Unassigned (NUC) 6720MW changed to 5-Unassigned (NUC) 6820MW Unassigned: 2-115 MW (NUC)
1974	Barbadoes: 2-26MW (Fuel Cell) - 1980, 1981 Chester: 1-600MW (Oil) - 1978 Croydon: 400MW (CT) - 1974 Eddystone: 2-400MW (Oil) - 1974, 1975 Fulton: 2-1160MW (HTGR) - 1982, 1984 Limerick: 2-1055MW (NUC) - 1979, 1980 Peach Bottom: 2-453MW* (NUC) - 1974 Salem: 1-464MW* (NUC) - 1975 Salem: 1-474MW* (NUC) - 1976 Summit: 2-115MW* (NUC) - 1981, 1983 Unassigned: 2-1500MW (NUC) - 1986, 1988 * - PECo Share	11,356	DEFERRED: 3501MW Limerick: 2-1055MW (NUC) deferred from 1978-1980 to 1979-1980 Salem: 1-464MW (NUC) and 1-474MW (NUC) deferred from 1974-1975 to 1975-1976 Peach Bottom: 1-453-MW (NUC) deferred from 1973-1974 ADDED: 52MW Barbadoes: 2-26MW (Fuel Cell) CANCELLED: 1900MW Croyden: 400MW (CT) Unassigned: 5-Unassigned (NUC) 6820MW changed to 2-Unassigned (NUC) 3000MW, plus Fulton 2-1160MW (HTGR) COMPLETED: 173MW Richmond: 173MW (CT)

NOTE: Summit units were listed as unassigned DP&L units in 1973.

GENERATION PLANS

EAR	MAJOR GENERATION PROJECTS PLANNED	MW PLANNED	CHANGES IN GENERATION PLAN FROM PREVIOUS YEAR
975	Barbadoes:2-26MW (Fuel Cell) - 1980, 1981 Eddystone: 1-400MW (Oil) - 1976 Fulton: 2-1160MW (HTGR) - 1984, 1986 Limerick: 2-1055MW (NUC) - 1981, 1982 Salem: 1-464MW* (NUC) - 1976 Salem: 1-474MW* (NUC) - 1979 Summit: 2-115MW* (NUC) - 1980, 1983 Unassigned: 1-600MW (Coal) - 1987 Unassigned: 2-800MW (Coal) - 1988, 1990 * - PECo Share	8,250	DEFERRED: 4430MW Limerick: 2-1055MW (NUC) deferred from 1979-1980 to 1981-1982 Eddystone: 1-400MW (Oil) deferred from 1975 to 1976 Fulton: 2-1160MW (HTGR) deferred from 1982-84 to 1984-86 Salem: 1-464MW and 1-474MW deferred from 1975-1976 to 1976-1979 ADDED: 2200MW Unassigned: 1-600MW and 2-800MW (Coal) CANCELLED: 3600MW Chester: 600MW (Oil) Unassigned: 2-1500MW (NUC) COMPLETED: 1706MW Croydon: 400MW (CT) Eddystone: 1-400MW (Oil) Peach Bottom: 2-453MW (NUC)
976	Eddystone: 1-400MW (Oil) - 1976 Limerick: 2-1055MW (NUC) - 1983, 1985 Salem: 1-464MW* (NUC) - 1976 Salem: 1-474MW* (NUC) - 1979 Unassigned: 2-600MW (Coal) - 1987, 1988 * - PECo Share	4,648	DEFERRED: 2110MW Limerick: 2-1055MW (NUC) deferred from 1981-82 to 1983-85 CANCELLED: 3602MW Barbadoes: 2-26MW (Fuel Cell) Fulton: 2-1160MW (HTGR) Summit: 2-115MW (NUC) Unassigned: 1-800MW (Coal); 1-800MW (Coal) reduced to 600MW (Coal)

GENERATION PLANS

YEAR	MAJOR GENERATION PROJECTS PLANNED	MW PLANNED	CHANGES IN GENERATION PLAN FROM PREVIOUS YEAR
1977	Limerick: 2-1055MW (NUC) - 1983, 1985 Salem: 1-464MW* (NUC) - 1977 Salem: 1-474MW* (NUC) - 1979 Unassigned: 2-600MW (Coal) - 1989, 1990 Unassigned: 2-1100MW (NUC) - 1992, 1994 * - PECo Share	6,448	DEFERRED: 1664MW Salem: 1-464MW (NUC) deferred from 1976 to 1977 Unassigned: 2-600MW (Coal) deferred from 1987-88 to 1989-90 ADDED: 2200MW Unassigned: 2-1100MW (NUC) COMPLETED: 400MW Eddystone: 1-400MW (Oil)
1978	Limerick: 2-1055MW (NUC) - 1985, 1987 Salem: 1-474MW* (NUC) - 1979 Unassigned: 2-600MW (Coal) - 1992, 1993 Unassigned: 2-1100MW (NUC) - 1994, 1996 * - PECo Share	5,984	DEFERRED: 5510MW Limerick: 2-1055MW (NUC) deferred from 1983-85 to 1985-87 Unassigned: 2-600MW (Coal) deferred from 1989-90 to 1992-93; 2-1100MW (NUC) deferred from 1992-94 to 1994-96 COMPLETED: 464MW Salem: 1-464MW (NUC)
1979	Limerick: 2-1055MW (NUC) - 1985, 1987 Salem: 1-474MW* (NUC) - 1979 Unassigned: 2-1100MW (NUC) 1994, 1996 * - PECo Share	4,784	CANCELLED: 1200MW Unassigned: 2-600MW (Coal)

GENERATION PLANS

EAR	MAJOR GENERATION PROJECTS PLANNED	MW PLANNED	CHANGES IN GENERATION PLAN FROM PREVIOUS YEAR
980	Limerick: 2-1055MW (NUC) - 1985, 1987 Salem: 1-474MW* (NUC) - 1980 Unassigned: 2-1100MW (NUC) - 1994, 1996 * - PECo Share	4,784	DEFERRED: 474MW Salem: 1-474MW (NUC) deferred from 1979 to 1980
981	Limerick: 2-1055MW (NUC) - 1985, 1987 Salem: 1-474MW* (NUC) - 1981 Unassigned: 2-800MW (Coal) - 1994, 1996 *PECo Share	4,184	DEFERRED: 474MW Salem: 1-474MW (NUC) deferred from 1980 to 1981 ADDED: 1600MW Unassigned: 2-800MW (Coal) CANCELLED: 2200MW Unassigned: 2-1100MW (NUC)
982	Limerick: 2-1055MW (NUC) - 1985, 1991	2,110	DEFERRED: 1055MW Limerick: Unit 2, 1-1055MW (NUC) deferred from 1987 to 1991 COMPLETED: 474MW Salem: 1-474 MW (NUC) CANCELLED: 1600MW Unassigned: 2-800MW (Coal)
983	Limerick: 2-1055MW (NUC) - 1985, 1988	2,110	ADVANCED: 1055MW Limerick: Unit 2, 1-1055MW (NUC) advanced from 1991 to 1988

PHILADELPHIA ELECTRIC COMPANY

GENERATION PLANS

EAR	MAJOR GENERATION PROJECTS PLANNED	MW PLANNED	CHANGES IN GENERATION PLAN FROM PREVIOUS YEAR
984	Limerick: 2-1055MW (NUC) - 1985, 1990	2,110	DEFERRED: 1055MW Limerick: Unit 2 1-1055MW (NUC) deferred from 1988 to 1990

ey:

- Name of Plant
- Number of Units
- Size of individual Units
- Anticipated service dates of the Units

984 Limerick: 2-1055MW (NUC) - 1985, 1990

ear in which plan as formulated.

Type of Units: NUC = Nuclear
HTGR = High Temperature Gas Reactor
CT = Combustion Turbine

Unassigned: Need for Unit established but site undetermined

OURCE: PECo Construction Budget and Forecasts

Q. WHAT ARE YOUR CONCLUSIONS REGARDING THE OVERALL JUSTIFICATION OF THE LIMERICK PROJECT FROM BOTH AN ECONOMIC AND A NEED BASIS?

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

D. EVALUATION OF SPECIFIC DEFERRAL ANNOUNCEMENTS

Q. PECO HAD PUBLICLY ANNOUNCED MAJOR PROJECT DEFERRALS FOR LIMERICK UNIT 1 IN 1974, 1976 AND 1978. HAS TB&A REVIEWED THE UNDERLYING FACTORS AND CONSEQUENT MANAGEMENT ACTIONS RELATING TO THESE ANNOUNCEMENTS?

A. Yes. TB&A's review of PECO's decisions to defer construction and/or the continuing justification of the Limerick project in 1974, 1976 and 1978 addressed both the internal and external conditions that existed during those periods.

Q. WHAT IS TB&A'S ASSESSMENT OF THE UNDERLYING CAUSES FOR THE ANNOUNCEMENT BY PECO IN 1974 TO DEFER CONSTRUCTION OF LIMERICK?

A. TB&A's analysis indicated that the decision to defer construction in 1974 was based upon the severe financial constraints then being experienced by PECO. As previously discussed, PECO's precarious financial position prevented them from obtaining the capital needed to fund their construction program at a level

necessary to meet the then current construction schedule. This was reflected by the following reduction in budgeted Limerick expenditures (excluding AFUDC and overhead costs):

• 1973 - Forecasted expenditures for 1974 were	$176 million
• 1974 - Budgeted expenditures for 1974 were	$107 million
Difference	$ 69 million

PECO also cut back substantially on its overall construction program. As stated in a PECO press release dated September 4, 1974:

> "Philadelphia Electric Company announced today that it is reducing its planned construction program by approximately $600 million for the five-year period 1974-1978 due to high interest rates, extremely tight credit, a severely depressed stock market, and uncertain economic conditions.
>
> The reduction in the construction program will result in delays of about two years in the scheduled dates of commercial operation of the Limerick and Fulton nuclear generating stations, which are re-scheduled for service in 1981-83 and 1984-86, respectively."

