APPENDIX C

ASSURANCE OF QUALITY IN NUCLEAR CONSTRUCTION PROJECTS: AN EXAMINATION OF SELECTED CONTRACTUAL, ORGANIZATIONAL, AND INSTITUTIONAL ISSUES

C.1 INTRODUCTION

This appendix summarizes and discusses the findings to date of a case study project examining the contract and procurement processes at nuclear power plants under construction. Section C.1 presents introductory material on the study's purpose and objectives, background and scope, technical approach and study limitations. Section C.2 summarizes project findings, conclusions, and recommendations. Section C.3 examines QA contractual issues in nuclear power plant construction, focusing primarily on insights gained at the sites visited. Section C.4 discusses organizational issues affecting quality assurance in nuclear power plant construction. Section C.5 examines institutional issues and their implications for the course and success of nuclear construction projects. Section C.6 lists references, and a bibliography is provided in Section C.7.

C.1.1 Purpose and Objectives

This appendix is intended to serve several purposes: 1) to constitute an extended progress report on project activities; 2) to communicate preliminary findings and suggest future directions; and 3) to form the basis for developing NRC staff recommendations regarding a course of action to improve the assurance of quality in nuclear power plant construction projects in response to Congressional directives in the FY 1982-83 Authorization Act. Because of this last purpose, project recommendations are offered, although these are based upon preliminary findings and conclusions.

C.1.2 Background and Scope

The complexity and extent of problems that have been identified in recent years at some nuclear power plants under construction have raised questions regarding the quality assurance (QA) programs required by the NRC and implemented by NRC licensees. As part of an effort to better understand and address these problems, the NRC initiated a study of the contract and procurement process employed by licensees at nuclear power plants under construction and of the organizational and institutional environments in which such projects are initiated and financed.

The purpose of the study is to examine how "quality" responsibilities are delegated, managed and controlled by the licensee in the contract and procurement process. This study is also to determine what improvements may or should be made to the QA programs required by the NRC, based on the review and study of the contract and procurement process and of organizational and institutional arrangements in the nuclear power industry. The

NRC will use the study's results in their analyses of QA programs and in the preparation of a report to Congress required by the FY 1982-83 Authorization Act.

Specific objectives of the study are to 1) characterize the aspects of contract and procurement that appear to affect quality during construction of a nuclear power plant; 2) determine the types of contract and procurement provisions and arrangements that could contribute most to enhance quality; 3) develop, to the extent possible, guidelines for construction contracts and procurement that could assist in achieving overall quality objectives; and 4) examine the contributions of selected organizational and institutional arrangements to the quality and success of nuclear construction projects.

This project is one of several initiatives undertaken by the NRC to improve the assurance of quality in the design and construction of nuclear power plants. The full range of initiatives that have been undertaken involve the following issues or topic areas:

- Measures at Near-Term Operating License Facilities
- Industry Initiatives
- Construction Inspection Programs
- Qualification and Designation of QA/QC Personnel
- Management
- Long-Term Review.

This project is included in "Long-Term Review." Three projects, also part of the Long-Term Review, that are closely linked to this project are described in Appendix A, "Quality in the Design and Construction of Nuclear Power Plants: Case Studies of Successes and Failures," Appendix B, "Management Review of the NRC QA Program," and Appendix D, "Outside Programs for Assurance of Quality in Design and Fabrication."

C.1.3 Technical Approach

The findings and recommendations in this appendix are based upon insights gained through site visits, review and analyses of selected secondary source materials, and other project activities including telephone contacts with state regulatory personnel. These activities were combined to allow the project team to examine both actual contracting and procurement practices used by firms involved in nuclear construction projects and the organizational and institutional environments in which these projects are initiated, guided, and completed. Approaches used to examine these topics are described separately below.

Examination of Contracting and Procurement Practices

To examine contracting and procurement practices, the perspectives, experiences, and practices of key groups involved in constructing nuclear power plants were collected through site visits. The following criteria were used to select the sites: geographic location, site reputation/success, experience of site personnel, and structural, contractual, and organizational arrangements of the site. Initially, four nuclear construction projects and the utilities constructing them, two architect-engineering (A-E) firms, one constructor, and two subtier suppliers were to be examined. However, because of time constraints, only a subset of the planned site visits have been completed to date (three construction projects and one A-E). During actual site visits, representatives of the sites provided useful insights into the contracting and procurement process and its relationship to the assurance of quality.

Site Visit Protocol. Each visit was conducted according to a site visit protocol, which consisted of personal interviews with designated individuals and examination of relevant documents and materials. Personnel interviewed included legal, contracting, and procurement specialists; key managers involved in bid evaluation and selection; construction and project managers; representatives of the utility's QA organization; inspection and audit specialists; and contractor on-site managers.

The following documents were identified as important to obtain and review (if possible): bid evaluation procedures/guidelines, standard procurement forms/guidelines, standard contracts for major project contractors (at construction sites visited), and special conditions for all major contracts (if separate from standard contract document).

Contractual, Organizational and Institutional Factors Examined at the Sites. The site visit protocol was tested and revised on the basis of a pilot site visit to a nuclear construction project. During the pilot visit, a series of contractual, organizational, and institutional factors thought to have potential significance for the assurance of quality was examined.

Contractual factors investigated included the following:

- types of contracts executed
- the use of incentive provisions in contracts
- assignments of responsibilities and risk sharing relative to quality between the utility and its contractors
- requirements for demonstration, review, and/or approval of QA programs
- procurement practices and procedures
- approaches used to communicate QA/QC requirements to subtier contractors and to monitor compliance with these requirements
- provisions for source and on-site inspections.

The following organizational factors were examined:

- prior nuclear experience

- project structure and participation in the engineering, construction management, procurement and constructor roles

- owner involvement in the engineering, construction management, procurement and constructor roles

- labor arrangements.

Two institutional factors were examined:

- project ownership arrangements

- the effects of state public utility commission policies on nuclear construction projects.

Profiles of Sites Visited. The site findings contained in this appendix are based upon visits to four sites: three nuclear construction projects and one A-E firm. Site 1 is a nuclear project being built by a relatively small investor-owned utility, and a small rural electric cooperative, neither of which has previous nuclear construction experience. The utility is being assisted by an experienced A-E and contractors. Quality-related problems identified at the site several years ago led the utility to stop construction and change its contracting and project management style. Site 1 served as the pilot site for this project.

Site 2 is a joint venture nuclear project being built by a group of utilities (four investor-owned and one public utility). The investor-owned utility serving as project manager for the owners had no previous nuclear construction experience. This utility is being assisted by a large, experienced prime contractor that serves as A-E and constructor and acts as the utility's agent for procurement and the management of project subcontractors.

Site 3 is another joint venture nuclear project being constructed by three small public utilities and one large investor-owned utility. The investor-owned utility, the subsidiary of a large holding company, has previous nuclear experience, owns just over 50% of the project and serves as the construction manager and agent for the owners' group. The utility is assisted by an experienced A-E and many contractors. The utility controls all project procurement. The project, which was delayed initially for financial reasons, has a solid reputation within the industry.

Site 4 is a large and experienced A-E firm that has been a major force in the nuclear construction industry. This firm has played all project roles either alone or in combination with others for many nuclear construction efforts. The firm has worked for owners and with contractors and suppliers possessing a wide range of expertise and experience in nuclear construction.

Examination of Organizational and Institutional Environments

Investigation of organizational and institutional factors at the sites visited, combined with findings from other NRC quality assurance studies contained in the Long-Term Review, stimulated the NRC Project Monitor to determine that the following two issues needed to be examined further: 1) effects of state public utility commission (PUC) policies on nuclear construction efforts, and 2) effects of ownership arrangements on project success. Subsequently, a separate set of project activities was initiated to provide additional information on these issues.

First, the project team consulted a wide range of relevant secondary sources pertaining to PUC actions and policies; and to the legal, organizational, and institutional parameters of the nuclear industry. All sources examined by the project team are contained in the Bibliography.

To examine the actions of PUCs, secondary source materials were supported by telephone contacts with state commissions having operating plants in their jurisdictions. In several cases, members of commission staffs provided materials related to special commission actions. In other cases commission staffs identified documents relevant to PUC decisions, and the project team obtained them. These telephone contacts and materials provided additional insights into the attitude of state PUCs toward nuclear construction projects.

Finally, the project's investigation of ownership arrangements in the nuclear industry was assisted by the NRC Review Group, a group of experts advising the NRC on its entire program of QA initiatives.[a] Group members provided insights from their own experiences and suggested sources of further information.

C.1.4 Study Limitations

Several factors of timing and approach necessarily limit the breadth of findings, conclusions, and recommendations discussed in this appendix. To provide the NRC staff with preliminary findings and to assist in preparing the Congressional report, the results had to be summarized based upon only a subset of the planned field work. In addition, because examination of the public utility commission and project ownership issues was initiated after completing some of the site visit activities, they have not been thoroughly studied. Finally, this project is based primarily on a series of case studies, which are intensive examinations of the experience of individual firms and/or construction projects. Therefore, while the experience of these firms may not be unique, it also may not be representative of, or generalizable to, other nuclear construction projects.

C.2 CONCLUSIONS, FINDINGS AND RECOMMENDATIONS

Based upon insights drawn from site studies, secondary sources and other project activities, the several general conclusions found below were reached. Second, findings specifically related to the site studies are discussed. The

(a) J. Christensen. Draft. Pacific Northwest Laboratory, Richland, Washington.

study team visited three nuclear construction sites and a large architect-engineering firm. At each site, contractual, organizational and institutional factors were examined to determine their relationship to and influence on the assurance of quality in nuclear construction programs. For each of the factors investigated, findings from the site visited are cited. Third, several observations growing out of project activities, but requiring further examination, are made. Finally, recommendations are offered, based upon the project's preliminary findings and conclusions.

C.2.1 General Conclusions

Based upon the findings at the sites visited, examination of relevant secondary sources, and other project activities, the project team has drawn several general conclusions.

First, no substitute appears to exist for an objective bid evaluation and selection process based upon relevant technical criteria. Where such criteria are rejected in favor of "people we're familiar with" or "country club cousins" problems can result. This is particularly significant for first-time owners because the "people we're familiar with" are not likely to have nuclear experience. (See Section C.3.1.)

Second, without substantially more complete designs before construction is begun, fixed-price contracting for most aspects of nuclear power plant construction projects does not appear to be justified. Instead, utilities involved in nuclear projects most frequently recommend cost-reimbursable contracts with fixed fees, particularly for assuring quality performance. Although such contracting de-emphasizes cost, it may be most cost-effective in that it is more likely to result in getting the job done correctly the first time. (See Section C.3.2.)

Third, the level of detail of the QA and QC requirements in contract and procurement documents is less important than the degree to which QA and QC programs are actually implemented. Actual checks of work done, source and on-site inspections, the implementation of worker and supervisor training programs, and required demonstrations of contractor expertise and commitments in both pre- and post-bid award periods are all examples of actions that demonstrate more about QA/QC programs than do written QA/QC requirements. (See Section C.3.3.)

Fourth, previous nuclear experience appears to provide a significant advantage in a nuclear construction effort. Utilities that do not have such experience internally should hire either a project staff or contractors who can provide such expertise. (See Section C.4.3.)

Fifth, with the NRC, state public utility commissions provide a major source of regulatory oversight for nuclear construction projects. Regulatory influence in this case is exercised through the rate base treatment of such projects. Historically, state PUCs do not appear to have been active in disallowing construction costs that may have resulted from lapses in quality assurance or project management. This position results in shifting the risks of quality lapses from the utility to its ratepayers. Recent developments suggest that this position is changing. (See Section C.5.1.)

Sixth, a nuclear construction project appears to benefit when its procurement agent is large enough and experienced enough to exert "marketplace presence." A large procurement entity offers the advantages of market familiarity and commercial power (based upon frequency and continuity of purchasing) as well as the expertise needed to secure satisfactory performance on procurements. (See Section C.5.2.)

C.2.2 Factors Affecting the Assurance of Quality in Nuclear Construction Projects: Site Study Findings

Contractual Factors

Site examination of contractual factors yielded the following findings:

- Kinds of contracts executed. The type of contract universally preferred for most aspects of nuclear power plant construction is the cost-reimbursable contract. This contract type offers several advantages for assurance of quality: 1) it permits extensive monitoring of contractor performance; 2) it encourages the taking of corrective action; 3) it flexibly accommodates scope and design changes; and 4) it allows construction to begin before design work is complete. (See Sections C.3.2 and C.3.4.)

- Use of incentive provisions in contracts. Incentive contracting is used at only one of the sites visited. In general, those interviewed argued that incentive provisions tended to place too much emphasis on cost and schedule, to the detriment of quality objectives. (See Sections C.3.2 and C.3.4.)

- Responsibilities and risk sharing between the utility and its contractors relative to quality. By using cost-reimbursement contracts, which limit or remove contractor liability for rework and errors, utilities assume virtually all the risks of completing nuclear construction projects successfully and on time. Generally, the owner's assumption of risk is reflected in relatively small fees earned by contractors. (See Sections C.3.2 and C.3.4.)

