IAEA-TECDOC-1052

XA9848504

Nuclear power plant organization and staffing for improved performance: lessons learned

INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA

29-49

The originating Section of this publication in the IAEA was:

Nuclear Power Engineering Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

NUCLEAR POWER PLANT ORGANIZATION AND STAFFING FOR
IMPROVED PERFORMANCE: LESSONS LEARNED
IAEA, VIENNA, 1998
IAEA-TECDOC-1052
ISSN 1011–4289

Printed by the IAEA in Austria
November 1998

The IAEA does not normally maintain stocks of reports in this series. However, microfiche copies of these reports can be obtained from

INIS Clearinghouse
International Atomic Energy Agency
Wagramerstrasse 5
P.O. Box 100
A-1400 Vienna, Austria

Orders should be accompanied by prepayment of Austrian Schillings 100,– in the form of a cheque or in the form of IAEA microfiche service coupons which may be ordered separately from the INIS Clearinghouse.

FOREWORD

Experience from well operated nuclear power plants (NPPs) around the world indicates that an organizational structure that effectively supports plant operations is essential in economically achieving high levels of safety and operational performance. At the same time, in many Member States, energy markets are being opened to competition. It is in consideration of this new competitive energy market that this publication focuses on organization and staffing of NPPs to improve efficiency and effectiveness.

This publication is primarily intended for senior NPP and utility managers. While it is not expected that any particular utility or NPP manager would consider all of the suggestions provided here to be appropriate, it is anticipated that nearly every NPP manager in IAEA Member States would find some of the ideas useful in improving the efficiency and effectiveness of NPP activities.

The IAEA wishes to thank all participants for their valuable contributions. The IAEA is particularly grateful to the US consulting firm Tim D. Martin and Associates Inc. for its considerable assistance in performing the NPP staffing survey and subsequent data analysis. The IAEA staff member responsible for this report was T. Mazour of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. OBJECTIVES

The overall objective of this document is to provide nuclear power plant (NPP) managers information on lessons learned on improving the organization and staffing of NPP activities. Within this overall objective, specific objectives are to:

1. Identify organizational design and staffing principles.
2. Provide examples of how NPPs implement these principles.
3. Identify typical NPP staffing levels, factors affecting these levels, and staffing trends among various NPP types.

While it is not expected that any particular utility or NPP would consider all of the suggestions provided here to be appropriate, it is anticipated that nearly every NPP manager in IAEA Member States would find some of the ideas useful in improving the efficiency and effectiveness of NPP activities.

1.2. BACKGROUND

Electric utilities have, in the past, generally had a monopoly on supply in their assigned area, and were either state-owned without direct links between electricity prices and NPP budgets, or were investor owned utilities with rates of return on investment fixed by governmental organizations. In these environments, there were sometimes insufficient incentives to control staff size and costs. That situation is rapidly changing in many Member States, as energy markets are being opened to competition. It is in view of this new competitive energy market situation that this document focuses on organization and staffing of NPPs to improve efficiency and effectiveness.

For most NPPs, the largest single contributor to operations and maintenance (O&M) costs are those related to personnel. Thus organization and staffing decisions are very important in open, competitive energy markets. Organization and staffing decisions also are a major factor in determining the safety and operational performance of NPPs.

In order to succeed in tomorrow's energy markets, operation of NPPs in Member States will need to reach and maintain high standards of performance in the areas of safety and operations while at the same time controlling costs. Some of the best performing NPPs in the world have outstanding safety records, excellent capacity factors, and smaller staffs than is the norm in the industry. These utilities have demonstrated that safety performance and operational excellence are closely related objectives.

1.3. STRUCTURE

Section 1 provides an introduction to the current environment in which NPP organizational design and staffing questions are being addressed. Section 2 provides good practices for NPP organizational design and staffing, along with associated principles, and examples of how these principles are implemented. Additionally, annexes are included to provide examples of how utilities are addressing particular organization and staffing issues.