These cutbacks occurred despite reserve levels that were forecasted to be well below the desired reserve margin of 20% given the new construction target schedule service dates (as oposed to the publicly announced service dates) of April 1981 for Unit 1 and April 1982 for Unit 2. PECO's difficulty in raising needed capital was highlighted by their year-end mortgage coverage ratio of 2.1, their market to book ratio of 0.54, and a bond downgrading (from AA to A) in October 1974.

Q. WHAT WERE THE RESULTS OF YOUR ANALYSIS REGARDING THE 1976 ANNOUNCEMENT TO DEFER CONSTRUCTION AT LIMERICK?

A. In May 1976, PECO announced a two-year deferral in Limerick Unit 1 and Unit 2 service dates from April 1981 to April 1983 and from April 1983 to April

1985, respectively. A PECO press release dated May 24, 1976, stated in part:

> "Philadelphia Electric Company today released a new forecast which calls for a reduction of $750 million in construction spending through 1980.
>
> .... Our near term policy is to reduce financing requirements to an absolute minimum until earnings rise to a level that will be adequate to support the high cost of obtaining money..."

The press release also stated that:

> "As a result of construction budget revisions the schedule for Limerick Generating Station, PECO's largest project, has been extended by two years ... The first unit is now scheduled for service in 1983 and the second in 1985."

By publicly announcing a deferral, PECO was able to reduce its projected capital requirements to a level it felt would be more acceptable to the investment community, while mitigating adverse reactions due to its previously demonstrated precarious financial position. It is TB&A's conclusion, based on the facts reviewed, that reduced load growth, while certainly a contributing factor, was not the overriding motivation to announce a deferral. Load growth projections compiled in 1976 (under the pre-deferral schedule) did not indicate reserve margins that were inordinately large in pre-deferral service years. TB&A concludes that the announced deferral was primarily a result of the five-year forecast of financial requirements being unreasonably capital intensive given the pre-deferral schedule.

Q. DID PECO'S PUBLICLY ANNOUNCED NEW SERVICE DATES FOR THE LIMERICK UNITS OF APRIL 1983 AND APRIL 1985 COINCIDE WITH THE CONSTRUCTION TARGET SCHEDULES?

A. No. TB&A's analysis indicates that internal PECO construction schedules were projecting earlier fuel load dates than those publicly announced. Review of the

monthly progress reports has shown that in May 1976, Forecast 2 was being prepared based on a Unit 1 service date of April 1982 and a Unit 2 service date of April 1984. These new completion dates represented a 14 month slip for Unit 1 and a 21 month slip for Unit 2 compared with recent Management Scheduling and Control System (MSCS) schedules, which showed Unit 1 and Unit 2 service dates at February 1981 and July 1982, respectively. Additionally, a May 20, 1976 update on the Limerick Generating Station revised construction program states:

> "Pursuant to a management directive issued May 6, 1976, the Limerick Project is now proceeding on a construction program consistent with Plan "A" (1982-1984 service dates) through 1977. Should financial restrictions dictate, the project can readily switch to Plan "B" (1983-1985 service dates) at the beginning of 1978."

A review of the funds (excluding AFUDC and overhead costs) budgeted for Limerick in 1976, along with the amount that had been forecasted the prior year, reveals the following:

• 1975	- Forecasted expenditures for 1976 were	$186 million
• 1976	- Budgeted expenditures for 1976 were	$156 million
	Difference	$ 30 million

The 1976 budget also reflected substantial reductions in later years forecasted expenditures.

Q. WHAT WERE THE RESULTS OF YOUR STUDY REGARDING THE 1978 ANNOUNCEMENT BY PECO TO DEFER LIMERICK COMPLETION AN ADDITIONAL TWO YEARS?

A. PECO, in May 1978, publicly announced an additional two-year deferral in the service dates for the Limerick units. The new C.O. dates for Unit 1 and Unit 2 were stated to be April 1985 and April 1987. Reasons for the deferral were

attributed to the same factors that affected the 1976 decision. A review of the monthly progress reports revealed that in January 1978, a cash constrained schedule was formulated that would have required service date deferment (from the then current internal construction target schedule) of 5 months, from April 1982 to September 1982 and from April 1984 to September 1984, for Units 1 and 2, respectively. The June 1978, monthly progress report indicated that a further slippage in service dates, to April 1983 and April 1985, was recognized. Hence, although a total one year slip in commercial operation dates was recognized between January and June of 1978, the subsequent construction target schedules were based on April 1983 and April 1985 plant completions - two years prior to the publicly announced service dates. This was possible because, as previously discussed in the 1976 decision, PECO was supplying funds for construction activities that would have allowed attainment of service dates earlier than those publicly announced. Limerick forecasted and budgeted expenditures (excluding AFUDC and overhead costs) for 1978 reveals the following:

• 1977 - Forecasted expenditures for 1978 were	$147 million
• 1978 - Budgeted expenditures for 1978 were	$147 million
Difference	0 million

It should be noted that there were substantial reductions in forecasted expenditures in later years.

PECO's decision to announce a deferral publicly but work internally toward more aggressive goals was the result of several factors. Its poor financial condition and lower than anticipated load growth dictated a cautious position with regard to both its near-term ability to finance the project and

short term capacity needs given projected increasing reserve margins. However, by supplying funds on a year-to-year basis sufficient to maintain the more advanced completion dates, PECO could effectively protect its options given changes in either its financial position or projected capacity needs.

The two-year slip in service dates for Units 1 and 2, to April 1985 and April 1987, was recognized by PECO in its construction target schedules in 1980 and was mainly related to increased project scope, decreased labor productivity and extensive regulatory changes and their consequent impacts.

E. SUMMARY

Q. WHAT ARE TB&A'S OVERALL CONCLUSIONS REGARDING PECO'S DECISIONS TO CONTINUE CONSTRUCTION OF THE LIMERICK PROJECT AS WELL AS PECO'S SPECIFIC ACTIONS REGARDING THE ANNOUNCED PROJECT DEFERRALS OF 1974, 1976 AND 1978?

A. TB&A's analysis of the Limerick project deferrals and the continuing justification of the facility can best be summarized by enumerating the major findings of our review of this area. They are as follows:

(1) PECO's contemporaneous financial planning process was similar to other large utilities and provided for a reasonable flow of information regarding financing alternatives and implications, such that it allowed reasoned and informed decision-making to take place.

(2) PECO's load forecasting efforts throughout the 1970s were the product of sound techniques and procedures and resulted in demand projections that were relatively accurate compared to the utility industry in general. These forecasts were a reasonable basis from which to plan for capacity additions.

(3) The PECO position that Limerick was the optimal, i.e. from a size, type, cost and lead time viewpoint, means to meet anticipated energy demand was the product of a reasonable number of studies and analyses.

(4) The project deferral announcements in 1974, 1976 and 1978 were

principally the result of adverse financial conditions which prevented PECO from supplying the necessary funds to support construction and engineering activities geared toward earlier operational dates for the units. The PECO management process underlying the announcements was reasonable and reflected an informed position with regard to both the costs and benefits of those decisions.

In summary, TB&A concludes that PECO management actions regarding the Limerick Project deferrals, as well as Limerick's continuing justification, were the product of a reasonable and effective management process.

VI. ANALYSIS OF PROJECT COST GROWTH

Q. PLEASE DESCRIBE THE PURPOSE OF THIS SECTION OF YOUR TESTIMONY.

A. Philadelphia Electric Company requested that TB&A prepare an accounting of the cost growth for Limerick Unit 1 and Common Plant to facilitate evaluations of major factors impacting such growth on the Limerick project.

Q. WHAT SPECIFICALLY WAS TB&A'S ROLE IN THE PREPARATION OF THIS STUDY?

A. TB&A administered the preparation of the analysis, defined the study's framework, reviewed and compiled the Project's cost data, and obtained, through numerous discussions with Project personnel, data verification and additional information, as needed, to facilitate the study's completion.

A detailed discussion of the results of this cost analysis, drafted by TB&A, are set forth in Section II of PECO Exhibit 2.

Q. PLEASE DESCRIBE HOW THE ANALYSIS WAS STRUCTURED.

A. The cost growth analysis was structured to compare the first Capital Authorization (CA) or Project estimate with the most recent cost estimate for Limerick Unit 1 and Common Plant, Cost Trend 7-13. The first comprehensive Project estimate for the Limerick Station was PECO's December 1970 Capital

Authorization which estimated total station cost to be $716 million. This represents a total direct cost (defined here as excluding AFUDC, PURTA taxes, overhead, and contingency) of approximately $344.1 million for Unit 1 and Common. The latest, most comprehensive cost estimate available at the time of the study's preparation was PECO's Capital Authorization Supplement 3 issued in July 1984. Subsequent to this estimate, however, thirteen Cost Trends were issued supplementing CA Supplement 3. The total estimated cost of Limerick Unit 1 and Common Plant as of Cost Trend 7-13, dated late July 1985, is $4150.4 million. When adjusted for ratemaking provisions, to exclude AFUDC on one-half of Common for the period from February 1986 (the anticipated Unit 1 commercial operation date) until July 1990, the cost of Limerick Unit 1 and Common is $3820.0 million. This represents a total direct cost of $2350.0 million.

Q. PLEASE DESCRIBE HOW THE CAUSES OF COST GROWTH WERE DETERMINED AND SUBSEQUENTLY QUANTIFIED.

A. Determination of cost causation factors by TB&A was accomplished within the framework of the project documentation review and interview process employed in formulating our overall assessment of PECO's management of the Limerick project. In addition, we also utilized our experience and knowledge of conditions and factors impacting the overall nuclear industry as well as other contemporaneous nuclear projects.

Factors affecting Project costs were also determined through a detailed review of Project cost documentation including Project Cost Forecasts, Cost Trend Reports, Notices of Change in Design (NCD's), PECO Capital Authorizations, and other supporting materials. Additionally, TB&A conducted

a significant number of review sessions with cognizant PECO and Bechtel Project personnel throughout the duration of the analysis to facilitate data clarification with respect to Project cost causation factors.