- Requirements for demonstration, review, and/or approval of contractors' QA programs. In addition to the necessary review and approval of contractors' QA programs, utilities visited felt that requiring contractors to demonstrate their approach to assurance of quality was important. The argument was that while some contractors might be able to describe an acceptable QA program on paper, the only way to evaluate their real understanding was to ask them to demonstrate how they planned to implement such a program. At some sites, pre- and post-award meetings with contractors were used for this purpose. (See Section C.3.3.)

- Procurement practices and procedures. At all sites, procuring materials, supplies, and equipment was helped by pre-screened and/or evaluated suppliers' lists. Such lists are typically updated as project experience warrants. Where adequate resources are available, surveillance programs may provide additional feedback on vendor performance. (See Section C.3.1.)

- Approaches used to communicate quality requirements to subtier contractors and to monitor their compliance. Communicating quality requirements appears to be divided between two approaches. One approach is to have detailed contract and procurement documents, incorporating directly all applicable QA/QC requirements, codes, and standards. The other approach relies on more general statements of quality expectations in procurement documents. With this latter approach, suppliers would be required to verify their compliance, for example, through mutually agreed upon audit procedures or through the submission of acceptable test and inspection data. In either case, all utilities visited agreed that communicating requirements would not assure quality unless compliance was actually monitored in some way--quality assurance requires follow-through. (See Section C.3.3.)

- Provision for source and on-site inspections. Procurement documents at all sites required suppliers to make their facilities available for inspection. The provision relating to this issue was nearly identical in documents reviewed at each site. Similarly, inspections on receipt were standard practice at all sites. Sites differed, however, in the scope of receipt inspection activities performed and in the resources available for inspections. In general, larger, more commercially active purchasers possessed both the economic incentive and resources to monitor systematically contractors' shops. (See Sections C.3.1 and C.3.3.)

Organizational Factors

Site examination of organizational factors yielded the following findings:

- Various combinations of engineering, management, procurement, and construction roles. The wide array of construction project role arrangements in the U.S. nuclear industry suggests that no one arrangement will insure success. External A-E firms performed engineering at all sites studied. Either the utilities or the A-E handled construction management. Procurements were managed by the A-E with utility supervision or by the utility alone. Construction arrangements at the sites studied varied greatly, ranging from one prime contractor to more than 30. (See Section C.4.)

- Various combinations of engineering, management, procurement, and construction roles for owners. Owners generally assumed the role of project manager, combining this role with that of construction manager at two sites. In-house engineering tended to be used only for A-E oversight or non-safety-related design work. Procurement was generally a function shared by the owner with the A-E and contractors. Construction at all sites studied was performed by external firms. (See Sections C.4.1 and C.4.2.)

- Prior nuclear experience. All sites recognized the value of previous nuclear experience although only two of the sites visited had such experience. In particular, previous experience increased familiarity with quality requirements and expectations; improved the selection of contractors; and permitted the utility, A-E, or contractor to anticipate the inexperience of others and to take steps to compensate for it. (See Section C.4.3.)

- Different Labor arrangements. All of the construction projects visited had negotiated broad labor agreements with major craft unions and locals before the project began. Given the size, duration, and complexity of nuclear projects, unions had sufficient incentive to enter into such agreements. Generally, these agreements benefited both sides: labor was guaranteed work for a long period of time, and the utility/contractors won concessions on job rules, work interruptions, and walk-outs. (See Section C.4.4.)

Institutional Factors

Site examination of institutional factors yielded the following findings:

- State public utility commission (PUC) policies. At all sites visited, state PUC policies were not reported to have been pivotal either in the original decision to build a nuclear plant or in later project and contracting decisions. (See Section C.5.1.)

- Project ownership arrangements. The sites visited exhibited a range of ownership arrangements. No one arrangement appeared superior to the others in producing project success. Joint projects did appear to offer some advantage for financial stability. (See Section C.5.2.)

C.2.3 Project Observations

In the course of project activities, the study team made a number of observations deserving of mention here as well as of further investigation and analysis. These observations are as follows:

The nuclear construction industry does not appear to make extensive use of incentive contracting of either a reward or punitive nature. Therefore, because most of the contracts are cost reimbursable, virtually all the risk lies with the utilities. Further examination of incentive contracting might reveal some particular advantages that would have implications for both the quality and cost of nuclear power plants. (See Section C.3.2.)

State PUCs, while not particularly active in scrutinizing nuclear power plant construction costs, appear quite aggressive in their examination of operating and maintenance costs. It was suggested that this is because better-accepted methodologies exist for evaluating costs associated with operations and maintenance than are available to assess construction expenditures. If this is the case, it would appear worthwhile to explore the development of such a methodology for assessing construction costs. (See Section C.5.1.)

Several commentators have suggested the value of greater consolidation and coordination of the nation's nuclear generating capacity. While initially there do not appear to be legal barriers to such consolidation, neither do there appear to be particular incentives to coordination. Should enhanced coordination be deemed desirable, antitrust and other potential legal issues would require more extensive examination. (See Section C.5.2.)

Finally, while some project ownership arrangements appear to have advantages over others, careful empirical examination of utility and project ownership arrangements and their relationship to construction project outcomes is lacking. Further study could begin to identify some of the relative strengths and weaknesses of different types of arrangements. Through such additional study, it might also be possible to determine the appropriate vehicle for advocating increased coordination, assuming that further investigation offered evidence of its merits. (See Section C.5.2.)

C.2.4 Recommendations

The focus of this project was on case studies of individual sites and their nuclear construction experience. This approach necessarily limits both the ability to generalize the project's findings and the development of recommended actions. With these limitations in mind, the following recommendations are offered:

- As part of their management review, the NRC should consider requiring applicants for construction permits to explain their proposed contracting methods, bid evaluation and selection procedures, and their reasons for choosing them.

  Given the overwhelming consensus about contractor selection processes and cost-reimbursement contracting, this item clearly seems to warrant NRC attention. Utilities are advised to require bidders to demonstrate their approach and commitment to a project, the NRC could demand the same of licensees. This would force the potential licensee to think through the contracting process with all its implications for risk sharing, cost control, and quality performance requirements.

- The NRC should examine methods to focus more attention on how a licensee proposes to insure that quality work is being performed rather than on the documents that describe general QA and QC programs.

An overemphasis on what is written about quality assurance and quality control appears to contribute little to the actual assurance of quality and may be detrimental. This is particularly true if such an emphasis diverts attention from how the elements of QA and QC programs will be implemented. The issue here is the difference between examining a utility's QA manual and examining the number and qualifications of the staff it assigns to QA functions. The former audits writing ability; the latter contributes to an assessment of the capacity to carry out a QA objective.

- The NRC should examine the implications for its own mission of state public utility commission scrutiny of and policies toward nuclear construction project costs and management.

  State PUCs appear to be taking more action in their examination and disallowance of unnecessary and unwarranted expenses. How this new posture affects execution of the NRC's safety mission, PUCs' expectations of the NRC, and the assurance of quality in nuclear construction projects is not yet clear. This shift represents what may be a major change in the institutional environment of nuclear power plant construction; thus, the NRC should examine carefully its implications.

C.3 CONTRACTUAL ISSUES

A key aspect of any major construction effort is the contracting and procurement process used. This process defines the scope and level of involvement for all project participants, establishes their relationships with each other as well as with the owner, and secures all of the materials, supplies, tools, and equipment for building the plant.

At each of the study sites, several features of the contracting and procurement process were examined to determine their contribution to assurance of quality in a nuclear construction project. Three aspects of the contracting and procurement process were of particular interest: 1) the procedures used to evaluate and select contractors and vendors; 2) the terms and conditions (including incentives, if any) of contracts and procurement documents; and 3) the nature and scope of quality-related requirements incorporated in contracts and procurement documents. The project team's findings in each of these areas are discussed below. A concluding section summarizes the findings.

C.3.1 Bid Evaluation and Selection Procedures

Selecting qualified contractors to perform construction tasks requires more than careful drafting of contract documents. For this reason, contracting and procurement guides typically view an objective bid evaluation and selection process as fundamental to successful contracting (Cibinic and Nash 1981; Federal Procurement Regulations). Such a process has several characteristics. It is independent of any particular procurement that is undertaken and involves procedures that are clear and can be readily communicated. Finally, for contractor selection, it uses criteria that are rationally related to the product or service being procured.

Recommended features of contractor and vendor bid evaluation and selection procedures suggested by those interviewed are described in the following discussion. To clarify the discussion, the term "contracting" is used to denote the process of selecting on-site suppliers of labor, expertise, and services. The term "procurement," on the other hand, is used to denote the selection of off-site suppliers/vendors of materials, supplies, and equipment.

Bid Evaluation and Selection Procedures for Project Contractors

The use of bid evaluation and selection procedures to select project contractors at the sites studied did not appear to affect the number of contracts and vendor agreements executed. Two of the sites studied involved utilities that had executed many contracts directly with construction contractors. One of these sites (Site 3) uses a detailed bid selection procedure for all contracting. The other site (Site 1) indicated that it had selected its original contractors because they were "people we were familiar with" from previous, non-nuclear construction efforts. In the last case, lack of contractor experience appeared to play a role in quality-related problems that resulted in a self-imposed work stoppage. Of the other two sites, Site 2 involved a utility that executed one prime contract and relied on the prime contractor to use its own bid evaluation and selection process to subcontract with others performing services for the construction project. However, the utility's selection of the prime contractor was highly formalized. At Site 4, the major A-E firm visited, the staff interviewed gave several examples of unsatisfactory contractor performance that resulted from inappropriate contractor selection procedures. One person noted that "hiring country club cousins" over technically or functionally superior bidders is not conducive to quality construction efforts.

Formalized bid evaluation and selection procedures were more likely to be used if they were expected to improve bid outcomes. Those who adopted such procedures stressed several important characteristics of an effective sound bidder evaluation and selection.

First, criteria must be established for developing a bidders' list that would not only restrict the number of proposals to be reviewed, but also prescreen prospective bidders. Having such criteria appeared more important than the content of the criteria used. People interviewed at all sites visited gave examples of problems that resulted from unrestricted bidders' lists or improper additions to such lists. One example involved a supplier added inappropriately to a bidder's list. Although the firm was not selected for the procurement, it was shortly revealed that the firm's president had been arrested for drug smuggling.

Those interviewed also felt it was important that bidders demonstrate their expertise to undertake procurement tasks. This expertise could be demonstrated partly by prior experience. Staff at each site also stressed the value of indicating the level of commitment of staff and other corporate resources that prospective bidders were willing to devote to the buyer's project.

Another feature of bid evaluation and selection procedures found useful at several of the sites was pre-award meetings with potential contractors. Such meetings typically occur after initial selections have been made from all the bidders. The purpose of these meetings is to provide the owner with a way to judge technically acceptable bidders on the basis of formal presentations of corporate capabilities and commitment to the project and staff to be committed to the project. Because contracting for nuclear construction projects is usually initiated before much of the design work is complete, contractors cannot demonstrate how they would accomplish specific tasks. However, those who used pre-award meetings as part of a bid selection process felt that the meetings made a significant contribution to successful contracting.

A final recommended component of an effective bid evaluation and selection process is establishing post-award meetings with the chosen contractor. The purpose of these meetings is to work out the process to develop job-related procedures, to communicate site-specific work rules, and to develop the details of QA and QC plans. These meetings also provide a way for utility and contractor personnel to build a project team philosophy and approach since they will be interacting regularly. Those who had used this process found both pre- and post-award meetings to be very helpful in establishing positive contracting and project relationships. (Specific benefits of the project team approach are discussed further in Section C.4.2.)

Bid Evaluation and Selection Procedures for Vendors/Suppliers

As noted earlier, the procurement process in this chapter refers to acquiring supplies and materials as opposed to acquiring labor and expertise. All the sites visited use some degree of formalized vendor selection process. In many cases this process is necessary because of the many potential vendors, particularly for non-safety-related or non-Q-class items.

Each site had some type of evaluated supplier listing or supplier review process. The formality and complexity of the process depended in part on the size of the reviewing body. A larger and therefore more commercially active reviewing body normally resulted in a more elaborate supplier selection and evaluation process. At Site 3, for example, a large utility involved in several construction efforts and servicing several operating plants performed the procurement function; there was also a formal vendor selection and review process. The A-E firm visited reflected a similar situation. Because of its size, the firm has developed an extensive vendor evaluation process, combined with quality surveillance procedures (discussed further in Section 5.3.3). While the extent of the process varied, each site attempted to maintain information on vendors and suppliers to make informed commercial and technical decisions in purchasing materials, supplies, and equipment.

The process for preparing purchase orders with suppliers was the same at all sites studied. Technical specifications are usually developed by design and engineering, reviewed by quality assurance, reviewed for commercial aspects by procurement, and then sent out to a pre-established list of acceptable bidders. The same actors or functional groups are involved in the review of bids received. If a supplier takes exception to any of the bid specifications, those points must also be reviewed and resolved before a procurement can take place. Subsequent changes generated by either the vendor or the purchaser are also subjected to technical and administrative review procedures.

The purpose of procedures to review and make changes in procurements is to ensure that necessary changes are made and reviewed in a timely manner so that everyone is working with the most recent and accurate specifications. Site visits indicated that success of this process depended upon the extent to which commercial aspects of a procurement were allowed to affect technical aspects. For example, at Site 1 purchase orders were written in such a way that suppliers understood that they were to respond to the latest technical direction given, with the commercial paperwork to follow. This was to avoid complete renegotiation of a procurement every time a technical change occurred. Interviewees stressed how critical it was for suppliers to be confident that good faith performance, as requested, would be fully compensated. The dictum, "You never want your suppliers to be losing money," was noted time and again.