2. LESSONS LEARNED WITH RESPECT TO NPP ORGANIZATIONAL DESIGN AND STAFFING

A premise of this publication is that there is no one organizational design or staffing approach that is appropriate for all NPPs. Any organizational design has inherent strengths and weaknesses. However, it is also the case that, given the future environment in which NPPs will be operating, there are certain lessons learned with respect to organizational design and staffing that can provide valuable insights.

Experienced NPP managers identified the following organizational design and staffing lessons learned that are critical to the continued success of NPPs:

1. Organize and staff NPPs using proven organizational design principles.
2. Compare NPP staffing against levels at other plants.
3. Create a learning organization.
4. Design the organization to help in achieving the production potential of the plant.
5. Encourage teamwork to improve performance.
6. Share human and other resources among utilities/NPPs.
7. Establish partnerships with contractors/suppliers.
8. Consider the special organizational situation of "international" projects.

On the following pages, each of these lessons learned is discussed. For each, a brief summary of the lesson learned is provided followed by considerations in addressing it.

2.1. LESSON LEARNED No. 1: ORGANIZE AND STAFF NPPs USING PROVEN ORGANIZATIONAL DESIGN PRINCIPLES

Organizational design is important and can be used to help improve performance. Much can be learned from principles that operators of successful operators of NPPs have used to design their organizations. Provided below are eleven proven organizational design and staffing principles with associated examples of how NPPs are applying them. Through understanding these principles other plants can then determine how these principles may also be useful to them. Annex A provides a case study of how these principles were used to conduct an analysis to re-design an NPP organization.

1. Clearly define the responsibilities and authorities of all organizational units.

- One senior manager is responsible for all aspects of NPP operation.
- Responsibility and financial authority are matched.
- Communication of responsibilities at different levels in the organization is ensured (e.g., managers spend time in the work places of their organizational units).
- Good communications among organizational units is ensured (e.g., multi-disciplinary teams).
- Each NPP staff member reports to only one manager (not several).
- Ownership is clearly defined (e.g., system and component specialists are responsibile for performance of assigned systems/components).

2. **Design the organization based on the company's vision, and related goals and objectives** (This vision integrates needs including: safety, production, costs, human resources, and public acceptance).

- Have a dedicated full-time outage manager (if the company's objective is to optimize outage duration).
- Have long, middle and short term outage scheduling to shorten outage duration by technical and organisational optimisation manager (if the company's objective is to minimize outage duration).
- Ensure decisions to modify/upgrade the plant are made by the operations organization, not by the engineering organization.
- If a utility's objective is to increase the sharing of resources among its NPP units during outages, then establish the necessary linkages such as a common maintenance and/or outage planning organization among NPPs.
- For major plant modifications, establish a project organization whose sole purpose is to implement the modification. The project organization can be disbanded at the end of the project, and project personnel returned to their parent organizational units

3. **Organize work functions and processes to be efficient and effective.**

- Maintain a dedicated operations shift for training (e.g., six shifts).
- Cross-train individuals (e.g., mechanics and electricians, electricians and I&C technicians, operations and maintenance, and operations and radiation monitoring).
- Centralize the engineering function into one organizational unit to improve efficiency.
- Use performance indicators to measure the efficiency and effectiveness of the organization. For some plants these indicators are available through a management information system.
- Evaluate the cost/benefits of out-sourcing some functions(e.g., radiation protection, health care, maintenance, engineering, outage services).

4. **Push decision making responsibility and authority as far down in the organization as practicable.**

- Organize related functions in the same organizational unit to encourage decisions to be made at the lowest level possible (e.g., radiation protection and chemistry functions report to a common manager who is a peer of the heads of shift operations and maintenance).
- Ensure that personnel from all levels of the organisation feel responsible to identify areas for improvement.
- Use an incentive system for employees tied to organizational objectives and associated performance (maximum achievable incentives should be sufficient to provide such incentives (e.g., 10% of annual base salary)).
- Use an incentive system for vendors (both individual employees and the overall organizations) to encourage vendors to contribute to achievement of plant performance goals.

5. **Increase spans of control and minimize layers of management where possible.**

- Have no more than three levels of management under the senior nuclear manager (for a single site utility)
- Have at least 5 persons reporting to each manager.
- Minimize the use of permanent assistants and deputy managers (make these functions part-time assignments, when needed, rather than full-time jobs).