Based on the above, TB&A divided the causes of direct cost growth into four categories: (a) those occurring as a result of regulatory factors and externally-imposed conditions; (b) design changes made to facilitate operability and reliability; (c) cost increases due to estimate refinement and other causes; and (d) unanticipated escalation.

Regulatory factors and other externally-imposed conditions include changes as a result of regulatory evolution accruing from both the NRC and other regulating bodies during the course of plant engineering and construction, in addition to the impact of cash constraints arising from adverse financial conditions. Examples of major regulatory issues and events affecting the project include TMI-2, fire protection, seismicity, ATWS, Mark II, ALARA, and equipment qualification, amongst others. Schedule 41 provides a listing of the regulatory and externally-imposed causation factors identified in this study. Appendix B sets forth a reference to NRC publications identified as affecting the Limerick Project.

A number of design changes made facilitating plant operability and reliability were found to have contributed to plant cost growth. Many of these changes were found to have been made as a result of PECO's operation of the Peach Bottom Atomic Power Station.

Cost increases due to estimate refinement and other miscellaneous causes were also identified. These costs represent estimate adjustments, pricing changes and re-evaluations, indirect impacts of regulatory

REGULATORY AND OTHER EXTERNALLY-IMPOSED CAUSATION FACTORS

- Three Mile Island-2
- Plant Staffing, Startup, and Training
- Mark II
- Fire Protection
- Electrical Separation
- As Low As Reasonably Achievable
- OSHA
- Anticipated Transients Without Scram
- Dynamic and Environmental Equipment Qualification
- ASME Code Requirements
- Seismicity
- Security Requirements
- Non-NRC Requirements
- Inter-Granular Stress Corrosion Cracking
- Licensing Costs
- Miscellaneous Other NRC Requirements
- Schedule Extensions Due to Licensing Delays and Other Factors

requirements, and subcontract changes not wholly attributable to specific causation factors.

Q. PLEASE SUMMARIZE THE RESULTS OF THE COST GROWTH ANALYSIS.

A. The Analysis results are summarized in Schedules 42 and 43. As these schedules illustrate, total direct costs for Limerick Unit 1 and Common Plant have increased by approximately $2005.0 million. When this increase of $2005.0 million in direct costs is added to the direct costs included in the original Capital Authorization, AFUDC, Overheads, PURTA taxes, and contingency, we arrive at a plant cost for Unit 1 and Common of approximately $3819.1 million.

Q. HOW ARE THE TOTAL DIRECT COST INCREASES APPORTIONED BETWEEN THE FOUR COST DRIVER CATEGORIES?

A. Results of the cost growth analysis indicated that of the $2005.0 million cost increase from the initial cost estimate to Cost Trend 7-13, approximately $1362.4 million was attributable to regulatory factors and other externally-imposed conditions. This represents approximately 68 percent of the growth of direct cost for Limerick Unit 1 and Common. Design changes made throughout the Project increased costs by $111.9 million, or approximately 6 percent. Further, $208.6 million resulted from estimate refinement and other causes, representing approximately 10 percent of the total Unit 1 and Common Plant growth of direct cost. Cost growth associated with unanticipated escalation was $322.1 million, or approximately 16 percent.

LIMERICK UNIT 1 & COMMON
COST GROWTH RECONCILIATION

($ in Millions)

Original PECO Capital Authorization		
Unit 1 and Common, Direct Costs		$ 344.1
Regulatory and Other Externally - Imposed Conditions		
- TMI-2 Analyses and Design Changes	57.5	
- Plant Staffing, Startup and Training	181.6	
- Seismicity	119.6	
- Impact of Mark II	136.1	
- Fire Protection & Electrical Separation	65.8	
- Equipment Qualification	38.6	
- Anticipated Transients Without Scram	20.9	
- ALARA & OSHA	39.6	
- ASME Code Requirements	20.9	
- Security Requirements	43.5	
- Intergranular Stress Corrosion Cracking	10.2	
- Licensing Costs	62.9	
- Miscellaneous Other NRC Regulations	116.3	
- Non-NRC Requirements	63.8	
- Cost Impact of Schedule Extensions due to Licensing Delays and Other Factors	385.1	
		1362.4
Design Changes To Facilitate Operability and Reliability		111.9
Estimate Refinements and Other Causes		208.6
Unanticipated Escalation		322.1
TB&A DIRECT COST RECONCILIATION TOTAL		$2349.1
AFUDC (TOTAL - EXCLUDING AFUDC ON ONE-HALF OF COMMON FROM 2/86 THROUGH 7/90).		1426.2
OVERHEADS (TOTAL)		5.8
TAXES (TOTAL PURTA)		30.5
CONTINGENCY (TOTAL REMAINING AS OF TREND 7-13)		7.5
RECONCILIATION TOTAL		$3819.1

DIRECT COST PERCENTAGES OF GROWTH BY CAUSATION CATEGORY

COST GROWTH BY PERCENTAGE OF TOTAL DIRECT COSTS	$ in Millions	Percentage
Regulatory Factors & Other Externally Imposed Conditions	1362.4	67.9
Design Changes to Facilitate Plant Operability and Reliability	111.9	5.6
Estimate Refinements and Other Causes	208.6	10.4
Unanticipated Escalation	322.1	16.1
Total Direct Cost Growth	2005.0	100%

Q. PLEASE DESCRIBE THE DOCUMENTS WHICH YOU RELIED UPON IN YOUR STUDY AND ALSO THE SUPPLEMENTARY REVIEW SESSION PROCESS.

A. Project documentation used to acquire cost information consisted of the following:

Project Forecasts. A total of seven Forecasts were prepared by Bechtel over the course of the Limerick Project. Project Forecasts were the basis for the cost growth analysis in that they provided the framework for Bechtel estimated costs associated with specific causation factors. As each Forecast contains within it a reconciliation of estimated cost changes between prior and current Forecasts, a chronological explanation of causes for cost growth was provided. Hence, bridging the Order-of-Magnitude estimate with the seven Forecasts and the thirteen subsequently-issued cost trends provided a reconciliation foundation for the tracking of cost changes by cause.

Cost Trends. In addition to Forecasts, Cost Trends, which provide documented input to the Forecast, were consulted to assist in determining further breakdowns of costs contained in Project Forecasts 1 through 7 by causation factor. The Cost Trend program's primary function is to provide an accounting for all changes in project cost between Forecasts. All resolved and unresolved trends and their associated impact on total project cost are then included in each Forecast update. Further, Cost Trends 7-1 through 7-13 were relied upon to obtain costs and associated causation factors for project cost increases subsequent to Forecast 7 and CA Supplement 3.

Notice of Change in Design. Where necessary and/or appropriate, a further level of detail in the form of the Notice of Change in Design, or NCD, was examined. The NCD was an important change control document which

provided for early management visibility and control of changes, contained detailed reasons for the proposed change, initiated the preparation of cost estimates, and authorized implementation following approval by PECO. The NCD thus provided supplemental detail regarding the nature of the change in cost.

Capital Authorizations. Cost information concerning Philadelphia Electric Company costs, i.e., nuclear steam supply system costs, turbine-generator, overhead, etc., were obtained from the Capital Authorizations. Subsequent to the original Capital Authorization in December 1970, three supplements have been issued (May 1977, March 1981 and July 1984). Cost changes within the CA's subaccounts were analyzed and dispositioned as to cause by reviewing, in detail, the sources of charges to each subaccount.

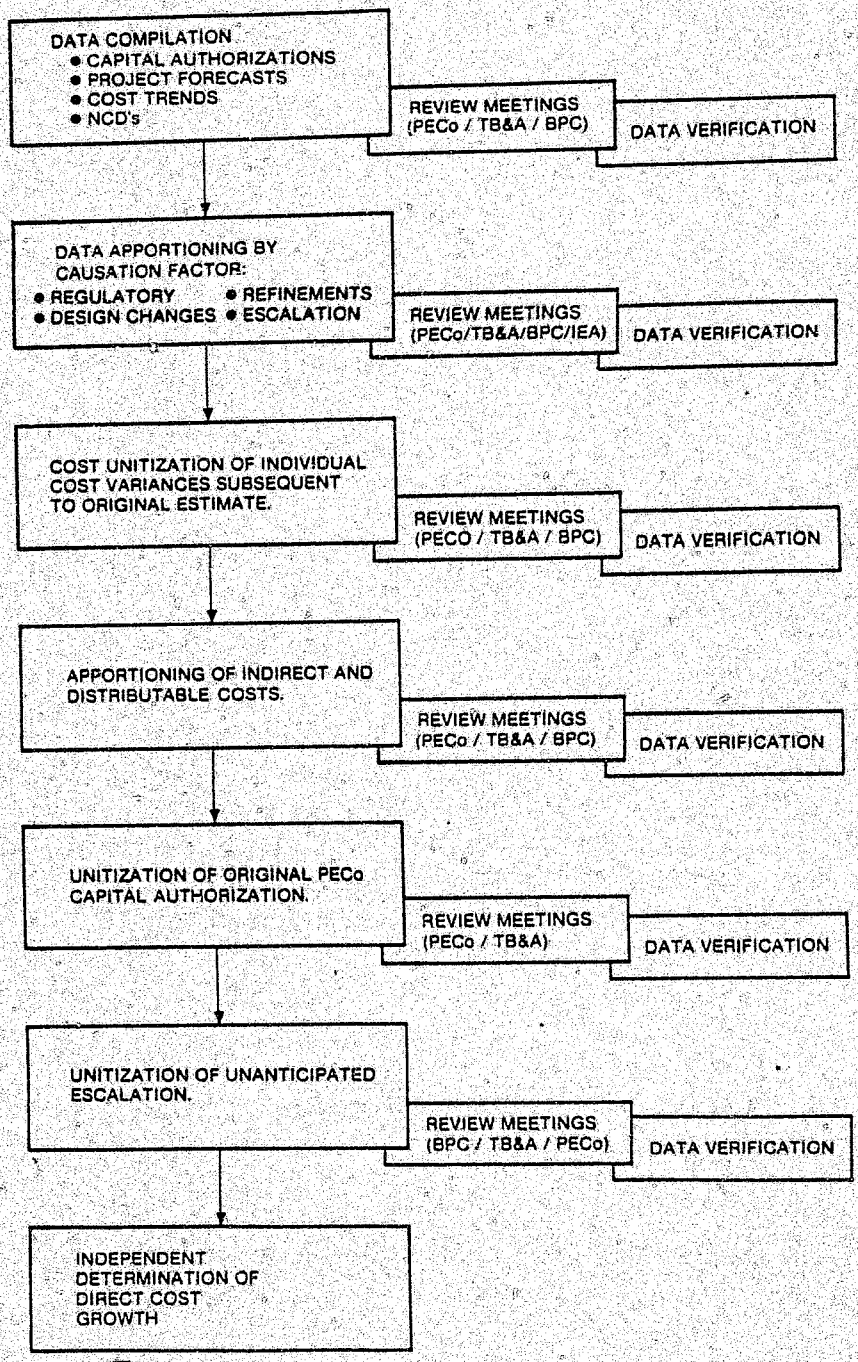
Supplementing the review of project documentation, a significant number of intensive review sessions were conducted between TB&A, PECO, and Bechtel project personnel to clarify data, where necessary, in terms of causation factors, in addition to verification of study results. Representatives from both PECO and Bechtel engineering and construction groups were included. These meetings, often extending 2 to 3 days per week, were held on a number of occasions throughout the study's preparation and were conducted at the Company's offices in Philadelphia, and in Bechtel's San Francisco home office.