Depending on the grade of materials being procured, purchase orders generally prescribed the appropriate shop inspection and monitoring provisions, as required by specific codes or standards. Typically, such provisions consisted of notifying vendors that their premises were to be available for inspection by the purchaser or his agent. Sites differed in the extent to which these inspection or monitoring provisions were followed. This is discussed further in Section C.3.3. However, all sites tended to include the same quality-related specifications and provide for the same level of monitoring. They differed in the resources made available to perform shop inspections, audits, and/or other monitoring activities. Again, the larger the entity executing the purchase order, the more likely adequate resources will be available for vendor surveillance activities.

C.3.2 Terms and Conditions of Contractual and Procurement Documents

Contractual documents themselves are generally not as important as the expertise, experience, and attitude of the contracting parties. Nevertheless, such documents often represent the only formal statement of the intended relationships among project participants. The specific terms and conditions of contractual documents may reflect not only the contracting parties' preferred style of interaction, but also the contract writer's preferences and experiences. In the absence of other formalized statements, the contracts set the parameters for project relationships.

Three features of contractual documents were reviewed at the construction sites visited: the primary type of contract being used to undertake construction tasks; some of the contract's general terms and provisions guiding project relationships; and the use of incentive provisions to effect particular project relationships or to achieve specific project goals.

Types of Contracts Used at the Sites Visited

The preferred form of contracting for nuclear power plant construction appears to have gone through several cycles. Johnson et al. (1976) describe contracting changes occurring in the nuclear power industry to date, indicating that initially (early 1950s) power plant construction was executed by cost-type contracts. By the late 1950s to mid-1960s, fixed-price, turn-key projects became more typical. With more stringent licensing requirements imposed and construction costs rising, modified fixed-price contracts with escalation clauses came into prominence by the late 1960s (Johnson et al. 1976).

The projects visited all began construction in the early to mid-1970s. By this time, fixed-price contracting was used only under special circumstances, and cost-reimbursement contracts were the most frequently used type. This preference remains strong today. For example, construction at Site 1 began in the early 1970s, with most contractors working under fixed-price contracts. During the project, several construction deficiencies were discovered, construction was halted, and the type of contracting used was changed completely. Resulting modifications to the original contracts transformed them from fixed-price to cost-reimbursement (Johnson et al. 1976).

Changes in contract preference reflect as much a response to external conditions as to any changes in relationships among utility owners, constructors, or design and engineering firms. Thus, fixed-price contracts are most appropriate under the following conditions: scope and specifications are known in advance; few changes are expected; and/or costs are not expected to fluctuate widely or increase substantially (Business Roundtable 1982). Cost-reimbursement contracts, on the other hand, are more appropriate in the following situations: full project scope is uncertain; changes and modifications are expected during the project; and little exists on which to base a firm fixed-price bid (Cibinic and Nash 1981; Business Roundtable 1982).

Since the mid-70s, cost-reimbursement has clearly been predominant in nuclear power plant construction. The use of the cost-reimbursement contract, then, reflects the industry's response to the situation in which power plant construction begins before the design is complete, inflation results in the expectation of widely fluctuating costs of materials and labor, and regulatory and economic uncertainties make architect-engineers and contractors reluctant to "lock in" fixed-price contracts.

Different forms of contracts also provide different levels of owner involvement with the contractor. The form of contract selected reflects the need of the parties, particularly the owner, to monitor contractor performance (Cibinic and Nash 1981). A fixed-price contract does not typically permit the owner extensive surveillance and monitoring of contractor records and activities. The owner has no basis for monitoring because performance is up to the contractor, within the parameters of the contract. In cost-reimbursement contracts, however, the owner must be involved in monitoring both the schedule and expenditures because the contractor's payment is based on demonstrated expenses of the work performed.

If quality of construction is the owner's primary goal, requiring owner acceptance of all work is one useful approach. Where the owner requires construction according to exact specifications, a contractual arrangement that permits the owner to closely monitor the costs and quality of the construction, i.e., the cost-reimbursement type contract, may be most appropriate (Cavanagh 1974).

The main difference between fixed-price and cost-reimbursement contracting for assurance of quality is not the method used to compensate the contractor, but the risks that each party assumes because of the method of compensation. In the fixed-price contract, the contractor assumes virtually all of the risk. He has made a firm bid and runs the risk of failing to perform as expected within a given budget. In a cost-reimbursement contract, on the other hand, the owner assumes the risk that the cost may exceed the estimate. Either way, the contractor will expect to be reimbursed for any changes the owner chooses to make. But with a fixed-price, lump-sum contract, additional compensation must be negotiated with the owner, or failing this, the contractor must seek legal redress. With cost-reimbursement contracts, the mechanism for providing additional compensation is built in. Responsibilities for risk associated with timing, costs, and quality of performance, therefore, shift back to the owner.

Many persons interviewed at the sites felt that utilities should assume the risks associated with nuclear power plant construction because, as owners, they clearly have the responsibility for the safety and quality of their plants. Therefore, the use of cost-reimbursement contracts seemed consistent with the owner's duties and obligations. The interviewees also preferred the cost-reimbursement contract because of the number of design changes typically involved in a nuclear project. Many of these changes were the result of the evolutionary nature of most projects, with design substantially incomplete at project initiation. Other changes were often the result of new regulatory requirements or guidelines. Because of the many changes, it was felt that these were risks that the owner, as licensee, should assume, rather than passing them on to contractors. Thus, it was viewed as unrealistic to expect contractors to anticipate the risks of unspecified changes by making firm price bids. Instead, the course recommended by interviewees was for licensees to recognize the likelihood of many regulatory and design changes and to plan to reimburse contractors for incorporating those changes as they were executed. It was agreed that this position not only serves time and budget needs but quality objectives as well.

Convertible contracts have been suggested as a way to combine the advantages of both fixed-price and cost-reimbursement contracts (Business Roundtable 1982). This type of contract can be changed once a specified level of project completion is reached. For example, in a nuclear project, such a contract might begin as a cost-reimbursement type when scope and design are still not completely defined. As the project continues and the design and scope of each contractor's area of performance is more clearly defined, cost-reimbursement contracts might be converted to fixed-price, target-price, or unit-price contracts to complete the job. Therefore, the owner would assume the risks initially, but over time, as circumstances change, risks would shift to the contractors in a well-defined and predetermined manner.

Convertible contracts permit some of the advantages of both major methods of contracting. In addition, responsibilities and risks are assumed more evenly by both parties. Ultimately, however, from NRC's point of view, the responsibility for construction and construction quality lies with the licensee. Most licensees have found themselves recently in a situation of considerable uncertainty in nuclear construction projects, emanating not only from the NRC but from the financial markets as well. In this environment, the cost-reimbursement form of contract has proven to be the most flexible.

In general, while a cost-reimbursement contract may be written in several ways, the preferred style at the sites visited was cost-reimbursement with a fixed-fee. This type of cost-reimbursement contract represents an attempt to control costs because the contractor's fee, or profit, is not tied to the size of the underlying contract, but is fixed. With this contract the contractor does not have the incentive to enlarge his contract scope or to engage in extensive rework to increase the amount of the contract and thereby increase his profit. Even where a fixed percentage fee has been negotiated, such fees are not typically large. To some extent, then, the contractor's guaranteed fee or profit is reduced to reflect the owner's assumption of most of the risks associated with project completion. Because of the duration of most nuclear projects, some argue that large fees might be preferable, to avoid loss of contractor interest or commitment over time. At Site 3, this situation has been addressed through periodic renegotiation of contractor fees to reflect current project and external conditions.

Not all contracting at the sites studied is the cost-reimbursement type. Fixed-price contracts continue for specific jobs associated with nuclear power plants. Generally, for these jobs, the scope was known early enough for detailed specifications to be written so that a realistic and firm price bid could be solicited. Such jobs also reflect a situation where it is reasonable for the contractor to assume the risks associated with executing the contract. Fixed-price contracts are frequently used for elements of heating, ventilating, and air conditioning work; and at one project, the cooling tower contracts were fixed price as well.

The General Provisions of Contracts

Several provisions of the cost-reimbursement contracts negotiated at the sites studied relate to quality assurance. Each of the sites visited dealt with some of these provisions in similar ways, although the exact language used differed. For example, each site visited had provisions on the assignment of contractor's key personnel to the project. This type of provision reflects the owner's interest in the assignment of individuals from the contractor's staff (particularly for key management and supervisory positions). The reason for inserting a key personnel clause appeared to be related to unpleasant experiences in prior nuclear projects or construction efforts where contractor personnel had proven difficult to work with or had demonstrated a level of commitment inconsistent with the owner's. In a nuclear construction project, trying to work with problematic contractor personnel was not considered satisfactory. Each project visited therefore included provisions in their contract reserving the right to approve and pass judgment on contractor personnel involved in their projects. At Site 1, the owner not only reserves the right to approve such personnel but also requires the personnel to participate in a series of team-building workshops to build project commitment.

Contractor liability for error, accident, or negligence by their personnel is another provision affecting quality assurance. In general, such liability was limited and was restricted to gross negligence or deliberate actions, not to typical errors or accidents since errors invariably occur. The utility at Site 2, for example, views the contractor's personnel as an extension of its own staff and expects the same level of errors among contractor personnel as among its own staff.

Support for this position is found in a recent court case in Virginia. In the case, a utility tried to avoid corporate liability by shifting responsibility to its employees and their "human error." The court rejected that argument, stating that "human error" was to be expected (Virginia Electric v. Division of Consumer Counsel 1980). Many interviewed at the sites argue further that if contractors are liable for simple errors, there might be a tendency to cover up problems, which could have serious quality-related implications. Therefore, most owners choose to control primarily for gross or deliberate negligence of contractor personnel and to accept simple error or accidental behavior as a normal part of the project.

Other contract provisions relating to quality assurance concerned the scope of contractor costs deemed reimbursable under a cost-reimbursement contract, for example, costs related to training. Site 3 placed particular emphasis on on-site training of craft and supervisory personnel and invested much time and energy in training programs directly related to the project work. At this site all contractor training costs were reimbursable. The utility felt that incurring those costs, up front, increased the likelihood that the work would be done properly. Thus, reimbursement for training costs was argued to yield substantial savings because costly rework would be avoided. In general, the scope of costs the owner is willing to reimburse reflects the importance that owner places on various aspects of the project. By reimbursing training costs, the owner is stressing that the quality of work is more important than cost or the schedule.

Incentive Provisions in Contracts

Site 1, when renegotiating contracts, developed some fairly detailed and profitable incentive provisions concerning productivity and completing certain key milestones on schedule. Of the sites visited, this was the only one, however, in which incentive provisions were extensively used.

Site 2 used negative incentives for contractor performance. The first x-millions of dollars of rework became the contractor's responsibility, after which the owner would begin to assume liability. Thus, there was a limited penalty for mistakes or rework, but only up to a certain amount. These incentives operated somewhat like a deductible in a standard insurance policy. Rework penalties constitute a financial check on unlimited contractor rework and shift some risks back to the contractor. For that reason, they are often suggested as important cost control leverage in cost-reimbursement contracts, where the contractor may not otherwise have incentive to perform efficiently.

An alternative to rework penalties is the use of positive incentives, i.e., rewarding the contractor for avoiding rework. Such provisions might be based on rework avoided over time or on performance of specific tasks. The efficiency of such provisions, however, depends on how well QA and QC programs detect unsatisfactory performance.

To meet an incentive's objective, a contractor must be able to control performance in that area of activity. This may require careful management of other contractors and their relationships with the incentive work. If the contractor cannot control the performance of others, the construction manager must adjust the incentive program. In a construction project with many contractors and a great deal of interdependence, incentive contracts may not be practical.

Another problem with incentive contracting is establishing equitable goals. Often cost-related targets are set because they seem easy to agree to, but negotiating cost-related incentives may send an inappropriate message that could negatively affect performance or other kinds of objectives. Thus, incentive contracting, despite its potential for cost efficiency, may actually result in increased costs because of the additional project management and project administration required to monitor contractor performance.

The performance incentive, a type used at Site 1, may have some value as the power plant nears completion. Such incentives encourage a contractor to surpass particular performance targets by providing a reward for exceeding them. Often such targets relate to overall contractor performance or completion of a particular installation or set of tasks. These incentives can aid in the timely completion of a construction project. This is particularly important if the cost of money is significant and is expected to increase over time and therefore could result in considerable savings.

Incentives typically are not developed for objectives that are essential or required under the general contract provisions. Therefore, quality-linked incentives in nuclear construction are inappropriate because quality is non-negotiable. Construction is required to be completed according to quality requirements and the design's technical specifications. Other aspects of contractor performance are more appropriate for incentive contracting than quality objectives. Quality-related incentives might be considered if an owner wants a level of performance exceeding the minimum contract standards.