6. **Minimize the number and size of administrative support units.**

- Centralize administrative functions for multi-site utilities to improve efficiencies.
- Centralize functions such as materials management, purchasing and warehousing for multi-site utilities to improve efficiencies.
- Ensure that end users participate in providing training, rather than having all training provided by a central training organization.

7. **Design the organization to be sufficiently flexible to meet changing demands.**

- Use multi-disciplined teams wherever possible.
- Provide developmental assignments (e.g., shift supervisors provided periodic assignments outside shift work).
- Use outsourcing to ensure competitiveness of in-house services (e.g. engineering) and flexibility in the use of resources.

8. **Train, qualify, develop and motivate staff to meet job requirements.** Examples of which include:

- Develop shift engineers/supervisors and other technical staff for management positions.
- To aid in motivating personnel, link completion of training programmes with promotion opportunities.
- Avoid providing training that isn't directly related to job performance or professional development, and ensure that necessary job-related training is provided.

9. **Match staff aptitude with job requirements.** Examples of which include:

- Provide written job requirements
- Provide a formal personnel selection process based on job requirements

10. **Provide sufficient staff to accomplish all necessary activities that support the company's vision, goals and objectives.**

- Use benchmarking as a tool to identify optimum staffing levels.
- Share personnel and resources among utilities (e.g., owner's groups and pooled spare parts).
- For outages and other projects, supplement plant staff with vendors/contractors.

11. Maintain everyone's focus on safety. While not strictly an organizational design or staffing principle, it is critical to the success of every nuclear organization to:

- Emphasize that implementing quality is the responsibility of the line organization.
- Maintain quality standards and oversight/audit functions in an independent organization reporting directly to the senior nuclear manager.
- Ensure there is an independent nuclear safety function (e.g., safety committees, nuclear safety analysis group).

Annex B provides additional details concerning methods to maintain a focus on safety.

2.2. LESSON LEARNED No. 2: COMPARE STAFFING AGAINST LEVELS AT OTHER NPPs

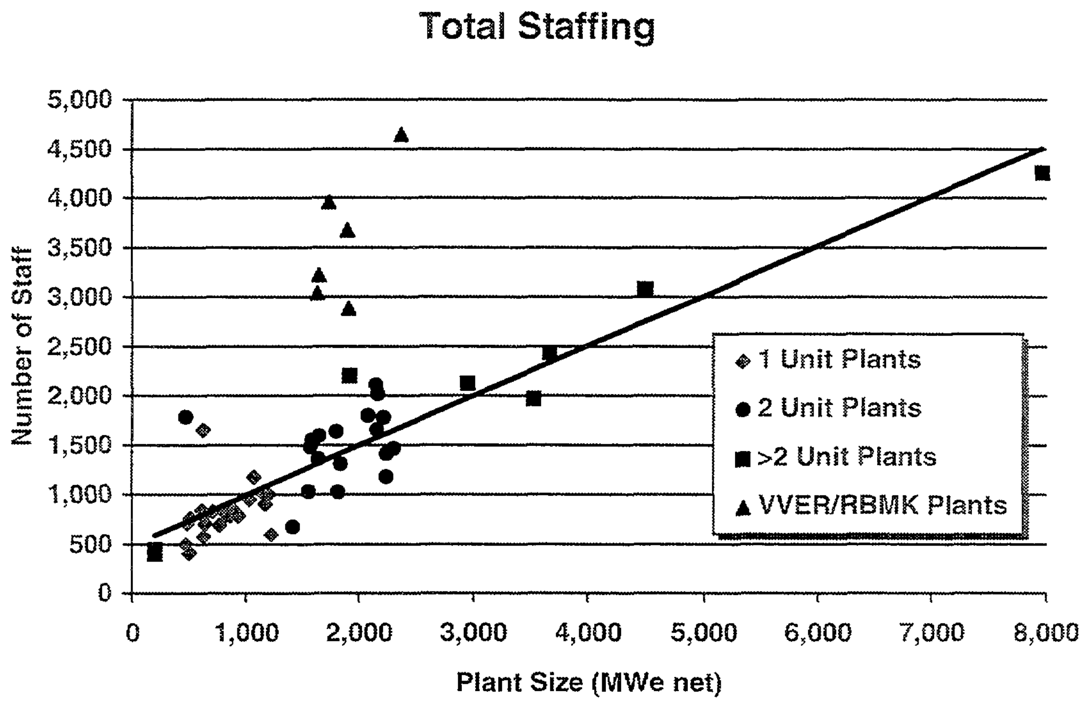
To remain a competitive source of energy, nuclear power must be produced as efficiently as possible while maintaining high safety standards. Because a large portion of the expense of nuclear power is related to staff size, efficient production means optimizing the staffing levels at nuclear plants. The specific number of staff needed to achieve this goal of safe and efficient operations depends upon many factors including plant design, size, and material condition, regulatory requirements, work processes used, organizational structure, and management decisions. However, comparing staffing to levels at other power plants can provide management with information needed to optimize staffing. If staffing is greater than at other plants, it may indicate that efficiency gains are possible that could reduce costs. If staffing is below that of other plants, it may indicate that efficiency is very good and further gains will be difficult. Lower staffing may also indicate the need for continued management oversight to ensure work is being properly performed.