Q. PLEASE DESCRIBE THE PROCESS USED BY TB&A TO COMPILE, APPORTION, AND RECONCILE LIMERICK UNIT 1 AND COMMON PLANT COSTS.

A. Schedule 44 illustrates the flowpath used by TB&A to reconcile Limerick Unit 1

PHILADELPHIA ELECTRIC COMPANY

FLOW PATH OF THE COST RECONCILIATION PROCESS



SOURCE: TB&A ANALYSIS

and Common Plant costs.

Data Compilation. As noted above, cost reconciliation data from the Bechtel December 1970 Order-of-Magnitude estimate, project cost Forecast reports, Capital Authorizations, NCD's, and Cost Trends was collected and extensively reviewed. In reconciling PECO owner's costs, the sources of charges were reviewed for each specific Capital Authorization subaccount. Forecast data was reviewed thoroughly to eliminate potential double counting of costs contained within both the Forecast and Capital Authorization. Where specific PECO costs were included in the Forecasts, these costs were removed from the forecast totals as they were reconciled through the CA's. A listing of all reconciliation entries reflective of all entry breakdowns, clarifications, and adjustments obtained from the above data was then compiled.

Data Apportioning by Causation Factor. Based on extensive and detailed reviews of all Forecast entries, supporting documentation, and the on-going review sessions with appropriate PECO and Bechtel personnel described previously, cost entries were individually apportioned to four specific cost causation categories: (1) regulatory factors and other externally-imposed conditions; (2) design changes made to facilitate operability and reliability; (3) estimate refinements and other causes; and, (4) unanticipated escalation. To the extent possible, all cost apportionment to causation factors was based on existing project documentation. Further, direct contact was always made with the cognizant PECO or Bechtel engineer to confirm and supplement the information and apportionment.

Costs apportioned to regulatory factors and other externally-imposed conditions were further classified according to specific regulations, regulatory

interpretations, and regulatory events, i.e., TMI-2, fire protection, Mark II, etc. In identifying NRC requirements and their associated impacts, additional input was also obtained from Dr. Roger J. Mattson, a former senior NRC official.

Cost Unitization. Individual project cost increases, with the exception of Forecast 7 and subsequent trends, were prepared and reported on a station basis with little or no "unitization" of costs, i.e., allocation of costs to Unit 1, 2, or Common Plant, specifically. Forecast 6 provided the initial unitization of costs between units, but it did so only on an account basis, not for individual cost increases. Additionally, all PECO Capital Authorizations, with the exception of Capital Authorization Supplement 3 issued in July 1984, reported costs on a station basis. Consequently, to reconcile those costs attributable to Unit 1 and Common, a unitization of Forecast entries and Capital Authorization accounts was necessitated.

The governing policy in all cost unitizations was physical location, not system, building or equipment functionality. This is consistent with the unitization procedure employed by PECO and Bechtel in allocating costs to Unit 1, Unit 2, and Common Plant for Forecasts 6 and 7, post Forecast 7 trends and for CA Supplement 3.

Three (3) percentages were used to calculate those costs attributable to Unit 1 and Common, with the exception of the unanticipated escalation category.

1) 100 percent of the cost change was included in the analysis if the description of the cost variance indicated that the change pertained to a physical section of the generating facility, or a system of the plant, that is

specific to Unit 1, or Common Plant; i.e., the ultimate heat sink, control enclosure and support subsystems, emergency service water system, residual heat removal service water systems, etc. Examples of buildings and systems identified as Common Plant which therefore called for a 100 percent unitization are listed in Schedule 45.

Additionally, 100 percent of costs was adopted if the cost change was reported in either Forecast 7, the subsequently issued thirteen cost trends, and Capital Authorization Supplement 3 as these estimates reported only costs for Unit 1 and Common.

2) 50 percent of the cost entry was used if the cost change affected equipment or facilities dedicated to each Unit, i.e., changes to the containments, turbines, cooling towers, emergency core coolant systems, etc.

3) For those cost variances pertaining to systems or equipment physically extending throughout Units 1, 2, and Common, 65 percent was used to calculate those costs associated with Unit 1 and Common. The 65 percent factor represents the allocation of manual manhours between Unit 1 and Common, and Unit 2 from the projects' initial unitization in Forecast 6. This factor thus provides the most accurate basis available specifically for Limerick for cost allocation based on the physical location of the construction activities involved for each cost change to which this factor was applied.

Apportioning of Indirect and Distributable Costs. Indirect and distributable costs in this cost reconciliation analysis consist of increases in Bechtel home-office engineering costs, field non-manual costs, field manual labor cost increases, changes in unit rates as a result of increased congestion and complexity, increased costs for distributable and support services, and general

EXAMPLES OF COMMON BUILDINGS, FACILITIES AND SYSTEMS

- Administration Building
- Control Enclosure
- Refueling Floor Elevation of Reactor Enclosure
- Radwaste Building
- Ultimate Heat Sink (Spray Pond)
- Security Systems
- Technical Support Center
- Emergency Public Notification System
- Radwaste System
- Spray Pond Pumphouse
- Circulating Water Pumphouse
- Water Treatment Plant
- Schuylkill River Pumphouse
- Auxiliary Boilers
- Yard Facilities
- Emergency Service Water System
- Residual Heat Removal Service Water System
- Standby Gas Treatment System & Support Subsystem
- Spent Fuel Handling Facilities
- Point Pleasant Facilities & Water Transmission Main
- Bradshaw Reservoir Facilities & Water Transmission Main
- Perkiomen Pumphouse & Water Transmission Main

increases in PECO engineering and support services necessary to support the project. These costs were determined to be attributable to the general level of ongoing project work and, hence, are a result of the simultaneous effects of regulatory change, design changes, and estimate refinement. Costs included in this category reflect principally the difference between the estimated cost impact of the various changes as identified in the NCD's and the actual cost of implementation.

As project cost accounting methods were not designed to actually track these costs by cause, project documentation did not support the direct apportionment of all the costs in these categories to specific causation factors. Thus, TB&A determined that the most equitable treatment, absent any documentation to the contrary, to those costs reasonably warranting distribution, was to allocate these costs as a percentage of their total in the same ratio as the regulatory and other externally-imposed changes, design changes, and, estimate refinements represented to the direct cost total. Those distributable costs apportioned to regulatory and other externally-imposed changes were similarly distributed directly to the individual sub-category causation factors (i.e., TMI-2; Mark II). Cost change items that did not warrant allocation of distributables were excluded from the above computations. Those cost change items which did not warrant an allocation of distributables included activities not directly associated with the completion of project construction activities such as taxes, insurance, material price increases, escalation and the time-related costs associated with schedule extensions.

Unitization of Original PECO Capital Authorization. The original PECO Capital Authorization for Limerick estimated total station costs at $716

million. This reflects a direct station cost of $565.0 million, $3.4 million for overhead, $52.0 million for contingency and $95.6 million for AFUDC. In the absence of existing project documentation, an analysis was performed of subsequent project cost estimates to determine a reasonable proration of the initial Capital Authorization between Units. Results from the Forecast 6 unitization by Bechtel indicated that, exclusive of overheads, PURTA taxes and contingency, the direct costs between Unit 1 and 2 reflected a 60.9 to 39.1 ratio of costs between Unit 1 & Common, and Unit 2. Hence, for purposes of this analysis, this ratio was adopted. As a result, total direct costs for Unit 1 and Common for the original Capital Authorization were determined to be 60.9 percent of $565.0 million, or $344.1 million.

Unitization of Unanticipated Escalation. Costs associated with escalation are not a function of physical location in the generating station, expended labor manhours, or any gross unitization percentage. Consequently, all entries pertaining to escalation necessitated a case-by-case treatment in terms of their unitization to Unit 1, Unit 2, and Common Plant, respectively. Escalation percentages associated with Unit 1 and Common for each escalation entry obtained from the Forecast report, or Forecast backup, were individually developed by Bechtel and TB&A based on the as-spent and to-go dollars for each unit.

Q. HOW DOES TB&A'S DETERMINATION OF UNIT 1 AND COMMON PLANT COST, USING THE METHODOLOGY DESCRIBED ABOVE, COMPARE TO THE TOTAL UNIT 1 AND COMMON PLANT COST REPORTED IN COST TREND 7-13?

A. The total variance between Cost Trend 7-13 and TB&A'S reconciled total is

$0.9 million or approximately .02% of the total project cost.