C.3.3 Quality Assurance Provisions in Contracts and Procurement Documents

At the studied sites, several approaches were used to incorporate quality assurance provisions in contracting and procurement documents. The approaches varied mainly in the level of detail that quality requirements were stated in the documents or in materials attached to those documents. In one case, the contract's quality assurance provision stated that all work related to the project was to be accomplished in accordance with applicable NRC and utility QA/QC standards. In another case, actual quality assurance manuals and quality control procedures were incorporated directly as appendices to a contracting document.

At sites where only general statements of quality assurance were contained in contract documents, specific job-related quality requirements and procedures were developed as work progressed. In this way, such requirements developed in the context of the project itself before a set of tasks was begun. This also permitted QA and QC procedures to be tied to the particular technical specifications guiding those tasks.

The logic behind handling quality requirements as work progressed is that incorporating detail into contract documents is too rigid. In detailed contract documents, a QA or QC change would accompany every specification change and requires a contract modification. To avoid these problems, at some sites a contract document containing a statement of basic quality requirements was developed, incorporating by reference whatever document or set of documents (e.g., 10 CFR 50, Appendix B, ANSI standards, or ASME codes) are appropriate for a contractor to consider. The contract therefore gives a general framework of quality expectations, with specific guidance on quality requirements coming from job-related experience that would develop with the project.

The alternative point of view is that quality requirements should be made very clear and explicit in contract documents. This argument led to a basic contract document that refers to appendix materials, including intended quality procedures and quality assurance manuals. In negotiating such contracts, the appendix materials, as well as the body of the contract, have to be negotiated and agreed upon by the parties.

In general, documents for procuring equipment and supplies incorporated the appropriate standard or code provisions, stipulating that, if appropriate, a supplier would be expected to have his premises open for inspection at the discretion of the owner. The specific quality requirements are typically contained in the technical specifications rather than in the general provisions of the procurement documents.

Those interviewed generally felt that the written detail of the quality requirements or their method and level of communication to a contractor or supplier is not as significant as the extent of QA/QC follow-through. The strong feeling was that it was possible to produce documents that reflect detailed quality control and quality assurance programs that might not ever be implemented. Real assurance of quality, it was argued, comes first from effective people performing the work and then from actual checks being made, materials actually being inspected and audits occurring at a supplier's facility or on a job site. The fact, as well as the expectation, were the most important aspects of a QA program.

The capacity to provide such effective QA/QC programs varies greatly, depending on the parties' resources. An owner may require very specific quality standards of his contractors but not have the capacity to review contractor performance. At the sites visited, most generally understood the requirements needed; for example, nearly every person could recite 10 CFR 50 Appendix B requirements. However, the sites had varying amounts of resources to ensure that such requirements were being met. If an owner doesn't have the resources to follow through on QA/QC requirements, some other mechanism is needed to assure that the follow-through occurs. For example, a project structure and organization that can assure that a QA/QC program actually "lives" may be required. Issues such as project structure and organizational arrangements are discussed in Section C.4.

C.3.4 Contractual Issues--A Summary

Three aspects of the assurance of quality in the contracting and procurement process were of particular interest during the site visits: 1) the procedures used to evaluate and select contractors and vendors; 2) the terms and conditions (including incentives, if any) of contracting and procurement documents; and 3) the nature and scope of the quality-related requirements incorporated in contracts and procurement documents.

An effective bid evaluation and selection process is fundamental to successful contracting. Those interviewed stressed the importance of developing a bidders' list based on established technical criteria. The exact criteria were regarded as less important than their implementation. It was felt that bidders should be required to demonstrate their expertise, both by prior experience and by a representation of the bidders' staff and other resources to be devoted to the work. Several of the sites found pre-award meetings with the finalists useful in assuring that the successful bidder would devote the required effort. Post-award meetings were also felt to be very helpful for establishing contracting and project relationships.

A formalized vendor selection process was also thought helpful for procuring equipment and supplies. A large owner/utility or project manager is generally better able to conduct a thorough and formal selection process than a small utility or "one-time" plant builder. This process can be successful whether it is performed by a large utility or by a large or experienced A-E. Interviewees recommended that purchase orders be written to allow suppliers to make rapid technical changes before the commercial paperwork is completed.

The cost-reimbursement type of construction contract was favored by interviewees over the fixed-price, lump-sum contract, because of the large number of changes in work during construction of nuclear generating facilities. Cost-reimbursement contracts typically include a fixed fee, set either as a lump sum or as a percentage of base costs. Some suggested that the advantages of both fixed-price and cost-reimbursement contracting can be realized by "convertible" contracts, which change compensation from cost reimbursement to a fixed price after the design is completed or at some other logical point. Where cost-reimbursement with fixed-fee contracts are used, provisions for renegotiating the "fixed fee" have been useful to avoid loss of contractor interest or commitment and to accommodate changed circumstances on the part of the owner or contractor.

In general, reimbursing contractor expenses like those associated with training indicates that how the work is performed is most important, not its cost. Also, interviewees suggested that limiting the contractor's liability to the owner for errors of key contractor personnel removes much of the incentive that contractor staff may have to cover up discovered error, avoiding even more costly rework and contributing to achieving quality objectives.

Positive incentives for exceeding performance expectations can be useful nd may be most effective when the project is nearly completed and many uncer-ainties have been removed. However, incentive provisions are generally inappropriate when developed around essential or required objectives (such as quality requirements).

The detail of QA provisions in contract and procurement documents has varied from site to site. Generally, however, detail was not as important as the implementation of QA/QC requirements by actual inspections, checks, and tests, which require an adequate commitment of resources.

C.4 ORGANIZATIONAL ISSUES

One aspect of a major construction project that will influence the nature, course, and outcome of that effort is its organizational framework. Therefore, the relationships between the assurance of quality and four organizational issues associated with contracting and procurement were examined: 1) the structure of construction projects; 2) the owner's role in the construction effort; 3) the owner's or utility's prior nuclear experience; and 4) arrangements for labor and labor relations. Each of these is discussed separately below.

C.4.1 Structure of Nuclear Power Plant Construction Efforts

Nuclear construction projects involve four major roles or functions: engineering, procurement, construction, and management. These roles may be performed singly or in combination and by individual or multiple firms. The U.S. nuclear industry demonstrates a wide array of project arrangements, suggesting that no one arrangement will insure success. However, some standard practices appear to reflect the industry's collective experience.

The engineering role is generally filled by a single A-E firm. However, the A-E may contract out parts of the engineering to other firms and maintain overall responsibility. Also, the A-E may or may not be responsible for on-site inspection of work during construction. If the utility has engineering expertise, it may use that expertise to support the outside A-E or may use it to design non-safety-related buildings and facilities. At each project visited, external A-Es had been hired for the design and engineering functions. One project, Site 3, used "in-house" engineering capabilities for non-power block, non-safety-related work.

The engineering role is frequently combined with other project functions. For example, at Site 2, the A-E was also performing project procurement functions and serving as construction manager and prime contractor for most of the construction work (assisted by subcontractors). The A-E firm visited by the project team, Site 4, had served in every conceivable role in nuclear construction projects, sometimes playing a single role and at other times undertaking responsibility for all project functions.

The only project function A-E personnel felt should be closely tied with engineering was procurement. Here, there was a strong feeling that the A-E should either undertake procurement as well or at least have direct input into the procurement process. The reason given for this important linkage was that the A-E knows to what extent the safety margin built into a design might be eroded by suppliers. If the design cannot compensate for deviations in materials, the A-E can advise the procurement functionary of an unacceptable shipment and/or an unsuitable supplier.

As noted above, the A-E at Site 2 was also serving in the project procurement role. This was not true at the other sites, although the A-E had input into procurement in each case. At Site 1, for example, each contractor provided his own materials and supplies, with major equipment purchases handled by the utility with A-E consultation. At Site 3, all procurement was handled by the utility itself, with the A-E providing the specifications and handling the bid evaluation and selection process for many items.

The utility at Site 3 had strong feelings about the procurement role. In the words of one top manager of the nuclear construction effort: "[Suppliers] are notorious for not delivering on schedule. This can bring a construction project to its knees. That's why we knew we wanted to control procurement ourselves." This view is supported by a 1981 study of construction productivity where the unavailability of needed materials, tools, and supplies was found consistently to be the most frequent source of delay on the construction projects studied (Borcherding and Garner 1981).

The number of firms performing the wide range of construction tasks involved in a nuclear project varies greatly. Sites 1 and 3 reflect some of the complexity that may characterize the constructor role. At both these sites, about 30 contractors have been on the project site at the same time, performing a variety of construction functions. At Site 2, on the other hand, a single prime contractor serves as constructor, assisted by its subcontractors and a few limited scope contractors.

Having many contractors on-site not only increases the number of participants in the construction effort but also increases the need for close coordination of contractor efforts. The coordination function is the responsibility of the construction manager, who must assure that the construction effort progresses within time and budget constraints. Where a prime construction contractor has been hired, the construction management role may also be assumed by this firm since most of the project personnel already report to him as subcontractors. Construction management may also be combined with the engineering function although some argue that in this arrangement no one oversees the A-E's work.

At Sites 1 and 3, the utility is serving actively as construction and project manager and employs approximately 900 on-site staff to carry out the function. The largest and most experienced utility visited (at Site 3) views the construction management function as one that the owner must play. As one of the utility's key managers noted: "If you intend to build one of these plants, you have to develop as well the expertise to build, license, and manage it." In this view, a utility that can not manage the construction effort probably would not be able to run the completed plant.

An entirely different approach exists at Site 2 where an experienced A-E serves as construction manager and is overseen by the utility. There, an inexperienced utility, rather than incurring the substantial staff investment for carrying out the construction management role, decided to take advantage of the experience and expertise of its A-E and prime contractor.

Whether performed by the utility itself, an independent construction management firm, or another project participant, the best interests of a construction effort in terms of quality, safety, schedule, and cost are served when the project has clear objectives and the resources to achieve them. The project manager should exert his authority within the project itself, in his absolute power to stop work, to order rework, and to mediate disputes. Personnel at all sites visited expressed frustration at the often lackluster performance of vendors and contractors alike unless continued surveillance was maintained. Those most successful in exacting contractor and vendor performance were the largest and most experienced firms. As one key manager at Site 3 noted: "This is all about tomorrow. They [suppliers and contractors] have to satisfy us because we're part of their future."

Where the utility assumes the project management functions, it must commit sufficient staff and resources to effectively direct, coordinate, and support the contractors' work. In addition, because the construction manager must assume a strong role, a weak owner (in terms of staff, economic backing, expertise, or experience) may not be in a position to be an effective construction manager. If the construction manager is not strong, the contractors may not be motivated enough to perform fully on the project, regardless of their contractual obligations. The advantages and disadvantages of the various roles of the owner are discussed in the next subsection.

C.4.2 Owner's Role in the Construction Effort

The extent of utility involvement in each of the job functions just discussed varies markedly. For example, the utility may handle all procurement for the construction project, as did Site 3, or procurement might be managed by the prime contractor with utility concurrence (Site 2). Similarly, the utility may assume little or no responsibility for construction management (Site 1, initially), or the utility may take a very forceful and active role in managing the construction project and its contractors (and subcontractors), as Site 1 does now.

The nature and level of utility involvement in construction projects typically falls into one of five categories that can be thought of as a continuum (Theodore Barry and Associates 1979). First, the "project management" arrangement is one in which the utility hires a project manager to select and coordinate project contractors and activities. In this case, the utility delegates not only the project management function but much of the responsibility for the project to its independent project management firm. This arrangement has been used rarely in nuclear power plant construction.

A second level of owner involvement is the "design-build" arrangement, in which the utility has a minimum of involvement in the project and contracts with one firm to design and build the power plant. This firm ordinarily handles the design, construction, and procurement work for project scheduling or auditing. Site 2 conforms most closely to this model.

A third category of owner involvement is the "general contractor" arrangement in which the utility enters into separate contracts for project engineering and construction. This arrangement gives the utility greater control over the project and requires greater staff involvement and commitment by the utility than either of the first two arrangements.

A fourth type of owner relationship is the "prime specialty contractor" arrangement, characterized by a utility that serves as its own construction manager and general contractor, hiring all its prime contractors for each of the major divisions of work. Sites 1 and 3 are variations of this organizational arrangement.

Finally, in the fifth category, the "in-house construction" arrangement, the utility handles virtually all aspects of the project. In this case, utility staff actually construct, if not design, the project. This arrangement requires the development of a tremendous level of expertise within the utility and a large utility staff.

As this discussion suggests, the level or degree of complexity involved in construction project organization can vary dramatically. For example, a utility that hires one large engineering and construction firm to design and build a nuclear plant ("design-build" arrangement) can be expected to evolve fairly simple contractual and organizational relationships with its contractor, and between the contractor and the subcontractors, vendors, and suppliers with which it works. On the other hand, a project for which the utility contracts directly with each contractor and subcontractor (a "prime speciality contractor" arrangement such as Site 1) is likely to involve a much more complicated project structure.

Regardless of what role(s) the utility assumes, an extremely effective strategy for coordinating the construction effort and for assuring a successful construction project involves establishing a project team. A utility may attempt to interact with its construction project through its traditional departments and sections. However, a strong project team appears to facilitate project relationships and to enhance performance.