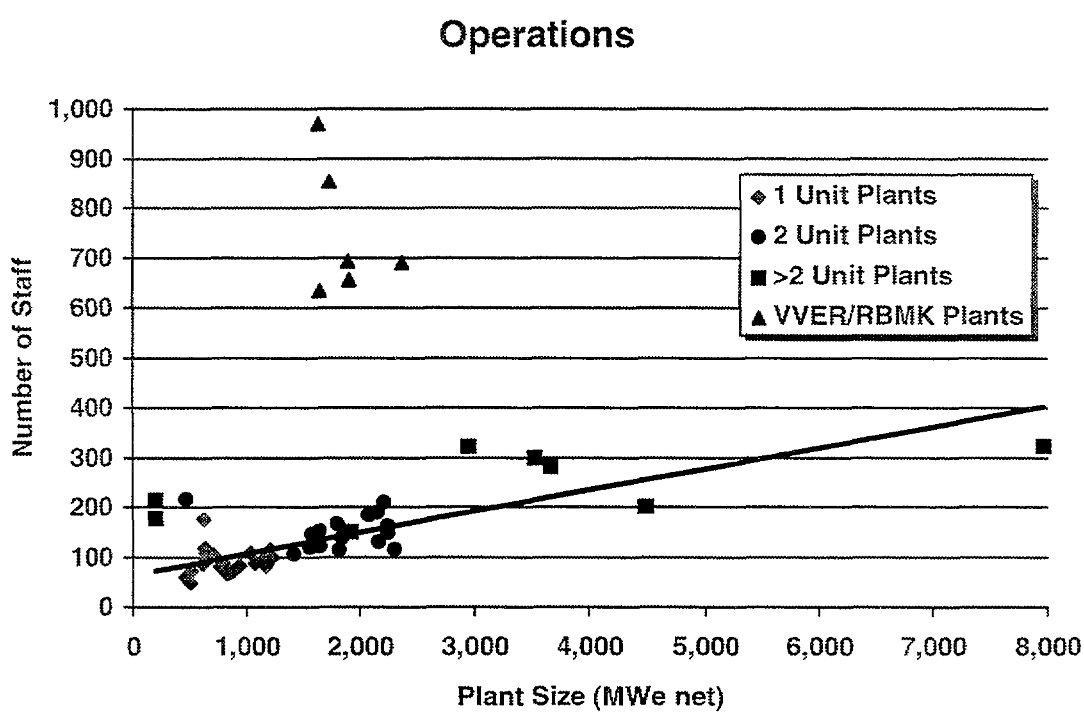
The following discussion is based on information obtained from a survey of staffing levels at 54 plants in 19 countries conducted by the IAEA with the assistance of the US consultancy of Tim D. Martin & Associates. Information on this survey including definitions of staffing categories, and how the data was collected and analyzed is provided in Annex C.