Q. TO WHAT DOES TB&A ATTRIBUTE THIS DIFFERENCE?

A. We attribute the variance between the two totals to the general imprecision of a retrospective cost reconciliation. Such factors as 1) general exclusion of cost items less than $50,000, 2) mathematical roundoff, 3) the use of estimates, as opposed to actual expenditures, and 4) differing accounting treatments, all contribute to the approximate nature of the analysis. Hence, variances between cost estimates are logically anticipated.

Q. WHAT REASONS DO TB&A FEEL EXIST TO EXPLAIN WHY THE PROJECT COST INCREASED SIGNIFICANTLY OVER THAT OF THE ORIGINAL CA ESTIMATE?

A. TB&A believes that several factors contributed directly or indirectly to deviations of actual or realized project costs from initial estimated costs. Such factors include,

- scope and design changes imposed on the project internally and externally;
- the economic environment; and
- a general limitation in estimating methods.

The original PECO CA and Order-of-Magnitude estimate prepared by Bechtel at the project outset was based on the then current forecast for the Peach Bottom project, adjusted for known Limerick site conditions, and existing or anticipated regulatory and economic environments.

Since 1970, however, a plethora of regulations over and above those known or anticipated were imposed on the project thereby initiating a heightened number of scope changes exceeding those envisioned at the time of

the original CA. The cost growth analysis prepared by TB&A has documented those changes made as a result of these regulations, in addition to changes made to enhance reliability and operability.

With regard to changing regulatory standards, the Rand Corporation in a 1979 study states that:

> "If a standard is already in effect when a plant is designed and estimated, but the costs of meeting it are misestimated, the fault lies with an endogenous plant and process factor (a design and/or estimation failure); it is not an exogenous perturbation of costs. But when standards change after an estimate is made, project personnel cannot be faulted justifiably."

TB&A agrees with this assessment.

Further, the Limerick Project was constructed under economic conditions different from those existing or anticipated at the time of the preparation of the original CA. From an estimating perspective, changes in the economic environment are difficult to foresee, and variances from the estimate result if construction market conditions and price level changes vary from those assumed at the time an estimate is made. Additionally, changes in the regulatory environment will have a significant impact on project cost and schedule if unanticipated at the time of the original estimate.

Lastly, while methods for estimating the capital costs of large construction projects have advanced during the past 20 years, inherent limitations in the estimating process still remain. These limitations include, as they did twenty years ago, the inability to accurately predict project costs when project durations and/or external factors change so as to invalidate the basis on which the original estimate was formulated.

Hence, due to the fact that nuclear plants have become progressively

more complex over time, and external factors such as escalation in construction costs and major regulatory changes have been imposed, estimation has remained difficult and is an understandable factor in the magnitude of apparent project cost increases.

Q. WHAT CONCLUSION DOES THIS COST RECONCILIATION STUDY PERMIT YOU TO MAKE?

A. This study, accomplished within the framework of our project documentation review and interview process employed in formulating our overall assessment of PECO's prudence in managing the Limerick project, demonstrates that:

- the majority of cost increases were a result of externally-imposed regulatory requirements and adverse financial conditions unanticipated at project outset. Imposition of regulatory requirements were uncontrollable by PECO and ubiquitously felt by the entire nuclear industry. Further, PECO's weakened financial condition was not dissimilar to that experienced by other utilities constructing nuclear generating facilities;
- a number of design changes were made throughout the course of the project as a result of PECO's experiences derived from operating the BWR units at its Peach Bottom Atomic Power Station, thereby, facilitating plant operability and reliability;
- the increases due to estimate refinements are reasonable based on the fact that at the time when the original PECO Capital Authorization was prepared in December 1970, station design was reported to be only approximately 22 percent complete, and construction, consisting primarily of site clearing, was reported to

be less than 3 percent complete; hence, estimate refinements are a logical expectation;

- Project cost documentation reflected appropriate management attention to the cost impact of changes in plant design. Further, TB&A experiences with cost records for other nuclear generating stations revealed that cost records for Limerick were generally superior to those maintained elsewhere; and
- Project cost documentation for cost growth was typically of sufficient detail and breakdown to allow an independent reconciliation of costs to be performed.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.

APPENDIX A

BASIL P. KONONETZ

EDUCATIONAL AND PROFESSIONAL BACKGROUND

I am employed by the management consulting firm of Theodore Barry & Associates (TB&A) of 1520 Wilshire Boulevard, Los Angeles, California 90017. I am a Managing Associate with TB&A working out of our Chicago office. In this position, I am responsible for directing client assignments and for ensuring that the TB&A obligations of the management of the project are met.

My educational background includes a Bachelor of Engineering Degree in Electrical Engineering from McGill University in Montreal, Quebec, Canada in 1967. In 1982, I received a Masters of Business Administration degree from the University of Michigan. I am a registered professional engineer in the states of California and Michigan.

Following graduation, I joined the Public Service Electric and Gas Co. (PSE&G) of New Jersey. Upon completion of their extensive and comprehensive nine-month training program for newly graduated engineers, I worked in PSE&G's System Planning Department. I performed computer-based transmission planning and economic studies for their entire high-voltage transmission system taking into account alternative generation (both nuclear and fossil) and transmission facilities, as well as the Pennsylvania-New Jersey-Maryland (PJM) power pool inter-connections.

From December 1969 to June 1972 I was employed by Commonwealth Associates, an architectural-engineering firm in Jackson, Michigan. Initially, I was responsible for performing transmission and distribution economic and planning studies. Assignments included a comprehensive analysis of PJM planned generation and transmission alternatives. Later I became involved in the design of electrical facilities for various fossil fueled power plants and industrial facilities including ammunition plants, automotive plants and Naval Communication Stations.

From June 1972 to March 1983, I was employed by Bechtel Power Corporation in San Francisco, California and Bechtel Associates Professional Corporation in Ann Arbor, Michigan. During my approximately eleven years with Bechtel I was associated with five nuclear power plant projects: Trojan, Monticello, Greenwood 2 and 3, Duane Arnold and Midland Units 1 and 2, in various engineering and engineering management capacities.

In my last position with Bechtel, I managed the mechanical, nuclear and plant design (equipment layout, piping and hangers) engineering and design groups on the Midland Project, consisting of approximately 250 engineering personnel. I was responsible for overseeing all the engineering, design and procurement activities for each of these groups. In addition, I was responsible for monitoring and control of their schedules and budgets and for ensuring the coordination of their work with other engineering groups and with construction activities. These responsibilities also included the oversight of the mechaical, nuclear and plant design resident engineering groups at the Midland jobsite.

Prior to that, I managed and supervised the electrical engineering design and procurement activities, including 125 engineering personnel, on the Midland project. I

was directly responsible for all the electrical engineering and design, including the technical, scheduling, and budgeting aspects of the work. Of significance, while in this position, I formulated and implemented a program which enabled electrical engineering bulk commodity design progress to move from being significantly behind construction requirements and on the critical path to being significantly ahead of construction.

In my previous positions with Bechtel, I was involved with the engineering and design of various electrical systems and components for nuclear power plants, including equipment procurement, review of vendor progress and coordination with construction activities.

I joined TB&A in March 1983. Since then I have been responsible for the TB&A staff work in the retrospective assessment of engineering management and procurement practices for several nuclear power plant projects, including Limerick Unit 1.

APPENDIX B

REGULATORY REFERENCES

Three-Mile Island-Related

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- NUREG-0696 (Draft), "Functional Criteria For Emergency Response Facilities," July 1980, Final Report, January 1981.
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PROFESSIONAL QUALIFICATIONS
THOMAS J. MADDEN III

I received a Bachelor of Science in Nuclear Engineering with high honors from the University of Tennessee in 1970, where I was a member of the Tau Beta Pi and the Phi Kappa Phi honorary societies. I also received a Master of Science in Computer Science in 1972 from the Stevens Institute of Technology and, in 1975, a Master of Business Administration from Farleigh Dickinson University with emphasis on management and finance. I am currently a member of the American Nuclear Society, the American Management Association, the New York Academy of Science and an associate member of the Institute of Management Consultants.

My professional experience includes approximately four years of employment at Bell Telephone Laboratories as a member of the Technical Staff, where I was responsible for the design and development of computer programs and attendant analyses to model the effects of nuclear weapons. My duties at Bell Telephone Laboratories included managing the collection and analysis of data, developing programs, assessing program results, and providing direction to subcontractor groups to Bell Laboratories for this project. Also, while at the Bell Laboratories I taught an "in-house" college level course on numerical techniques for computer application.

In 1973, I left Bell and joined the staff of the Jersey Central Power and Light Company, a subsidiary of the General Public Utilities Corporation, where I became head of the Nuclear Safety and Licensing Group. In this position, I was the utility's

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representative before the Nuclear Regulatory Commission (NRC) and was responsible for the preparation, direction, and management of submittals to the NRC on safety and licensing requirements for the company's nuclear power plant. My responsibilities in this position involved working with company executives, the engineering department, outside contractors, plant groups, and other parties necessary to provide and develop the information and analyses to meet the requirements of the NRC. I was responsible for the timeliness and completeness of the submittals and for presenting and discussing these with the regulatory agency.

I also chaired a utility industry group that represented several utilities and was established to assess the NRC's developing positions on safety requirements for older operating plants.

I joined Theodore Barry and Associates (TB&A) in 1978. My responsibilities at TB&A have been mainly in utility consulting assignments leading to my present position as head of the utility and telecommunications practice.

My assignments at TB&A have been heavily involved in consulting on management of major projects and in directing management analyses of all phases of utility operations. I have, for example, presented testimony before the Federal Energy Regulatory Commission on the efficiency of the management of the engineering and regulatory relations functions of the Trans Alaska Pipeline on behalf of the State of Alaska, directed TB&A's review and assessment of the management and cost and schedule

estimate of the Nine Mile II nuclear power plant and provided testimony on the effectiveness of the engineering and regulatory relations management of the Shoreham nuclear power plant for the Staff of the Public Service Commission of New York. Also, I have reviewed and assessed the engineering management of the Office of Engineering Design and Construction of the Tennessee Valley Authority (TVA), at a time when the Office had some 2600 engineers involved in the design of 14 nuclear power plants, directed the review and assessment of the design and construction management of the Hope Creek nuclear power station of the Public Service Electric and Gas Company and participated in the review of the management of the engineering function of the Diablo Canyon nuclear plant of the Pacific Gas & Electric Company.