The project team concept draws all participants in the construction project (utility, engineers, constructors, etc.) into a single unit focused on the project itself, regardless of each actor's organizational or disciplinary background. Furthermore, the project team approach can support matrix management, which allows team members to benefit from technical supervision and support without diffusing responsibility or authority, which has caused some matrix management arrangements to fail.

All of the sites visited had adopted a project team orientation, and utility staff were able to cite examples of how the team approach facilitated relationships among contractors, the utility, and construction managers. For example, at Site 3, the assignment of procurement staff to the nuclear project appeared to streamline the cost and administrative procedures involved in purchasing. The procurement staff were able to obtain guidance from corporate procurement and simultaneously work closely with the construction project group to assure that the project's procurement needs were being satisfied. The project team can create and maintain cooperation and clear lines of authority, two ingredients that the Electrical Power Research Institute found in a recent study to be important in assuring a successful construction project (Bauman, Morris and Rice 1983).

C.4.3 Prior Nuclear Experience

The value of experience in the construction of nuclear power plants was frequently mentioned as important by individuals interviewed at all four sites visited. Obviously, experience increases the ability to perform effectively in most any activity.

Individuals at Site 4 suggested that experience of all project participants is particularly important because nuclear power plant construction is unique in several respects. First, it is extremely complex. Construction typically begins well before design work is completed. Also, design specifications change throughout the course of construction--not only in response to the construction work itself, site characteristics, and contractor input, but also because of changing regulatory requirements. A second reason nuclear construction differs from other construction efforts is that the individuals and firms involved in nuclear power plant design, construction, and operation comprise a rather small community characterized by fairly effective channels of communication. Experience in nuclear construction establishes the utility, architect-engineer, construction firm, or other contractors in the nuclear community; facilitates the sharing of expertise and experience; and encourages working effectively with that community and marketplace.

A third aspect that makes nuclear power plant construction unique is the stringency of standards. While other types of construction projects are built to exacting standards, the stringency of their standards may vary from discipline to discipline. In other construction, material substitutions may be liberally permitted and documentation of work may be performed infrequently. None of this is typical of a nuclear plant construction effort, and experience with nuclear projects makes it possible to anticipate and deal with the potential inexperience of other project participants. Utility staff at Site 3, for example, suggested that their prior nuclear experience made it possible for them to effectively use contractors with strong disciplinary capabilities who lacked specific nuclear experience.

Depending on the role the utility assumes in project management, particularly in procurement, the utility's nuclear experience becomes crucial. Some argue that a utility considering construction of its first nuclear plant should rethink its decision (Bauman, Morris and Rice 1983). However, experience indicates that a utility can have a successful first nuclear construction project by hiring experienced, effective staff to serve on a project team and experienced contractors to act on its behalf. For example, combining the project team concept, several strategic hiring decisions (extremely capable and highly experienced individuals), and an experienced A-E/prime contractor has led to a successful first nuclear construction project at Site 2. Although the utility had no prior nuclear experience, project costs and schedules, as well as construction quality, benefited from the experience (and expertise) of the utility's project team and its prime contractor.

C.4.4 Labor Arrangements

The final organizational issue examined at the sites visited involved labor arrangements and relationships at nuclear construction projects. Because the project team visited only union-staffed projects, the team cannot comment on the impact or influence of union vs. non-union vs. open shop arrangements. However, an important insight concerning labor arrangements was gained from the three projects visited: a carefully structured agreement with union organizations is very helpful in controlling project costs and schedules.

An example of this structured agreement is found at Site 2, where a no-strike, no-lock-out agreement was negotiated with unions. Under this agreement, work is disrupted minimally if a dispute occurs, and there is no risk of other union groups slowing or halting work when a dispute arises with one particular union. Accordingly, project costs and schedules have been virtually unaffected by work stoppages or slowdowns. In seven years of construction, only nine days have been lost to labor disputes.

Size and duration of most nuclear construction projects create an advantage in negotiating these structured agreements. Craft unions and locals have a strong incentive to enter into long-term agreements and to abide by project-specific work rules and procedures when they can guarantee large numbers of their members steady work for many years to come.

The complexity of nuclear construction projects may also be an advantage in negotiating labor agreements. At Site 3, for example, the utility has established extensive training programs for craft workers and supervisory personnel, enabling union members to acquire new skills. While obviously benefiting the quality of the work done on the project, such programs also enhance the skills and hence future marketability of union members at the utility's expense.

Finally, these labor agreements give the construction projects stability. Labor-management negotiations occur before the project begins and therefore tend to stay outside the construction site itself. All project contractors are bound by the agreement, assuring equity among classes of workers and similar work environments and rules for all. These factors can minimize disputes and prevent the harmful effects of work stoppages and slowdowns.

C.4.5 Organizational Issues--A Summary

From the four organizational issues examined by the project team, several insights are relevant to the assurance of quality in nuclear power plant construction. First, while the major roles in a nuclear construction project can be executed through various organizational arrangements, all roles must be played by strong and effective occupants.

Second, all objectives of a nuclear construction project appear to be enhanced by the owner's establishing a project team. Normal organizational departments and channels are not as effective as a project team, with established authority and lines of communication to the construction personnel.

Third, because of differences between nuclear construction and other types of construction, experience is crucial in building a nuclear power plant. If the utility/owner lacks experience, others should be hired to act on its behalf. Experience helps in selecting competent project participants and in anticipating and dealing effectively with emergent problems. Both these functions make important contributions to project success.

Finally, a nuclear construction projects' size, duration, and complexity allow adoption of long-term, labor agreements. Such agreements can benefit not only cost and schedule but the quality of work performed.

C.5 INSTITUTIONAL ISSUES

Nuclear power plant construction projects are defined by the contractual obligations established as well as by the organizational arrangements that govern their interactions. At the same time, a larger institutional environment exists in which these projects and their owners are regulated, financed, and find competition. A full examination of the impact of the institutional environment surrounding nuclear power plant construction projects was well beyond the scope of this study. However, at each project visited, two institutional issues were examined: 1) state pubic utility commission (PUC) policies toward nuclear power plant construction efforts; and 2) various types of ownership arrangements for nuclear power plant construction projects. The reasons for examining both of these issues and the insights gained from the site interviews, secondary sources, and other project activities are described below.

C.5.1 State PUC Policies Toward Nuclear Construction Efforts

States have almost exclusive responsibility for determining the rates that utilities may charge for the costs of constructing new generating facilities.[a] The state PUCs are responsible for determining when (and whether) costs of new plants are to be passed on to consumers by including such costs in the utility's rate base. If a utility is to regain its investment in a nuclear construction project, then it must be aware of its PUC's policies on construction programs. Similarly, a PUC's policies potentially have significant impact upon the initiation, progress, and completion of a nuclear construction effort.

Rate Base Approaches to Costs of New Plant Construction

Over the years, the PUCs of the various states have developed generally uniform rules concerning when costs, incurred by utilities for constructing new generating facilities, can be passed on to customers as part of the rates charged for power usage. Recently, utilities and PUCs have responded to the economic pressures of nuclear power plant construction by advocating or adopting changes in these rules.

Historically, a plant is not included in a utility's rate base until it is placed in service, i.e., until it becomes "used and usable." Typically, a utility's rate base includes the original or historic cost of bringing the plant into service. Many jurisdictions have allowed some small amount of this cost to be offset by "contributions in the aid of construction." These contributions are non-refundable amounts that utilities have charged customers for installing abnormally costly or extensive facilities, before such plant is placed in service (Howe and Rasmussen 1982). The major offset to the cost of a plant in service in the rate base is accumulated appreciation on the plant.[b]

Construction Work in Progress. Presently, much controversy exists on whether construction work in progress should be included in the rate base. Construction work in progress (CWIP) is the investment in the plant under construction. A recent nationwide survey of privately owned utility companies concluded that, historically, approximately three-fourths of the commissions allowed all or part of CWIP in the rate base, and that currently 27 commissions, approximately half, allow all or some portion of CWIP in the rate base (Edison Electric Institute 1983).[c]

(a) An exception is sales of electricity between utilities (wholesale sales), which are regulated by the Federal Energy Regulatory Commission under the Federal Power Act (FPA) of 1935, 16 U.S.C. §§ 791a et seq. These wholesale sales account for approximately 10% of the "firm" power sales of electricity in the U.S. (U.S. House of Representatives 1983).

(b) There are other offsets to the cost of a new plant, including refundable customer advances for construction, certain deferred income taxes resulting from accelerated depreciation, and pre-1971 income tax credit and customer deposit (Howe and Rasmussen 1982).

(c) The survey covers companies operating in all states except Nebraska, which does not have any investor-owned electric utilities, and the District of Columbia.

The debate regarding CWIP has focused upon several issues: the unpredictability of nuclear plant construction costs; fairness to rate payers; and financial hardship to utilities undertaking large and costly new plant construction (Edison Electric Institute 1983; U.S. House of Representatives 1983). Thus, the Edison Electric Institute (1983), an association of electric companies, concludes that including CWIP in the rate base represents "sound regulatory policy that has been shown to benefit both rate payers and utilities" (p. 1). The House Committee on Energy and Commerce (H.R. 555), on the other hand, has concluded that CWIP is not favorable to consumers and has moved to prohibit the Federal Energy Regulatory Commission (FERC) from allowing CWIP to be included in the rate base of regulated utilities (U.S. House of Representatives 1983). State legislatures, expressing similar sentiments, have also moved to prohibit inclusion of CWIP in the rate base (Edison Electric Institute 1983).

Although nuclear construction projects have figured prominently in the CWIP debate, the focus has been on the total costs of such projects. Little attention has been given to identifying and disaggregating unnecessary or unwarranted costs stemming, for example, from quality assurance breakdowns. Instead, advocates to the debate regard either all costs or no costs as unreasonable.

Construction Cost "Phase In". A similar concept to that of including CWIP in the rate base is that of phasing construction costs into the rate base before a new plant is placed into service. Such "phase-in" plans include paybacks to consumers in the form of lower rate increases after the plant is constructed and in service. Connecticut has revised its law on rate-base treatment of electric plants under construction to allow "phase in" of costs associated with two nuclear generating facilities, Millstone 3 and Seabrook 1, before they are completed.[a] This legislation requires the utilities requesting "phase in" to show that serious financial difficulties are being encountered by the utility or are likely to be encountered unless "phase in" is allowed (State of Connecticut 1983).

Like CWIP, the "phase-in" approach allows the utility to collect funds from rate payers for the new facility before it is placed in service. However, the Connecticut "phase-in" legislation, for example, requires that the funds are to be paid back within the same amount of time after the facility was completed as was allowed for collecting such funds from rate payers before the facility was "used and useful for public service" (State of Connecticut 1983). CWIP differs in that payments made by customers are returned to them over the full useful life of the facility. The 1983 application of Connecticut

(a) The New York Public Service Commission is reviewing a similar "rate moderation" plan for the Shoreham nuclear plant (telephone interview with Jack Treilsen, New York Public Service Commission Rate Section, November 8, 1983). In a separate proceeding, the New York Public Service Commission is also reviewing the prudence of utility management decision-making regarding Shoreham.

Light and Power Company to Connecticut's Department of Public Utility Control suggests that consumers be refunded through lower rates within less than three years after Millstone 3 is placed in service (Furland 1983).

As with CWIP, reimbursing a utility for quality-related construction cost overruns has not been the focus of debate in the "phase-in" approach. Instead, the focus has been on the financial condition of individual utilities as it has been affected by nuclear construction projects. Proponents view "phase in" as a reasonable and necessary financial assist to a utility; opponents see such plans as unreasonable. Investigating individual cost items or types of costs has had no place in such a discussion, to date.

Influence of PUC Policies on Sites Visited

Because of the potential impact of a PUC's policies on financing a nuclear project and its effect on the financial integrity of the utility itself, this aspect of the project's environment was examined. At each site visited, utility staff were asked what impact, if any, state PUC policies had on 1) the initial decision to build the plant; 2) subsequent decisions on project organization and progress; and 3) the contracting process generally and, in particular, the requirements placed upon contractors and vendors.

At Sites 1 and 3, a single PUC had rate setting jurisdiction. At Site 2, four state PUCs had rate setting authority. However, none of the interviewees figured PUC policies prominently in their decisionmaking for the nuclear project. Instead, in their initial decisions to build the plants, all sites indicated that the major factor involved assessing projected load requirements and existing capacity.

State PUCs were not reported as significant when major decisions were made during the course of the projects, despite the fact that two of the sites had themselves halted project construction for significant periods. At Site 1, the institutional factor that most influenced the self-imposed work stoppage was the NRC. At Site 3, on the other hand, the project was stopped early to secure adequate financing. Also, none of the sites reported being influenced by PUC policies in their contracting practices and requirements. Rather, the utilities' own contracting styles and preferences as well as various NRC and code requirements appeared to have the greater impact on these project decisions.

Although a PUC's policies have a potential impact, the sites visited appeared to have been little affected by state regulators. This situation may be a function of the particular PUCs and utilities visited, or it may typify the relationship between nuclear construction projects and their PUCs, generally. To examine this, several PUCs were contacted to determine their policies toward the construction phase of nuclear power plants.

PUCs' Historic Position Toward Nuclear Power Plant Construction

Telephone contact was made with 24 PUCs involving states in which currently operating nuclear power plants are located. Each PUC contacted was asked if any of the initial construction costs of operating nuclear plants had been excluded from the rate base and, if so, which costs and why. The study team hoped the survey would reveal the extent that quality-related breakdowns were considered in PUC cost disallowance decisions.