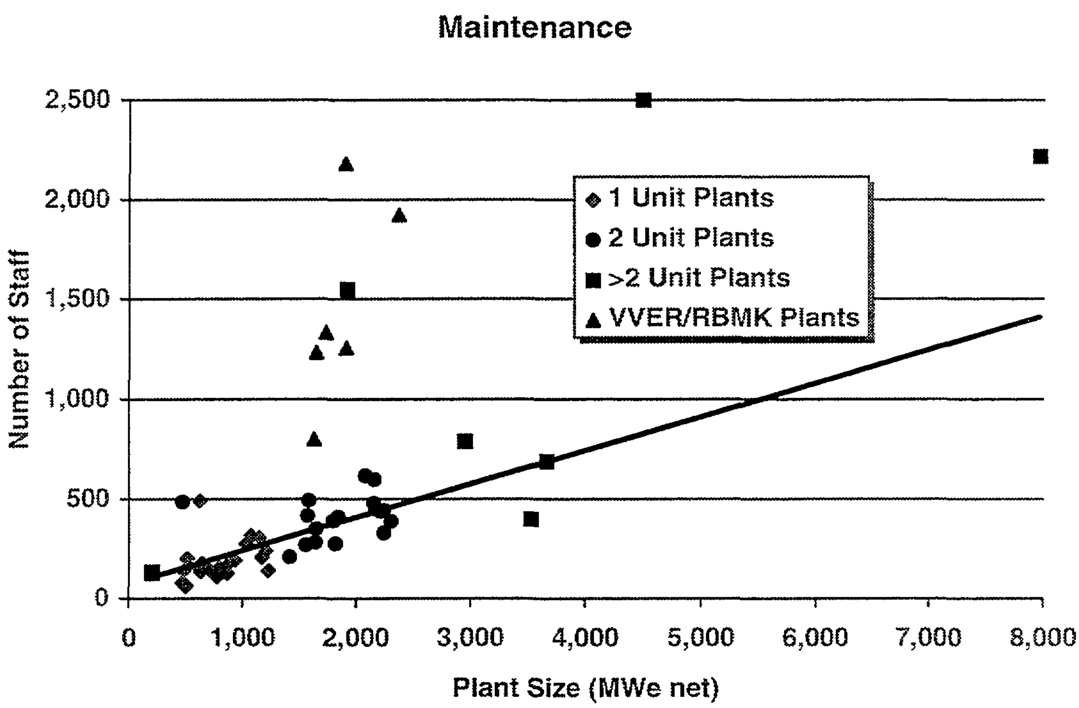
1. Staffing levels. The graphs on the following pages show the staffing survey results (staffing includes nuclear plant and headquarters staff, corporate staff, and on-site and off-site vendors and services). Lines drawn on each graph show the relationship (best-fit regression line) between plant size and staffing for 1 and 2 unit plants (excluding WWER/RBMK plants). Overall, about 70% of the difference in staffing at 1 and 2 unit plants is explained by the differences in plant size.