My responsibilities in these projects have included working with and assessing the management of major architectural and engineering firms involved in these projects. Other assignments have included the analysis and support of the negotiation of a major contract for the architect and engineer of a nuclear power plant construction project. More generally, I have managed projects such as the review and assessment of the management activities of the Central Hudson Gas and Electric Company and the Niagara Mohawk Power Company for the New York Public Service Commission, and the review and analysis of the management activities of the gas operations of Northeast Utilities for the Connecticut Department of Public Utilities Control. I have also managed and directed consulting projects evaluating utility organizational structures and customer and management information

systems. Currently I am directing and overseeing management audits in the New York and Bell of Pennsylvania Telephone Companies. I was responsible in TB&A's Audit of the Limerick 1 unit for the evaluation of the regulatory relations function.

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PROFESSIONAL QUALIFICATIONS
TED K. OSBORN

I received a Bachelor of Architecture degree from Cornell University, Ithaca, New York in 1963 and a Masters in the Science of Management degree from the Massachusetts Institute of Technology, Cambridge, Massachusetts in 1978. I am a licensed architect in the states of Massachusetts and California and holder of an NCARB (National Certification of the Architectural Review Board) Certificate. I am also a member of the Pacific Coast Electric Association (PECA), the Project Management Institute (PMI) and the American Institute of Architects (AIA).

My professional career of some 20 years duration has had two separate but related components. From 1963 until 1977, I was employed by architectural and architectural/engineering firms where my responsibilities progressed from designer to project manager to a member of the firm's management team. During the last ten years of that period, I had responsibility for the management of numerous large commercial projects, as well as the development, implementation, and quality control of project planning methods and standards, and production controls.

In 1978, subsequent to receipt of my business degree from M.I.T., I joined Theodore Barry & Associates (TB&A) as a Senior Associate specializing in facilities planning, project management, and construction surveillance. I was promoted to Managing Associate in 1981 and elected a Principal of the firm in 1983, with responsibilities in the areas of project planning and management in the utility industry. I was appointed Vice

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President, Engineering and Construction in 1984 and Senior Vice President, Engineering and Construction Operating Officer in 1985. Although my consulting assignments have covered a variety of management discipline areas for many clients, my primary area of specialization has been that of analyzing engineering and construction issues for utility clients. Specifically, I have been involved with project planning, strategy and management.

I have also been involved in various nuclear power project retrospective reviews conducted by TB&A and have been a key participant in developing this area of TB&A's practice. My roles within this area have been and continue to be many, including participation in the establishment of policy and direction for performance of retrospective reviews, acting in an advisory role to multiple assignments on an as-needed basis, chairing a Quality Review panel having universal application to TB&A retrospective assignments, and serving as both engagement director and active consulting participant on specific projects. In total, I have been involved with seventeen utility projects, seven of which have involved nuclear retrospective procedure reviews. Additional detail on my participation in these consulting activities follows below.

I have been a key participant in TB&A's Engineering and Construction group during the years in which there has been a heavy focus on nuclear retrospective reviews. As such, I have either convened or been party to most discussions and development activities that have established the definition of our services, the assessment methodologies applied, the general

standards by which we conduct our analyses and evaluations, and the depth to which issues are studied.

I have also become involved in several of the ongoing project assessments in an advisory capacity on both policy and procedural/methodology questions and specific management evolution issues pertaining mainly to preplanning and project management.

In early 1983, because TB&A was then participating in multiple retrospective assignments, a Quality Review panel was established and charged with the internal mandate of reviewing each project's approach and developing products for consistency of policy application, depth of investigation, and interpretation and application of evaluative standards. I currently chair the Quality Review panel and have been a member since its inception.

My direct consulting involvement in retrospective assignments has included service as engagement director and project managment function consultant on LILCO's Shoreham plant and Pacific Gas and Electric's (PG&E) Diablo Canyon Units 1 and 2. The Shoreham engagement, for which the New York State Public Service Commission was our client, is completed. I filed testimony on behalf of the New York Commission Staff and served as expert witness in the Project Management/Owner's Oversight and Diesel Generation functional areas. Regarding PG&E, I am presently involved as team manager and project management functional specialist.

I have also been involved in an advisory capacity with the TB&A Limerick investigation team since the commencement of the

assignment. Participation has included both general and detailed discussion of specific issues, interpretation of the application of specific evaluative standards, and assistance as to how and when to approach effective discovery of several given issues. At one time or another, I have conversed with each team member on questions of content, methodology, and/or interpretation.

At an eary stage in the Limerick assignment, I convened a series of meetings attended by key participants of all our retrospective studies, including Limerick, to discuss policy, methodologies, standards, and to identify potential points of conflict or differing interpretations of apparently similar circumstances from project to project. At these meetings, the principle issues of the various projects were enumerated and critical similarities and/or points of differentiation were delineated. These sessions and the aforementioned discussions with indivdiual team members constituted my early participation with the Limerick assignment.

As TB&A's initial findings and conclusions with respect to Limerick began to be documented, the Quality Review panel made a thorough review of the draft products. I and others on the panel, reviewed all draft testimony products and engaged in feedback sessions in which inconsistencies and questions of completeness of investigation were conveyed. A second round of review was performed following clarification and/or incorporation of the earlier inputs. A third reading followed completion of the published documents.

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Q. OCA-4-29.

Please provide all workpapers, studies, analyses or other support for each of the cost reconciliation figures on Exhibit 2, Schedule 1.

A. OCA-4-29.

The attached compendium provides supporting documentation for the cost reconciliation figures cited in PECo Exhibit 2, Schedule 1. Included in this detail are the individual reconciliation items apportioned to specific cost causation factors; the total costs ascribed to each item; the Unit 1 and Common percentage of the total cost for each item; the Unit 1 and Common cost for each item, rounded to the nearest $ 0.1 million; and the referenced Forecast basis for each of the cost items. The methodology used in compiling, unitizing and apportioning costs to specific cost causation factors is detailed in Section VI of PECo Statement No. 8.

Responsible Witnesses:
B. P. Kononetz, TB&A
David R. Helwig, Supervising Engineer, Nuclear Services Branch, PECo

COST RECONCILIATION BACKUP

TO

PECO EXHIBIT NO. 2

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APPENDIX A: LIST OF ACRONYMS

NOTE: ITEMS WITHIN THIS REPORT ANNOTATED WITH AN (*) IN THE COLUMN LABELED "UNIT 1 & COMMON COST" INDICATE THAT THOSE ITEMS WERE DETERMINED TO NOT WARRANT AN ALLOCATION OF DISTRIBUTABLE COSTS FROM SECTION V.

SECTION ONE: REGULATORY AND OTHER EXTERNALLY-IMPOSED CONDITIONS

RECONCILIATION ITEM	TOTAL COST ($MM)	UNITIZATION %	UNIT 1 & COMMON COST ($MM)	FORECAST BASIS
NON-NRC REQUIREMENTS (cont'd)				
Redesign of Schuylkill pumphouse and discharge per PaDER requirements.	0.4 (0.3) 0.1	100% 100% 100%	0.4 (0.3) 0.1	1(P.III-2) 1(P.III-5) 1(P.III-5)
Indirects and distributables prorated to Non-NRC requirements.	---	---	11.3	All
COST IMPACT OF SCHEDULE EXTENSIONS DUE TO LICENSING DELAYS AND OTHER FACTORS				
Costs of schedule extension from 54 months to 60 months.	2.0	65%	1.3*	Pre. Est.
Costs associated with a revised construction schedule reflecting a January 1973 construction start.	13.0	65%	8.5*	Pre. Est.
Construction Permit delay from 1-73 to 6-74.	18.6 21.0 (4.5) 0.2 0.6 5.8 (0.8) 21.7	65% 100% 100% 100% 65% 65% 65% 65%	12.1* 21.0* (4.5)* 0.2* 0.4* 3.8* (0.5)* 14.1*	1(P.III-1) 1(P.III-2) 2(P.III-5) 1(P.III-2) 2(P.III-1) 2(P.III-1) 3(P.I-6) 2(P.III-1)
Fuel load delay for Unit 1 from 4-79 to 8-80; from 9-80 to 1-82 for Unit 2.	29.6	65%	19.2*	1(P.III-1)
Costs associated with a fuel load delays (10/81-10/83).	31.9	55.3%	17.6*	2(P.III-1)
Cost associated with fuel load delay to 3/82; 5/84.	22.6	57%	12.9*	4(P.14)
Delay in fuel load date to 10/82 and 10/84.	11.6	72.2%	8.4*	4(P.14)
Schedule delay from 10/82 to 10/84 for Unit 1 and 10/84 to 10/86 for Unit 2.	141.6	65%	92.0*	5(P.17)

SECTION ONE: REGULATORY AND OTHER EXTERNALLY-IMPOSED CONDITIONS

RECONCILIATION ITEM	TOTAL COST ($MM)	UNITIZATION %	UNIT 1 & COMMON COST ($MM)	FORECAST BASIS
COST IMPACT OF SCHEDULE EXTENSIONS DUE TO LICENSING DELAYS AND OTHER FACTORS (cont'd)				
Home office engineering associated with schedule delay.	4.5	65%	2.9*	4(P.16)
Unit 1 schedule delay from 7/84 and 9/84 fuel load.	3.4	100%	3.4*	7(PT-174)
Commercial operation delay from April to August 1985 due to delay in issuance of full power license.	28.5	100%	28.5*	Trend 7-7-7F
Commercial operation delay from August 1985 to December 1985 due to delay in issuance of full power license.	95.9	100%	95.9*	Trend 7-10-1F
Additional funds needed due to schedule delays in the HVAC balancing operation.	0.1	100%	0.1*	Trend 7-7-3F
Commercial operation delay from December 1985 to February 1986 due to delay in issuance of full power license.	27.8	100%	27.8*	Trend 7-13-1F
Modification of ITT HVAC damper actuators due to seal shelf to seal shelf life being exceeded.	0.4	100%	0.4	7(P.60)
Condenser tube cleaning and plugging to mitigate deterioration during project delay.	3.3 (0.1)	100% 100%	3.3* (0.1)*	7(P.132) Trend 7-6-6F
Cost of maintaining meteorological towers and monitoring equipment during extended schedule.	1.4	100%	1.4*	PECo(325)
NSSS contract cost increases due to delay.	3.6 2.1 0.1	100% 100% 100%	3.6* 2.1* 0.1*	PECo(301) PECo(301) PECo(301)