Of the 24 PUCs contacted, only 6 instances were reported where any initial construction costs had been disallowed. This was out of a possible 52 operating nuclear projects reviewed for rate-base treatment. In cases where costs had been disallowed, they were generally small amounts ($1-2 million) when compared with the total cost of most nuclear plants. In addition, construction cost disallowances typically involved special circumstances, e.g., warranty litigation between the utility and major contractor, or the propriety of ratepayer reimbursement for a plant visitors' center. Specific conclusions about breakdowns in project quality assurance, management, or oversight did not appear to be considered in any of the PUCs' decisions to disallow construction costs.

PUC treatment of construction costs appears to differ from their position on CWIP and on operating and maintenance expenses. In these latter areas, several of the same PUCs that had never disallowed construction costs had taken action on CWIP and/or disallowed replacement fuel costs or maintenance expenses. PUC disallowance of operating or maintenance costs appears to be based primarily on its conclusion that utility management had been "imprudent," "improvident," or "unwise." Several of the PUCs indicated that they have not disallowed construction costs because they are not convinced that current methodologies can accurately determine whether costs should be disallowed. This is less true in the operational phase of nuclear plants where PUCs report feeling on firmer ground in reviewing the propriety and prudence of costs incurred.

Recent Developments in PUC Scrutiny of Nuclear Power Plant Construction Projects

The traditional rate-base treatment of nuclear construction costs by PUCs appears to account for their reported significance by the projects visited. However, recent developments in several states suggest that the traditional position of PUCs toward nuclear power plant construction costs is changing and in directions that could significantly impact such projects. Several of these developments are summarized below.

New York's and New Jersey's Incentive Rate of Return Approach

The New York Public Service Commission (hereafter "PSC") has adopted an innovative approach to including one nuclear plant's construction costs in the rate base of participating utilities. This approach is known as the Incentive Rate of Return (IROR). The New Jersey Board of Public Utilities has adopted a similar plan, known as the "Incentive/Penalty Revenue Requirement Adjustment Plan" (New Jersey Board of Public Utilities 1983).

The New York Commission's adoption of IROR resulted from its decision on an inquiry into the cost implications of continued construction of the Nine Mile Point No. 2 nuclear station. New York's inquiry was initiated in response to public and PSC staff concerns regarding repeated increases in construction cost estimates and repeated extensions of the estimated completion time of the station. The New Jersey plan was proposed by the participating utilities to ensure continued funding for the project.

The New York PSC adopted IROR from among several options under consideration. Another option included a shutdown of the project to prevent alleged severe financial and economic implications for both the participating utilities and the affected rate payers. The PSC found that continuing with construction, which had been under way for some time, was the best option, but only if there was IROR to provide some assurance to rate payers that construction costs would not continue to escalate and that the completion schedule would not continue to slip.

The New York plan provides an incentive for the co-tenant utilities to complete construction on or before the scheduled date and at a cost which is at or below the PSC's target cost. Similarly, a disincentive exists for exceeding the "target cost" set.[a] If the completion cost exceeds the target cost, only 80% of such excess costs may be included in the co-tenants' rate base. The remaining 20% will not be passed on to consumers. There is an incentive for completing the station at less than the target cost, since 20% of any cost underrun from such target costs will be allowed into the rate base under the IROR plan (State of New York 1982).

New York's IROR approach allows for the target cost to be modified upward or downward upon request, given "extraordinary events" (State of New York 1982). The PSC also limited any IROR-induced reduction in the return on common equity, applicable to prospective investments in the station, to no more than one-half the normal rate of return (State of New York 1982).

Two of the seven Public Service Commissioners dissented, arguing that the target cost was set too high, that application of the 20% constant sharing factor allocated too great a risk to rate payers because it failed to take into account different tax treatments afforded investors. The dissenters pointed out that several events besides increased construction costs could render the station uneconomic and contended that no meaningful risk sharing could result under the plan unless the "extraordinary events" under which target costs could be modified were clearly delineated (State of New York 1982).

Standard and Poor's, commenting during PSC proceedings, stated that IROR "could have the harmful effect of weakening investor confidence in these utilities and subjecting them to risks, over and above those inherent in the heavy nuclear construction program, particularly since the NRC looms as an immense, exogenous variable" (Standard and Poor's Corporation 1983, p. 20). The

(a) The PSC set the "target cost" following public hearings and contested case proceedings before an administrative law judge. The figure was arrived at following review of time and cost estimates submitted by the co-tenants, by PSC staff, and by an independent consulting firm retained at the PSC's request and expense.

dissenters argued that such a "risk premium" would in turn lead to higher rates. On the other hand, both the New York and New Jersey decisions conclude that these plans would not adversely affect the utilities' ability to attract outside financing at reasonable rates.

The New York dissenters also argued that, by including only capital and interest costs in the target cost, the IROR approach would provide incentives for the co-tenants to cut necessary capital expenditures with resultant higher operation and maintenance expenses. Finally, the New York dissenters contended that IROR was legally questionable on two issues. First, the IROR purposed to bind future commissions that would determine the actual rate base of the co-tenants when construction is completed and secondly, the incentives/-disincentives depart from what has legally been considered in the past to be a just and reasonable rate of return.

At present, whether New York's IROR has affected the quality of construction at Nine Mile Point No. 2 positively or negatively is not known. The New Jersey decision is also too recent to have produced any discernable effect upon construction quality at Hope Creek 1. Some have argued that IROR plans have the potential to negatively affect construction quality because they place special emphasis on time and costs rather than on quality considerations. Others welcome the scrutiny such plans introduce to nuclear project construction costs. In any case, the adoption of such plans reflects a more proactive PUC position than has been the case historically.

Other PUC Decisions on Nuclear Construction Costs. The Ohio and California PUCs also have recently taken action on the construction costs of nuclear plants under their jurisdiction. In November, 1982, the Ohio PUC decided that only 25% of construction costs associated with the Zimmer plant should be included in the rate base under Ohio's CWIP allowance (State of Ohio 1982). The plant was 75% complete when the order was issued and was expected to be in service by 1975 at a cost of $235 million. The total cost is now expected to be $1.7 billion and a start-up date is still uncertain.

During 1981, the Ohio commission continued to permit inclusion of Zimmer in the rate base despite an NRC report that a widespread breakdown in implementing the Zimmer QA program had occurred. The plant had been included based on assurances that no more breakdowns would occur. In this proceeding, the owners argued that because the plant was 75% complete, the plant should be included on the basis of a state statute that allowed costs to be entered into the rate base when the plant was at least 75% complete. The PUC, however, exercised its discretion to include only 25% of the total cost associated with Zimmer in the CWIP allowance because the plant would not be providing service as soon as was expected in previous proceedings, wherein CWIP allowances were set at higher levels (State of Ohio 1982). The commission denied a request by a consumer group for a management audit of construction of Zimmer but did not bar the possibility of a future audit.

The California PUC recently allowed only a very limited rate increase for the San Onofre 2 nuclear plant. The PUC is planning a lengthy investigation of the reasonableness of construction costs. Unit 2 has been on-line for some time and is running close to full capacity. A spokesman for the PUC stated, "...for the time being rate increases related to plant costs will be limited to match decreases in rates associated with fuel savings produced by the plant. Rate increases for plant costs that are beyond fuel savings will be held in abeyance pending review of the prudency of construction costs." The PUC will also review San Onofre Unit 3, which is due on-line shortly. (Energy Daily 1983).

These developments reflect once again a new PUC position of active involvement in investigating the prudence of management decisions made during the construction of nuclear power plants. The effects that these and other PUC decisions may have on the quality of projects currently under construction, however, are unknown.

The Relationship of the NRC to State Regulation of Nuclear Construction Projects. PUC positions on nuclear construction projects was examined partly to determine the extent to which the NRC was sharing, or could expect to share, responsibility for construction quality assurance with state regulators. Some recent PUC action and subsequent litigation in Florida may indicate the limits/possibilities of shared federal/state regulatory action.

The case involved a forced outage at Florida Power Corporation's Crystal River 3 plant. The issue was whether planning and supervision of a work activity involving the use of a test weight device was deficient. The PUC first ruled that the planning and supervision of the project was inadequate and that Florida Power Corporation must bear the responsibility for the replacement fuel costs. The PUC found that 55 days of the forced outage were attributable to a dropped test weight, which corresponded with replacement fuel costs of $11,056,000, plus interest. Florida Power Corporation then appealed the decision to the Florida Supreme Court.

The Supreme Court reversed the PUC's decision and remanded the case to the PUC for reconsideration. The court stated that the PUC had relied excessively on an NRC notice of violation and a Nuclear General Review Committee (NGRC) report. The court reasoned that use of the documents was analogous to using evidence of subsequent repairs and design modifications to show that the original design was faulty. The court independently reviewed the record and held that the test weight incident was not, per se, safety-related. The court further ruled that the NRC and NGRC reports were issued after the incident, and hindsight should not be the basis for the PUC's decision.

On remand, the PUC re-examined the entire record and decided that an independent basis for disallowing the costs did exist. The PUC ruled that they could rely on the NRC and NGRC reports as secondary sources of information for their conclusion. The PUC's review states that the basis for finding imprudent management was that Florida Power Corporation lacked a formal plan or written firm directives specifying procedure in this type of situation. Additionally, supervision of the work activity was lacking by management. Therefore, whether or not the work should have been considered "safety-related", the PUC ruled that the work was not adequately planned or supervised (State of Florida Public Service Commission 1983).

The PUC stated that the Florida Supreme Court exceeded the normal scope of review, that is, whether substantial evidence supported the PUC's finding. Instead, the court found it necessary to reweigh the evidence and conclude that both the PUC and the NRC were wrong that repair work was safety-related. In its defense, the PUC cited other states that have disallowed costs that were over and above the costs of efficient operations. These states included Arkansas, New York, Iowa, and Virginia.[a] In addition to these states, Ohio has also disallowed operating expenses. According to the Ohio PUC, several million dollars of every rate increase is disallowed on the Davis Besse plant because of its poor operating history.

The Florida litigation suggests that while PUCs may be willing to follow the NRC's lead and undertake special scrutiny of a utility where the NRC has found problems, state courts may not view such a relationship favorably. Thus, while there may appear to be a basis for parallel or complementary actions on the part of PUCs and the NRC with respect to the quality of nuclear plant construction projects, this may only develop to the extent that their respective missions are viewed as complimentary.

Recent State PUC Actions--An Overview

PUCs, such as those in Ohio and Florida, have actively investigated the prudence of management decisions. Ohio investigated a plant's management during the construction phase; and the Florida PUC investigated management decisions during operation of the plant. Although only a few state PUCs have disallowed costs incurred during construction, several other states have, or are considering, disallowing imprudently incurred operating expenses.

Two states, New York and New Jersey, have adopted a wholesale approach to reviewing construction costs. The IROR approach, which does not involve active examination of individual construction management decisions, affords some protection to consumers from further rate increases. Both New York's and New Jersey's PUCs state that their approaches do not involve relinquishing the Commission's authority to review and disallow imprudently incurred construction costs when the plant is completed (New Jersey Board of Public Utilities 1983; State of New York 1982).

The judicial system has become more involved in examining PUC decisions to disallow costs arising from imprudent management decisions. The Florida Supreme Court, for example, is examining more carefully PUC decisions that may result in disallowing costs. The court is looking at whether the experts' data, i.e., the NRC notice of violations and the NGRC report, are sufficient basis for a PUC ruling to deny recoupment of costs incurred by the utility. In

(a) Florida Power Corporation has appealed and this case is, again, before the Florida Supreme Court.

one case, the Florida Supreme Court distinguished between the NRC's and the PUCs' primary function. In the Court's view, the NRC's primary function relates to safety. A PUC judgment on the prudence of management decisions must rely on information directly related to such a decision. NRC safety violation reports were not viewed as an appropriate basis for such a PUC decision.

C.5.2 Project Ownership Arrangements

The second institutional issue examined at the construction sites visited was the project ownership arrangement. This issue was examined to determine what impact the ownership arrangement had on the construction effort and, in particular, what benefits certain ownership configurations might have for assuring quality in construction projects.

Of the three nuclear projects visited, Site 1 is joint-venture owned and financed primarily by a small private utility, with participation of a small, rural electric cooperative. Site 2 is a joint venture involving five separate utilities (four investor-owned and one public cooperative) in four states. Site 3 is also a joint venture of four utilities (one investor-owned and three public utilities). This project is dominated by the largest owner, the investor-owned utility, which owns more than 50% of the project. In addition, the investor-owned utility at Site 3 is the subsidiary of a larger holding company, introducing further ownership variety.

Because of the differences among the sites, the benefits of various project ownership arrangements could be examined from the point of view of those interviewed. However, the effects of such arrangements on construction quality could not be assessed objectively. Nevertheless, changes in ownership arrangements, particularly those resulting in enhanced coordination, have been generally regarded as positive developments for the nuclear industry [Jaskow and MacAvoy 1975; International Energy Associates Limited (IEAL) 1979].