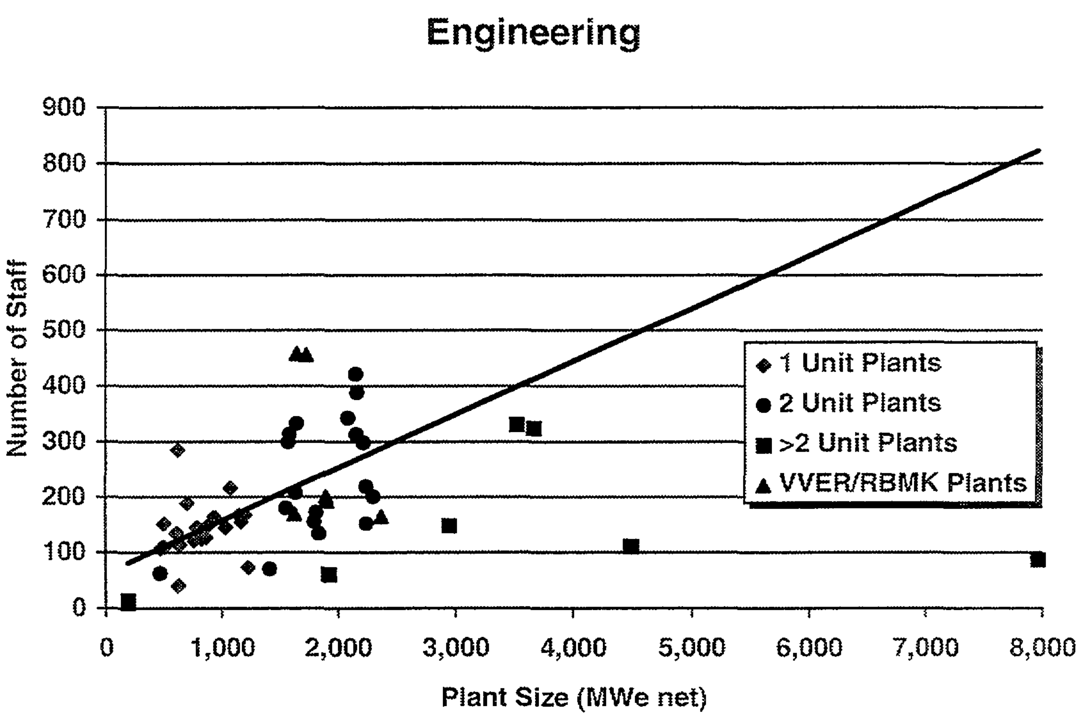
2. Factors influencing staffing. Key factors impacting the size of staff in each staffing area are identified below as reported by plants participating in the survey:

Operations:
- Degree of automation,
- Size and layout of plant,
- Use of shift personnel to perform minor maintenance, radiation protection and chemistry tasks,
- Degree of flexibility in work rules,
- Amount and quality of training,
- Attrition (turnover),
- Number of auxiliary, part-time duties.

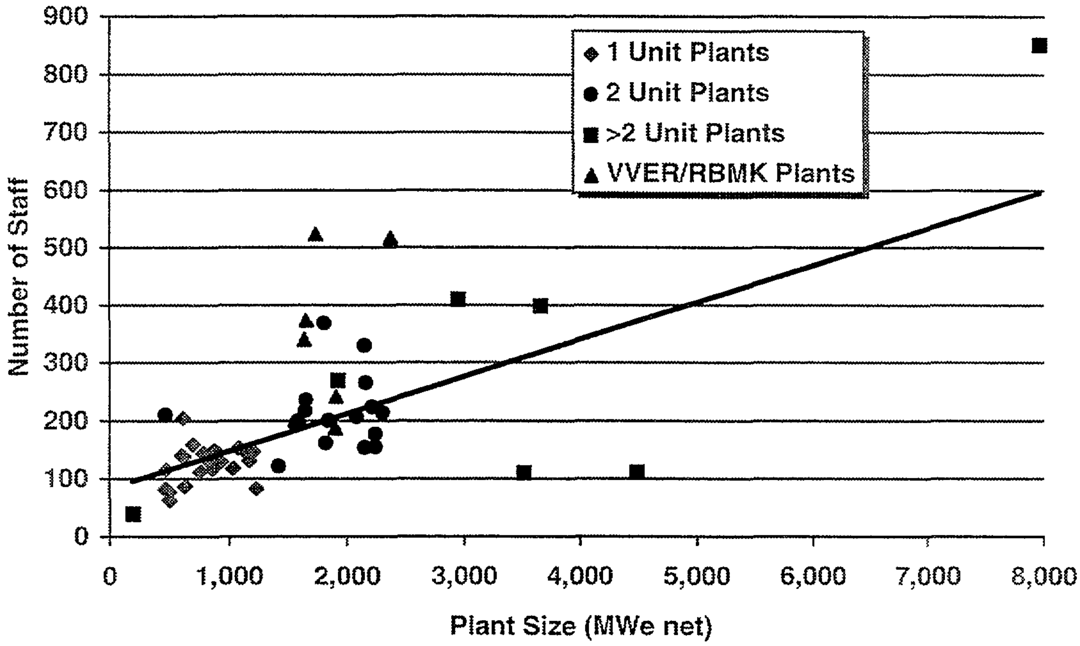

Total Staffing
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Number of Staff
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
Plant Size (MWe net)
1 Unit Plants
2 Unit Plants
>2 Unit Plants
VVER/RBMK Plants