SECTION ONE: REGULATORY AND OTHER EXTERNALLY-IMPOSED CONDITIONS

RECONCILIATION ITEM	TOTAL COST ($MM)	UNITIZATION %	UNIT 1 & COMMON COST ($MM)	FORECAST BASIS
COST IMPACT OF SCHEDULE EXTENSIONS DUE TO LICENSING DELAYS AND OTHER FACTORS (cont'd)				
Increased cost of environmental monitoring.	5.7	100%	5.7*	PECo(8334)
	0.5	100%	0.5*	PECo(8139)
	2.8	100%	2.8*	PECo(8332)
Indirects and distributables prorated to cost impact of schedule extensions.	---	---	0.2	All

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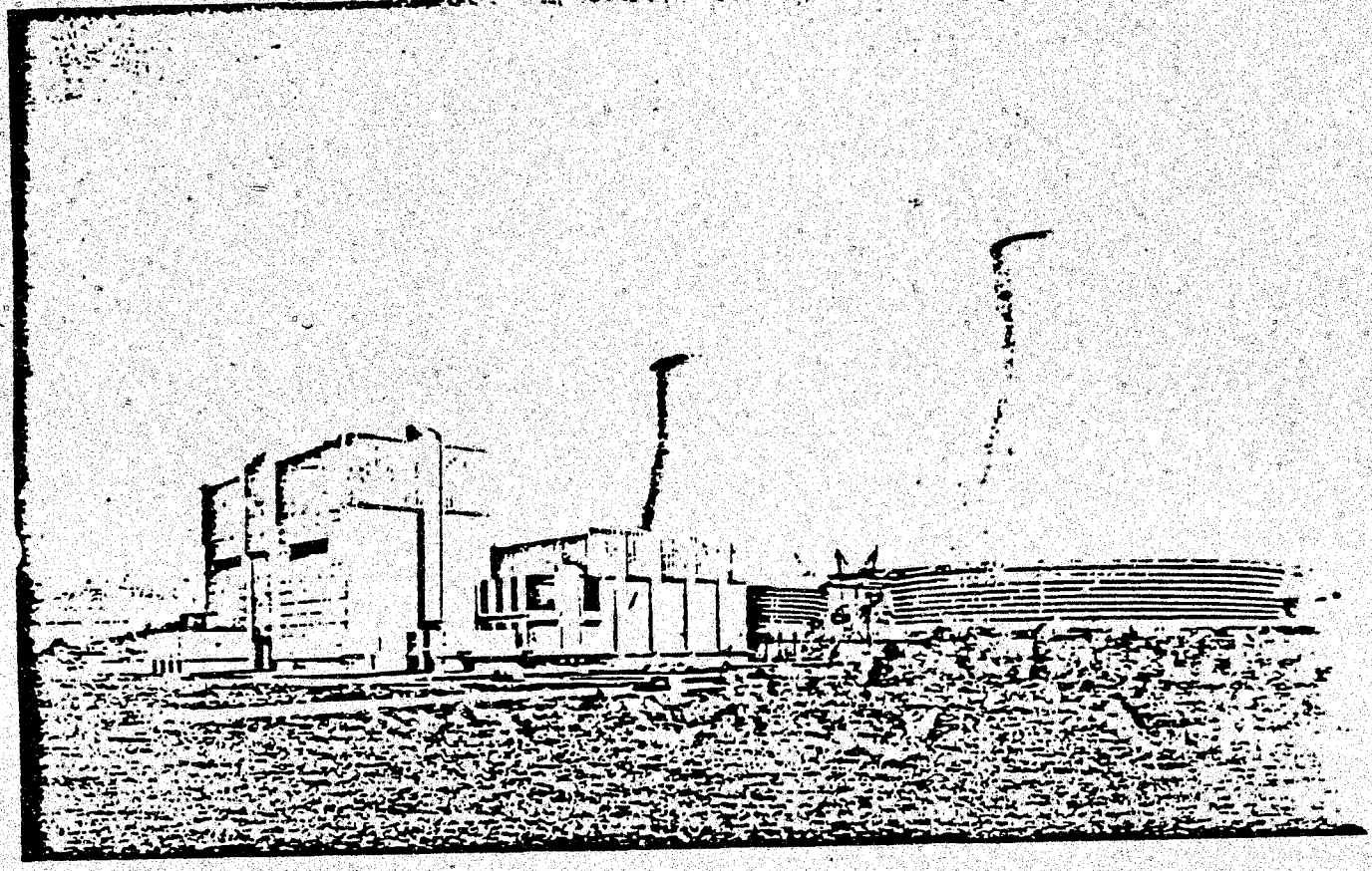
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Limerick Generating Station

Units 1 & 2
Philadelphia Electric Company



Forecast 5 Presentation

Bechtel Power Corporation
San Francisco Power Division

1.0 GENERAL INFORMATION

1.1 INTRODUCTION

This presentation contains the fifth cost and schedule forecast for the design, procurement, construction, and startup support, in accordance with the contract provisions, of Limerick Generating Station, Units 1 and 2. The last complete forecast, Forecast 4, was presented to PECo in December 1979. The engineering scope reflected in this forecast is based on information available as of August 1, 1980.

The preparation of the forecast was carried out on a 10/84 and 4/87 Fuel Load date basis.

All data referenced as Forecast 4 plus trends in this report is data as submitted to PECo, thru Trend number 4-9. The effects of these trends in dollars and manhours are shown in Exhibit 1 for Reference.

1.2 PROJECT SCOPE

Limerick Generating Station, Units 1 and 2, consists of two 1100-Mwe, nominal capacity, nuclear power generating units on the Schuylkill River near Pottstown, Pennsylvania. Each unit includes a GE boiling water reactor (BWR) nuclear steam supply system (NSSS), a tandem compound six-flow GE turbine-generator, a closed cycle cooling water system with a hyperbolic natural draft cooling tower, primary and secondary river makeup, and plant auxiliaries and accessory equipment.

Excluded from Bechtel's scope of work are the switchyard, transmission lines, procurement of nuclear fuel, land and recreational areas.

The technical scope and design basis for the project facilities and systems are described in the Scope Document for Forecast 1, Vol. 1 and approved NCD's issued since Forecast 1.

The cost reimbursable contract between PECo and Bechtel for engineering, procurement, and construction services was signed August 15, 1974. Burden on Home Office services is 75 per cent. Burden on field non manual services was 30% of the first 2,500,000 manhours ($6.814 million). Amendment 1 of the Contract, effective January 1, 1977, modifies Exhibit B to provide additional Field non manual burden of $6.586 million to be paid in 84 installments of $78,409 beginning in July 1977. For the non manual effort which extends beyond September 1984, Bechtel shall receive an additional 8% of the cost of these hours.

Startup services are furnished at a unit rate.

Liability is limited to $2,000,000 as per article 8 of the contract.

1.3 FORECAST 5 BASIS

1.3.1 INCLUSIONS

a. Compliance with the NRC Regulatory Guides is to the greatest degree practicable for areas which are entirely the responsibility of PECo/Bechtel. For areas which are entirely the responsibility of General Electric for the NSSS/TG packages, compliance is generally only to the degree actually required by the NRC.

b. Resolved Trends as of September 1980, as listed in Exhibit 23

c. Construction testing and startup support until fuel load, in accordance with Bechtel's Nuclear Plant Construction/ Start-up/Owner Activity Interface Diagram.

d. Tax costs, when paid directly by a subcontractor.

e. Insurance-Contingent Public Liability and Auto Public Liability and Property Liability (includes job owned/owner furnished autos). Contingent 3rd party property damage liability. Contractors all risk equipment for rentals. Excess and additional excess public liability and property liability.

f. Cost of PECo purchased permanent plant equipment.

g. Forecast 5 includes the cost of Bechtel manual and non manual support labor to project completion, which is assumed to be 6 months after Unit 2 fuel load.

1.3.2 EXCLUSIONS

a. PECo's costs, including engineering, operating, licensing, training, environmental and land costs, inspection, nuclear fuel and associated costs, and interest during construction.

b. Pennsylvania sales and use taxes on Bechtel purchase orders that are paid directly to the State of Pennsylvania by PECo.

c. Insurance-Owner Furnished Primary Insurance - Public Liability and Property Liability excluding automobilies. Builders risk and Workmen's Compensation.

d. Supply and installation of the telephone system.

e. Operating spare parts and supplies except construction spares and spares covered by presently issued purchase orders (negligible amount).