Because various ownership arrangements are used in the U.S. nuclear industry, the current arrangements and the statutory and regulatory parameters that shape them were examined. This examination was aided by insights gained at the sites visited.

Current Ownership Arrangements in the Nuclear Industry

The three basic types of electric utility ownership in the United States are investor-owned, government-owned, and cooperative. Investor-owned utilities comprise about 84% of the nation's generating capacity and annual electric power production. Government-owned utilities comprise 13.6% of the U.S. generating capacity, of which municipalities are the most frequently encountered public owners (IEAL 1979). Cooperatives generate comparatively little of the nation's electric power (3%), and only one currently operates a nuclear plant (Osborn et al. 1983).[a]

(a) According to this study, several cooperatives own shares in investor-owned nuclear projects. For example, approximately 40 cooperatives own shares in the financially troubled, publicly owned Washington Public Power Supply System nuclear projects.

Investor-owned utilities vary in size and are organized in several different ways. Some utilities are owned directly by shareholders and some are subsidiaries of holding companies. These holding company arrangements also differ. For example, some parent companies sell power to the public, while others have no such role (with the subsidiary utility handling the sale of power). The largest nuclear generating system in the country, Commonwealth Edison, owns 7 units, comprising 10% of the nation's nuclear generating capacity. Of the 69 U.S. nuclear power plants operating in June 1979, 60 were investor-owned (IEAL 1979).

Within this environment that supports a variety of ownership arrangements, utilities appear to have recognized the importance of coordinating the planning and operation of generating facilities, as well as other facilities, to achieve, for example, more rational investment planning and to minimize dislocations caused by power outages (Breyer and MacAvoy 1973). Observers of the nuclear industry also have noted the potential advantages of increased coordination (IEAL 1979; Gilinsky 1983).

Reviews of relevant statutes and regulations, literature, and information collected during the site visits suggest that coordination is not precluded by existing legal or economic considerations. Neither, however, are there clear incentives (particularly within statutory and regulatory frameworks) for increased coordination. Therefore, despite the possible advantages, increases in coordination are not expected without a compelling impetus, such as might be provided by new legislation. Whether such an impetus is appropriate, however, remains something of an open question.

The Statutory and Regulatory Parameters of Project Ownership Arrangements

Several state and federal laws and regulatory agencies affect the financial and/or ownership arrangements of utilities with nuclear generating projects. Most of the laws and the agencies charged with enforcing these laws are concerned with utilities generally, although certain procedures for enforcing antitrust laws are found in the Atomic Energy Act and are specifically related to the licensing of nuclear power generating facilities.

The number and variety of existing ownership arrangements suggest that these laws and regulations have not prevented formation of varied, viable ownership arrangements for nuclear power plant construction. None of the construction sites visited mentioned the existence of these laws and regulations as a significant obstacle to the project's success. Two sites visited (Sites 2 and 3) indicated that antitrust concerns had been a factor encouraging joint project participation. Nevertheless, while the Federal Power Act provides the Federal Energy Regulatory Commission (FERC) with authority to increase the amount of coordination and efficiency in the industry, this authority has not been broad enough to force changes in project planning and management by individual utilities. Thus, while no insurmountable obstacles to coordination are present, there are also no real incentives in the legal and regulatory system for increased cooperation in project planning and management.

In some foreign countries, nuclear plant ownership and regulatory arrangements differ dramatically from those in the U.S. For example, France has standardized nuclear power plants and just one operating company (Gilinsky 1983). Plants in the Japanese nuclear industry, also highly centralized, experience fewer automatic scrams than do U.S. plants (Dircks 1983). Nevertheless, foreign practices are not detailed here because they involve major changes in industry structure that are generally considered unlikely to be implemented in the U.S. (IEAL 1979; Johnson et al. 1976; Osborn et al. 1983).

The Effect of Federal Antitrust Laws on Project Ownership Arrangements. Through Section 105 of the Atomic Energy Act the NRC is charged with three forms of responsibility for enforcing federal antitrust laws.[a] The NRC must enforce antitrust judgments reached elsewhere, report any apparent antitrust law violations to the Attorney General, and follow the procedure outlined in Section 105 of the Act to solicit the views of the Attorney General on possible antitrust implications of a construction permit application.

The antitrust provisions of Section 105 have been cited as a source of costly delay in the licensing of new nuclear power generating facilities (IEAL 1979). The vast majority of antitrust reviews under Section 105 have resulted in agreements among the utility or utilities, the Department of Justice, and the NRC staff for resolving antitrust concerns, usually in the form of license conditions (Johnson et al. 1976).

Historically, where the NRC's licensing reviews have involved antitrust concerns, the issue has been access to the generating capacity of the plant, rather than the procurement of the design, construction, or supply of components for nuclear plants. Thus, license conditions that have arisen because of antitrust concerns have been grouped into the following four categories (Johnson et al. 1976):

1. Unit Access - involves arrangements for outside utilities to use a nuclear facility.

2. Transmission Services - involves agreements about services to be provided by the applicant to facilitate access.

3. Coordination - involves requirements for such things as emergency and scheduled maintenance support and participation in joint planning and development.

4. Contractual Provisions - involves requirements that the applicant delete discriminatory or restrictive conditions from its contracts, including restrictions on interconnections and coordination agreements, power pool membership, and use or resale of power.

Johnson et al. (1976), authors of this categorization, suggest that if, for example, breeder plants were to be clustered in "nuclear energy centers" resulting in much greater generating capacity than the nuclear plants currently being constructed, special antitrust problems could arise. However, they further suggest that "licensing conditions could probably be worked out to assure equitable access by smaller utilities" (Johnson et al. 1976, p. 51). Nevertheless, Johnson et al. (1976) speculate that such a clustered development might lead to a more complex and time-consuming antitrust review process than that experienced today by utilities with single plant proposals. It seems certain that antitrust laws would have to be addressed by any legislation or initiative providing the impetus for increased coordination in the nuclear industry.

The Effects of Other Federal Legislation. In addition to the NRC, the Federal Energy Regulatory Commission (FERC) and the Securities and Exchange Commission (SEC) play roles in regulating public utility ownership arrangements. The SEC enforces the Public Utility Holding Company Act of 1935. This legislation led to the breakup of several corporate empires that held diverse utility assets in widely separated states and that had been effectively outside the control of state public utility commissions (Breyer and MacAvoy 1973).

It has been suggested that the Public Utility Holding Company Act and SEC review have impeded mergers of public utilities through stock acquisition (Breyer and MacAvoy 1973). However, the thrust of governmental policy appears to be in favor of pooling among individual utilities, not mergers of utility ownership (Breyer and MacAvoy). Furthermore, the Act specifically encourages mergers within the utility industry which would rationalize the production and generation of electricity (Breyer and MacAvoy 1973; 15 U.S.C. 79z-4).

The FERC, formerly the Federal Power Commission, is authorized by Title II of the Federal Power Act (15 U.S.C. 791 et seq.) to "divide the country into regional districts for the voluntary interconnection and coordination of facilities for the generation, transmission and sale of electric energy" [16 U.S.C. 824(a)]. Under its power to regulate interstate commerce, the FERC has asserted jurisdiction over nearly all U.S. generating and transmitting electric facilities because of the existing degree of interconnection among facilities (Breyer and MacAvoy 1973).

The immediate practical effect of such jurisdiction is that companies, including those that are primarily engaged in intrastate commerce, must now obtain FERC approval before entering into mergers and certain security transactions, submit information that the FERC requests, and subject interstate wholesale electricity rates to supervision by the FERC (Breyer and MacAvoy 1973). Although the FERC has authority over almost all utilities, its efforts have been to promote voluntary interconnection within the industry, rather than to compel interconnection or to seek additional legislative authority for compulsory pooling, interconnection, and planning of future generating projects.

(a) The Sherman and Clayton antitrust laws are made specifically applicable to licensees by Section 105, 42 U.S.C. §2135.

Site 3 is a project undertaken by a subsidiary of a large parent firm that is registered as a holding company under the Public Utility Holding Company Act of 1935. This site is an example of a utility and a parent firm that are subject to regulation by the SEC under the Act. Also, certain aspects of the holding company and subsidiary's operation are subject to regulation by the FERC under the Federal Power Act, as discussed above. The other sites visited are similarly subject to FERC regulation. In addition, virtually all significant utilities in this country are subject to state regulation of wholesale or retail rates charged for power.

Insights into Ownership and Management Arrangements: The Effects of Size and Market Power

The construction project management arrangements as well as the utilities' size and nuclear experience varied at the three sites (see Section C.4). Site 1 was being constructed by a relatively small utility and a rural electric cooperative with no prior nuclear experience. Site 2 was being undertaken jointly by several investor-owned and public utilities, also without prior nuclear experience. Site 3 was also a joint project undertaken by several small public utilities and the subsidiary of a large parent firm, registered as a holding company under the Public Utilities Holding Company Act of 1935. This subsidiary (and another subsidiary of the parent firm) had previous nuclear experience.

The site visits suggested that these project ownership arrangements are feasible. However, the sample of sites was small and it is not practical to draw conclusions concerning different ownership and management arrangements. For example, comparisons among investor-owned, government-owned, and cooperative ownership arrangements cannot be made since the site visits were restricted to investor-owned utilities or dominated by such entities.

The site visits did suggest that the presence of the utility or its agent in the marketplace can impact the project. The subsidiary utility acting as the agent for the owners' group at Site 3, closely linked to a large holding company, was in a position to effectively negotiate with contractors, suppliers, and vendors for the goods and services necessary to a successful, high-quality project. The advantage of this association with a major parent company is, in the words of one utility executive, "all about tomorrow." The holding company and the utility are not only contracting for a nuclear project today, they will also be contracting for construction and maintenance projects for years to come. Furthermore, the utility's position is supported by prior experience in nuclear construction projects, providing familiarity with the marketplace and increased knowledge and expertise that can benefit the project. Procurement and contracting are thereby facilitated, as is the expertise necessary to secure satisfactory performance on the procurements and contracts.

The joint owners at Site 2, without prior nuclear experience, took a different approach to meet its goals in the marketplace. They established a major A-E firm as their agent. The A-E, with its well-established systems for evaluating and auditing suppliers' and contractors' bids, products, and performance, has its own considerable market presence. Although the owners lacked nuclear experience, they did not suffer from unfamiliarity in the marketplace. Rather, they used the A-E's experience to the benefit of their project.

Size also is an issue in determining the economic viability of a particular construction project. A small utility beginning a necessarily complex and costly nuclear project can find that the costs and investment in the construction project far exceed the utility's net assets. For this reason, economic decisions within holding company systems may be typically made by the holding company, considering the overall system rather than the operation of the particular subsidiary involved in the project (Breyer and MacAvoy 1973; Osborn et al. 1983).

One of the reasons that most nuclear generating capacity in the United States is owned by investor-owned utilities may be that many investor-owned utilities are larger than government-owned or cooperative companies. Therefore, the investor-owned utilities may have resources that other utility companies lack to invest in nuclear projects (Osborn et al. 1973). Joint ventures and holding companies may also provide necessary support and back-up for nuclear projects, as at Sites 2 and 3 (Osborn et al. 1973). Thus, pooling resources may represent one vehicle for increasing coordination within the industry and for enabling initiation and continuation of a nuclear project that might otherwise be fiscally, if not managerially, impossible. However, for managing the project a joint venture requires an effective arrangement that avoids the difficulties often linked to management by committee (Breyer and MacAvoy 1973).

C.5.3 Institutional Issues--A Summary

Nuclear power plant construction projects are affected to some extent by the larger institutional environments in which these projects and their owners are regulated, financed, and compete. Two aspects of this institutional environment were examined at the sites visited: 1) state PUC policies toward nuclear power construction efforts; and 2) various types of ownership arrangements of nuclear power plant construction projects.

The utilities visited indicated that possible PUC disallowance of construction costs associated with quality problems has not been a significant consideration in utility decisionmaking. This attitude reflects the fact that in the past PUCs have been relatively uncritical of new plant construction costs proposed for inclusion in the rate base. However, recent activity by certain PUCs, such as those of New York, Florida, and California, creates a potential for a significant deterrent to a laissez-faire owner attitude toward contractors of new generating facilities.

While this potential trend may or may not result in better utility management of quality-related construction problems at nuclear projects, such rate scrutiny by PUCs can seriously affect the financial health of utilities, as is true of rate regulation policies generally. The negative side of the trend toward PUC disallowance of quality-related construction cost overruns, then, is that it may increase the risk of undertaking and completing nuclear stations to the point utilities may find otherwise justified power generating projects to be uneconomical. Thus, the impact of a more active PUC posture toward nuclear construction efforts remains unclear. Further examination of state regulatory policy on the quality of nuclear construction projects, and of the NRC's relationship to that policy, is needed.

On the second issue examined, nuclear generating facilities being built or in operation in the United States today reflect a wide variety of plant ownership arrangements also found in the electric utility industry generally. Statutory and regulatory parameters shaping project ownership arrangements in the U.S. include federal and state antitrust laws, the Federal Power Act, and the Public Utility Holding Company Act. These parameters do not appear to have prevented the development of a great variety of project ownership and management arrangements, nor are they likely to prevent further efforts at coordination in the industry. However, antitrust laws could delay formation of more consolidated ownership arrangements in the U.S. Furthermore, positive regulatory incentives for further coordination or consolidation within the industry appear to be lacking.