Operations
1,000
900
800
700
600
500
400
300
200
100
0
Number of Staff
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
Plant Size (MWe net)
1 Unit Plants
2 Unit Plants
>2 Unit Plants
VVER/RBMK Plants

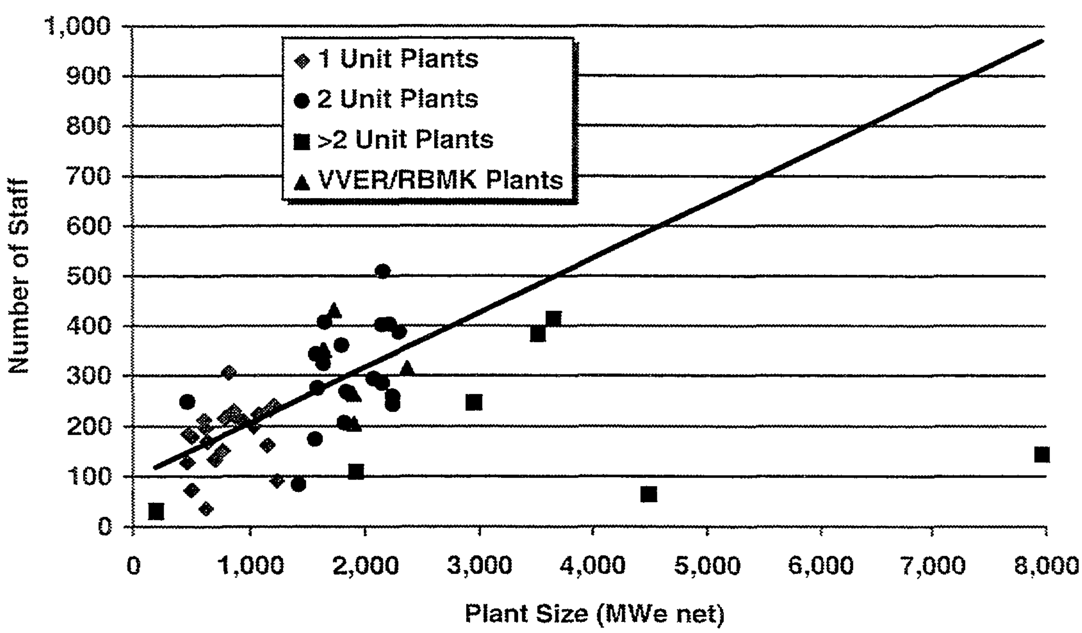

Maintenance
2,500
2,000
1,500
1,000
500
0
Number of Staff
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
Plant Size (MWe net)
1 Unit Plants
2 Unit Plants
>2 Unit Plants
VVER/RBMK Plants