1.3.3 QUALIFICATIONS

a. Escalation and lead time evaluations when better information is unavailable are based on Bechtel's interpretation of present US economic conditions. The to-go escalation rates (%) used in Forecast 5 are:

	80	81	82	and thereafter
. Home Office	10	10	8	
. Field Manual	12*	12*	8	
. Materials	10	10	8	
. Subcontracts	10	10	8	
. Field Non-manual	10	10	8	

* Based on actual wage agreements

b. Regulatory agency approvals are assumed obtainable with the design defined in the Preliminary Estimate Scope Document modified for Forecast 1 and approved NCD's.

c. Licensing is assumed obtainable without schedule delays or redesign.

d. The Forecast 5 basis assumes that sufficient qualified labor is assumed to be available to support the schedule without financing training programs and/or large scale recruitment programs.

e. The Forecast 5 basis assumes that scheduled overtime will not be required to attain the required manning levels.

f. It is assumed that GE and the other vendors will support the Engineering and Construction schedules.

g. Pennsylvania sales and use tax is assumed to be in accordance with the tax quidelines established and approved by PECo.

h. No contingency is included for PECo furnished material and equipment.

i. In Forecast 5, outstanding and pending backcharges are all assumed collectible.

j. The Forecast Schedule is based on Bechtel's best effort to meet the 10/84 and 4/87 fuel load dates.

k. The construction schedule basis was developed by evaluating the to-go manpower and installation rates by major facility.

l. Unresolved Trends are included only on an Order-of-Magnitude basis as below the line items.

m. No contingency is included for additional costs incurred as a result of delaying the scheduled fuel load dates beyond 10/84 and 4/87.

2.1 Cost

The Forecast 4 cost of $1,722 million included an allowance of $95 million for future scope changes. Since Forecast 4, 75 scope changes worth $92 million have been added to the project and $29 million still remains in the Unresolved Trend category. These changes are mainly Regulatory, TMI and Mark II related issues.

These changes, which significantly affect piping and electrical activities, plus restricted cash, limited critical crafts and increased unit rates have caused the two year schedule extension with the associated cost increase.

Forecast 5 shows a total cost increase of 12% ($235 million) over trended Forecast 4, which brings the total project cost to $2,245 million. A summary of these changes is presented in the cost reconciliation section.

2.2 Schedule

In June 1980 PECo directed a one year delay in the Unit 1 Fuel Load to 10/83. Bechtel had been recommending an extension of 18 to 24 months. The underrun in the actual vs scheduled manpower and the increase in the actual vs. forecasted labor unit rates resulted in "to-go" manpower levels that may be unattainable and would exceed the $200 per year million funding guideline. This along with a licensing schedule which may be too short and the project's ability to resolve key technical issues such as MK II and ATWS within the required schedule necessitated this schedule change.

Forecast update 4B issued in August projected the "to go" cash flow and required manpower levels to cover the scope added to the project through trends in support of 10/83 and 10/86 Fuel load dates. This preliminary program required a cash flow of $200 million in 1981 and 1982 and an effective manual force of 1700 through 1982. The pipefitter force peaked at 800, and the electricians peaked at 500. PECo was advised that this program would have to be confirmed during F/C 5.

The manhours added by Forecast 5 resulted in manpower levels to support a 10/83 Fuel Load schedule that would have exceeded the $200 millions cash flow ceiling specified by PECo and projected craft levels that could probably not be obtained under existing job work rules. Forecast 5 also added conduit quantity which will delay bulk wire pulling and cause a late peak in the electrician's manpower. As a result, Forecast 5 is recommending 10/84 - 4/87 Fuel Load dates as the new project goals. The required manpower for total manual, pipefitters and electricians peaks at 1900, 750, and 600 respectively. These levels are believed to be achievable and are consistent with the available work and engineering/design program.

Fuel Load Dates

	Forecast 4		Forecast 5
	Target Dates	Official Dates	Recommended Dates
Unit 1	10/82	10/84	10/84
Unit 2	10/84	10/86	4/87

T-3/6

2.4 Detail Reconciliation Including Unresolved Trends

Forecast 4 to Forecast 5	Trended	Not Trended	Total
		(Dollars in Millions)	
Total Forecast 4			1,722.5
Scope Changes (Resolved and Unresolved)			
1. Delay Fuel Load Dates from 10/82 to 10/84; 10/84 to 10/86 for Units 1 and 2, respectively.	200.0	24.3	224.3
2. Delay Unit 2 Fuel Load from 10/86 to 4/87 due to cash flow restriction		27.6	27.6
3. Modifications due to Mark II Containment loads on adjacent structures	20.0		20.0
4. Redesign radwaste solidification System	7.0		7.0
5. Improve plant security and surveillance system	7.2		7.2
6. Modify fire protection system to include heat detectors and sprinklers on cable trays	4.5		4.5
7. Modifications due to ATWS (Anticipated Transients Without Scram)	12.0		12.0
8. Provide permanent Startup Transient Test Recorder System (STARTREC)	8.5		8.5
9. Addition of a Technical Support Center	2.3		2.3
10. Relocate exhaust stack radiation monitoring rooms to Reactor Enclosure roof	3.1		3.1
11. Provide for post-accident radiation monitoring per Reg. Guide 1.97	4.2		4.2
12. Redesign ECCS and F.W. line fill system to "Q" listed	1.1		1.1

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SECTION IV

UNANTICIPATED ESCALATION

SECTION FOUR: UNANTICIPATED ESCALATION

RECONCILIATION ITEM	TOTAL COST ($MM)	UNITIZATION %	UNIT 1 & COMMON COST ($MM)	FORECAST BASIS
IV. UNANTICIPATED ESCALATION				
Escalation associated with the upgrading of the Schuylkill River Facilities.	3.0 (0.2)	100% 100%	3.0* (0.2)*	Pre. Est. 4(P.16)
Escalation associated with the refueling floor missile protection.	3.0	100%	3.0*	Pre. Est.
Escalation associated with a seismic criteria change of .12g to .15g.	3.0	60.0%	1.8*	Pre. Est.
Escalation associated with civil commodity and material increases.	11.0	57.3%	6.3*	Pre. Est.
Escalation associated with large and small process pipe quantities.	3.0	53.3%	1.6*	Pre. Est.
Escalation associated with re-evaluation of field manual labor.	5.0	62.0%	3.1*	Pre. Est.
Escalation associated with re-evaluation of non-manual requirements for Quality Control.	1.0	65.0%	0.7*	Pre. Est.
Other unanticipated escalation.	0.1 1.0	100% 65.0%	0.1* Trend 7-8-10F 0.7*	Pre. Est.
Escalation associated with engineering and other home office support.	4.0	52.5%	2.1*	Pre. Est.
Escalation associated with a revised construction schedule reflecting a January 1973 construction start.	43.0	60.5%	26.0*	Pre. Est.
Escalation associated with a schedule extention from 54 months to 60 months.	20.0	60.0%	12.0*	Pre. Est.

SECTION FOUR: UNANTICIPATED ESCALATION

RECONCILIATION ITEM	TOTAL COST ($MM)	UNITIZATION %	UNIT 1 & COMMON COST ($MM)	FORECAST BASIS
UNANTICIPATED ESCALATION (cont'd)				
Reduced delay charges on fan cabinets.	(0.1)	65%	(0.1)*	4(P.16)
Escalation rate adjustment from 6 to 7 percent for 1978 and beyond, to agree with SFPD guidelines.	16.9	52.7%	8.9*	1(P.III-1)
Escalation rate re-evaluation to reflect actual 1974 escalation and to incorporate new guidelines.	111.0	58.8%	65.3*	1(P.III-1)
Increased escalation for reinforcing steel and drywell framing system.	1.0 0.2	65% 50%	0.7* 0.1*	1(P.III-2) 1(P.III-2)
Re-evaluate escalation for reactor shield.	0.2	50%	0.1*	2(P. III-3)
Additional escalation for miscellaneous mechanical subcontracts.	1.9	65%	1.2*	2(P.III-4)
Re-evaluation of to-go escalation for pipe.	(1.4)	65%	(0.9)*	2(P.III-4)
Re-evaluation of to-go escalation for large fabricated pipe.	(5.6)	69.4%	(3.9)*	3(P.I-7)
Deletion of unallocated escalation from Forecast 2.	(23.9)	32.6%	(7.8)*	3(P.I-5)
3 year multi-trade agreement labor escalation from 7% to 3 1/2%.	(23.0)	40%	(9.2)*	4(P.14)
Revise projected escalation rates (7% to 8%).	12.8	55.5%	7.1*	4(P.14)
NSSS contract escalation.	0.8 1.6 14.0	100% 100% 100%	0.8* 1.6* 14.0*	PECo(301) PECo(301) PECo(301)

SECTION FOUR: UNANTICIPATED ESCALATION

RECONCILIATION ITEM	TOTAL COST ($MM)	UNITIZATION %	UNIT 1 & COMMON COST ($MM)	FORECAST BASIS
UNANTICIPATED ESCALATION (cont'd)				
Increase in home office wage rates over forecasted due to actual escalation exceeding forecast.	9.8	66.3%	6.5*	4(P.16)
Reactor shield access doors increase in commitment amount due to change in escalation rate.	0.2	50%	0.1*	5(P.22)
Change in escalation rate since Forecast 5.	15.7	37.0%	5.8*	6(P.152)
Escalation associated with schedule delays.	69.7	58.8%	41.0*	1(P.III-1)
	61.7	58.8%	36.3*	1(P.III-1)
	69.1	49.1%	33.9*	2(P.III-1)
	14.0	37.9%	5.3*	4(P.14)
	5.3	54.7%	2.9*	4(P.14)
	80.9	49.0%	39.6*	5(P.17)
Re-evaluation of labor rates.	1.7	100%	1.7*	Trend 7-5-5F
	7.8	65%	5.1*	5(P.18)
	2.8	65%	1.8*	1(P.III-4)
	14.0	65%	9.1*	1(P.III-2)
	(22.0)	65%	(14.3)*	1(P.III-2)
	(17.6)	65%	(11.4)*	2(III-4)
	(3.0)	65%	(2.0)*	3(P.I-7)
	34.6	65%	22.5*	5(P.18)
	0.2	100%	0.2*	7(P.102)
	(1.2)	100%	(1.2)*	Trend 7-12-[illegible]
Price relief to Ingersoll-Rand Co. for chilled water circulation pumps.	0.1	65%	0.1*	3(P.I-5)
Additional price relief to Byron Jackson for emergency service water pumps and RHR service water pumps.	0.4	50%	0.2*	3(P.I-5)
Price relief granted to other vendors.	1.1	65%	0.7*	2(P.III-1)
Price relief to Crane-Deming for vertical radwaste pumps.	0.1	100%	0.1*	3(P.I-5)