Increased coordination may be desirable in ownership arrangements. While some individuals have reviewed utility ownership arrangements and project management issues (Breyer and MacAvoy 1973), careful empirical examination of many aspects of utility and project ownership arrangements and their relationship to project outcomes is lacking (Osborn et al. 1983). The limited site work undertaken here, when combined with additional site work at government-owned or cooperative utility companies, or the study of different construction management arrangements (such as one undertaken by a single, large utility company), could begin to identify some of the relative strengths and weaknesses of different types of ownership and management arrangements. Through such additional study, it might also be possible to determine the appropriate vehicle for advocating increased coordination within the industry, assuming that additional investigation offered further evidence of the merits of coordination.

C.6 REFERENCES

Atomic Energy Act. U.S. Code. Title 42, Section 2135.

Bauman, D. S., P. A. Morris and T. R. Rice. 1983. An Analysis of Power Plant Construction Lead Times, Vol. 1: Analysis and Results. Prepared by Applied Decision Analysis, Inc. for Electric Power Research Institute, Palo Alto, California.

Borcherding, J. D. and D. F. Garner. 1981. "Work Force Motivation and Productivity on Large Jobs." Journal of the Construction Division, Proceedings of the American Society of Civil Engineers. 107(CO3):443-453.

Breyer, S. and P. W. MacAvoy. 1973. "The Federal Power Commission and the Coordination Problem in the Electrical Power Industry." 46 So. Cal. L. Rev. 661.

Cavanagh, J. B. 1974. "Risks and Remedies--The Nature and Extent of Liability." In Risks and Remedies in Government Contracting. Proceeding of a Briefing Conference held in Los Angeles (American Bar Association).

Cibinic, J., Jr., and R. C. Nash, Jr. 1981. Cost Reimbursement Contracting. George Washington University, Washington, D.C.

Connecticut State. June 1983. Public Act No. 83-239.

Edison Electric Institute. 1983. State Commission Policy on Construction Work in Progress in Rate Base. Edison Electric Institute, Washington, D.C.

Federal Power Act, U.S. Code. Title 16, Sections 791a et seq. (1935).

Federal Procurement Regulations, 41 C.F.R. Chapter 1, Parts 1-2 and 1-3.

Florida Power Corporation v. Public Service Commission, 424 So. 2d 745 (1982).

Furland, E. J. July 1983. Testimony on behalf of applicant. Docket No. 83-07-15.

Gilinsky, V. May 25, 1983. Statement of Commissioner Victor Gilinsky before the Committee on Environment and Public Works, Subcommittee on Nuclear Regulation on Nuclear Licensing Reform.

House Committee on Energy and Commerce. H.R. 555, 98th Congress, 1st Session.

Howe, K. M. and E. F. Rasmussen. 1982. Public Utility Economics and Finance. Prentice-Hall, Inglewood Cliffs, New Jersey.

International Energy Associates Limited (IEAL). 1979. "Institutional Options for Nuclear Power Generation in the United States." Prepared for the U.S. Department of Energy, Washington, D.C.

Johnson, L. J. et al. 1976. Alternative Institutional Arrangements for Developing and Commercializing Breeder Reactor Technology. Rand Corporation, New York, New York.

Joskow, P. L. and P. W. MacAvoy. May 1975. "Regulation and the Financial Condition of the Electric Power Companies in the 1970s." American Economic Review. 65(2).

New Jersey Board of Public Utilities. August 12, 1983. In the Matter of Utility Construction Plans; Hope Creek Inquiry. Docket No. 8012-914-IPRRA, Decision and Order.

New York State, Public Service Commission. April 16, 1982. Proceeding to inquire into the financial and economic cost implications of constructing the Nine Mile Point No. 2 nuclear station. Opinion No. 82-7, Case 28059.

Ohio State, Public Utilities Commission. November 5, 1982. Opinion and Order

Case Nos. 81-1058-EL-AIR and 82-654-EL-ATA.

Osborn, R. N. et al. 1983. Organizational Analysis and Safety for Utilities with Nuclear Power Plants. Vol. II, NUREG/CR-3215, U.S. Nuclear Regulatory Commission, Washington, D.C.

Public Utility Holding Company Act of 1935, U.S. Code. Title 15, Section 79z-4.

Standard and Poor's Corporation. March 29, 1983. Comments on Incentive/Penalty and Risk-Sharing Mechanisms. Submitted in New York Public Service Commission, Case 28059, Opinion of the Dissent.

State of Florida Public Service Commission. July 13, 1983. In Re: Investigation into Federal Shutdown of Florida Power Corporation's Crystal River No. 3 Unit. Order on Demand, Docket No. 780832-EU.

State of New York, Public Service Commission. August 31, 1983. "Staff Requirements--Continuation of Evaluation of Implications of Salem Event." Memo from W. J. Dircks, NRC Executive Directors for Operations. Opinion No. 82-7.

The Business Roundtable. 1982. Contractural Arrangements--A Construction Industry Cost Effectiveness Project Report. Report A-7.

The Energy Daily. Wednesday, September 14, 1983. "California PUC Trips Up Utilities Over San Onofre 2 and 3 ..."

Theodore Barry and Associates. 1979. A Survey of Organizational and Contractual Trends in Power Plant Construction. Theodore Barry and Associates, Los Angeles, California.

U.S. Code. Title 15, Sections 79 through 79z-6.

U.S. Code. Title 16, Sections 791 et seq.

U.S. Code. Title 16, Section 824(a).

U.S. Code. Title 16, Section 824a(v).

U.S. House of Representatives. 1983. Construction Work in Progress Policy Act of 1983. Report No. 98-35, Washington, D.C.

Virginia Electric and Power Company v. Division of Consumer Counsel. 220 VA 930 (1980).

C.7 BIBLIOGRAPHY

C.7.1 Sources Cited

Bauman, D. S., P. A. Morris and T. R. Rice, An Analysis of Power Plant Construction Lead Times, Vol. 1: Analysis and Results, prepared by Applied Decision Analysis, Inc., for Electric Power Research Institute, Report of Research Project 1785-3, published by Electric Power Research Institute, February 1983, at p. 4-6.

Breyer, S., and P. W. MacAvoy, "The Federal Power Commission and the Coordination Problem in the Electrical Power Industry," 46 So. Cal. L. Rev. 661 (1973).

Borcherding, John D., and Douglas F. Garner. "Work Force Motivation and Productivity on Large Jobs," Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 107, No. CO3, September 1981, pp. 443-453, at pp. 445-446.

The Business Roundtable. Contractural Arrangements--A Construction Industry Cost Effectiveness Project Report, Report A-7, October 1982, at p. 26.

Cavanagh, John B. "Risks and Remedies--The Nature and Extent of Liability," pp. 20-30 in Risks and Remedies in Government Contracting, proceedings of a Briefing Conference presented by the American Bar Association Public Contracts Section, Federal Bar Association, and National Contract Management Association, in Los Angeles, CA; published by American Bar Association, 1974, at p. 21.

Cibinic, John, Jr., and Ralph C. Nash, Jr. Cost Reimbursement Contracting, Washington, D.C.: George Washington University, 1981, at Chapter 5, pp. 170-217 and pp. 254-273.

Edison Electric Institute, Special Report No. 1, State Commission Policy on Construction Work in Progress in Rate Base, published by Edison Electric Institute, August 5, 1983.

Howe, Keith M, and Eugene F. Rasmussen, Public Utility Economics and Finance, Inglewood Cliffs, NJ: Prentice-Hall, 1982, at Chapters 2 and 3.

International Energy Associates Limited, "Institutional Options for Nuclear Power Generation in the United States," prepared for the U.S. Department of Energy, November 30, 1979 (hereafter cited as IEAL Report), at 41.

Johnson, Leland, J., Edward W. Merrow, Walter S. Baer, and Arthur J. Alexander, Alternative Institutional Arrangements for Developing and Commercializing Breeder Reactor Technology, report prepared under Grant No. OEP 76-01895 from the National Science Foundation, Santa Monica, CA: Rand Corporation, November 1976, at Chapter 5, pp. 61-74.

Joskow Paul L. and Paul W. MacAvoy, "Regulation and the Financial Condition of the Electric Power Companies in the 1970s," American Economic Review, Vol. 65, No. 2, May 1975.

Osborn, R. N., J. Olson, P. E. Sommers, S. D. McLaughlin, M. S. Jackson, M. V.

Nadel, W. G. Scott, P. E. Connor, N. Kerwin and J. K. Kennedy, Jr., "Organizational Analysis and Safety for Utilities with Nuclear Power Plants," Vol. II, NUREG/CR-3215, U.S. Nuclear Regulatory Commission (July, 1983).

Theodore Barry and Associates, A survey of organizational and contractural trends in power plant construction, Theodore Barry and Associates, March 1979, at pp. IV-1.

C.7.2 Sources Relied On But Not Cited

Allen, Bruce T., and Arie Melnik. The Market for Electrical Generating Equipment, East Lansing, MI: Michigan State University, 1973.

Asbury, Joseph G., Ronald O. Mueller, and Jarilaos Stavron. "Rate of Return Regulatory Policy Alternatives and Their Effects," Public Utilities Fortnightly, June 9, 1983, pp. 42-48.

"CWIP in Rate Base: The Financial Needs Standard," Public Utilities Fortnightly, February 18, 1982, pp. 65-69.

Ford Foundation. Energy: The Next Twenty Years, report by a Study Group, Cambridge, MA: Ballinger Publishing Co., 1979.

Ford Foundation. Nuclear Power Issues and Choices, report of the Nuclear Energy Policy Study Group, Cambridge, MA: Ballinger Publishing Co., 1977.

Frout, Robert R. "A Rationale for Preferring Construction Work in Progress in the Rate Base," Public Utilities Fortnightly, May 10, 1979, at pp. 22-26.

Heinmann, Fritz F. "Nuclear Litigation from the Supplier's Perspective," in Nuclear Litigation, New York, NY: Practicing Law Institute, 1979.

Hughes, William R. "Scale Frontiers in Electric Power," in William M. Capron (ed.), Technological Change in Regulated Industries, Washington, D.C.: The Brookings Institute, 1971, at pp. 44-85.

Hunt, Raymond G. "Concepts of Federal Procurement: The Award Fee Approach," Defense Management Journal, Second Quarter 1982, at pp. 8-17.

Johnson, Johnny R. "Construction Work in Progress: Planning for the Rate Case," Public Utilities Fortnightly, August 2, 1979, pp. 15-21.

Kalbe, A. Lawrence. "Inflation-Driven Rate Shocks: The Problem and Possible Solutions," Public Utilities Fortnightly, February 17, 1983, pp. 26-34.

Kelley, Doris. Electric Utility Industry--Nuclear Power Annual Power Plant Review. Merril Lynch, Pierce, Fenner & Smith, Inc., May 1983, pp. 1-36.

Keys, W. Noel. Government Contracts in a Nutshell, St. Paul, MN: West Publishing Co., 1979.

McBride and Wachtel. Government Contracts: Cyclopedic Guide to Law, Administration, and Procedure, 1963, Chapters 19 and 20.

Model Procurement Code for State and Local Governments. The American Bar Association, 1979.

Model Procurement Code for State and Local Governments: Recommended Regs. American Bar Association Section of Public Contract Law, 1980.

Muhs, William F., and David A. Schauer. "State Regulatory Practices with Construction Work in Progress: A Summary," Public Utilities Fortnightly, March 27, 1980, pp. 29-31.

Nash, Ralph C. and Cibinic, John, Jr. Incentive Contracting. Federal Procurement Law, George Washington University, 1966.

National Regulatory Research Institute. Commission-Ordered Management Audits of Gas and Electric Utilities, report prepared for U.S. Department of Energy, July 1979.

National Regulatory Research Institute, The Measurement of Electric Utility Performance, Preliminary Analysis, report prepared for the U.S. Department of Energy, December 1981.

Restrick, John K. "The Nuclear Contract," in Nuclear Litigation, New York, NY: Practicing Law Institute, 1982.

Sartonius, Scott. New Nuclear Plants: Will "Phase-Ins" Be Necessary?, New York, NY: Salomon Brothers, Inc., December 14, 1982.

Sichel, Werner and Thomas G. Gies. Application of Economic Principles in Public Utility Industries, Ann Arbor, MI: University of Michigan, 1981.

Simon, Louis P. "What's Really Wrong with the Nuclear Power Industry: An Operator's Viewpoint," Public Utilities Fortnightly, November 19, 1981, pp. 26-30.

Smith, Bruce A. Technological Innovation in Electric Power Generation 1950-1970, East Lansing, MI: Michigan State University, 1977.

Stevenson, J. D. and F. A. Thomas. Selected Review of Foreign Licensing Practices for Nuclear Power Plants, NUREG/CR-2664, U.S. Nuclear Regulatory Commission, April 1982.

U.S. Department of Energy. The Future of Electric Power in America: Economic Supply for Economic Growth, Report of the Electricity Policy Project, DOE/PE-0045. Washington, D.C., U.S. Department of Energy, June 1983.

York, Stanley and J. Robert Malko. "Utility Diversification: A Regulatory Perspective," Public Utilities Fortnightly, January 6, 1983, pp. 3-8.