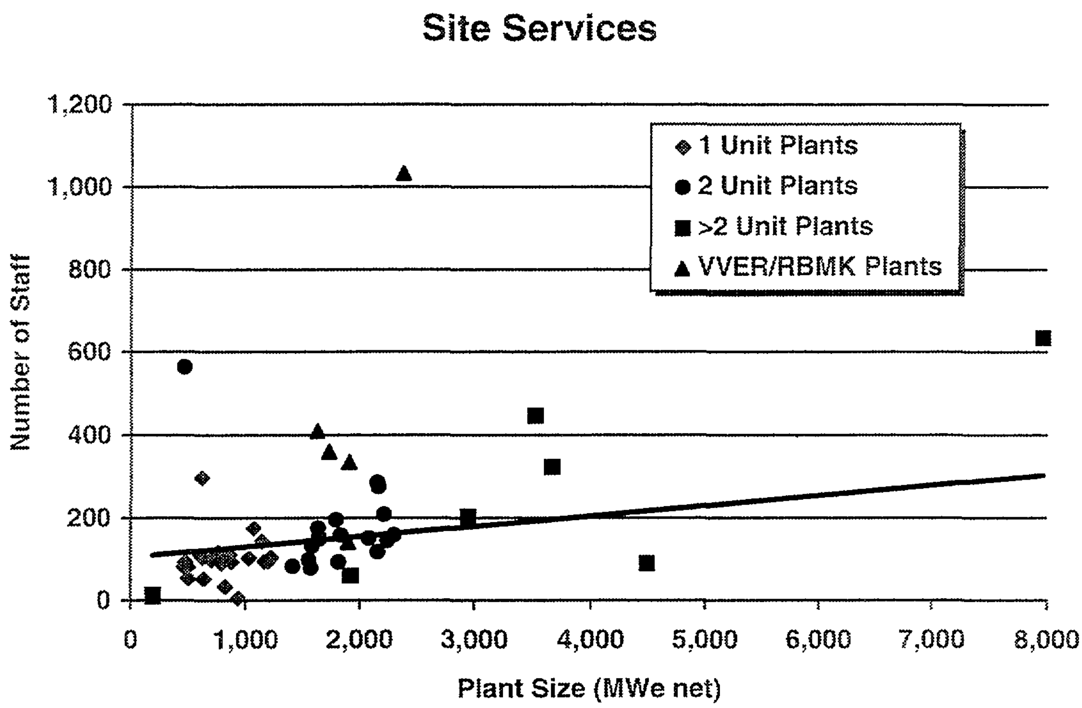

Engineering
900
800
700
600
500
400
300
200
100
0
Number of Staff
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
Plant Size (MWe net)
1 Unit Plants
2 Unit Plants
>2 Unit Plants
VVER/RBMK Plants

Safety



Support





Maintenance:
- Availability and use of contractor maintenance services,
- Degree of flexibility in work rules,
- Use of reliability centred maintenance/predictive maintenance,
- Extent to which multi-skilled workers are used,
- Plant design characteristics (e.g., design of components).

Engineering:
- Number and size of modifications,
- Availability of vendor services,
- Plant design characteristics (e.g., design of components),
- Quality and organization of plant documentation,
- Planned outage duration and scope,
- Use of system engineers,
- Reliance by maintenance organization on engineering for technical support.

Safety:
- Requirements of the QA program,
- Physical size of the site,
- Amount of radiation/radioactive waste,
- Relationships with regulators,
- Quality of training programmes,
- Plant cleanliness,
- Skill levels of plant workers,
- Plant design characteristics.

Support:
- Amount of training provided to plant staff,
- Use of multi-skilled workers,

- Extent of the use of computers,
- Relationships with contractors,
- Impact of competition,
- Amount of decentralization,
- Use of management control system.

Site services:

- Amount of social services provided by the plant based on national policies and plant location,
- Use of multi-skilled workers,
- Responsibility for the waste cycle,
- National and organizational safety policies.

3. Changes in staffing. Plants in most countries surveyed expect staffing levels to decrease modestly over the next 5 years. Plants in about 70% of the countries surveyed expect staffing to decrease through the year 2002. The size of the planned decrease ranged up to 5 percent per year in some countries. The median planned change in staffing of the surveyed countries was a 2% decrease in 1998 and a 1.5% decrease per year through 2002.

Most utilities that expect their staff to decrease believe the decrease will occur primarily in two areas:

- **Site services**, because functions not directly related to production (such as housing and transportation) were being transferred to other organizations, and

- **Maintenance**, as plants improve worker efficiency through process improvement initiatives, increased use of cross training and multi-discipline teams, and greater use of reliability centred maintenance.

4. Staffing benchmarking. Staffing benchmarking is a technique used by many plants to help identify how to optimize staffing levels at their plants. The process of benchmarking staffing allows management to understand how staffing at their plant differs from that at other well run plants, why these staffing differences exist, and actions which can be taken to reduce the staffing differences. A discussion of how to benchmark staffing is contained in Annex D. A case study of staffing benchmarking for an NPP is provided in Annex E.

2.3. LESSON LEARNED No. 3: CREATE A LEARNING ORGANIZATION

Many utilities are finding that the pace of change due to external factors is faster than ever before. The challenge for these utilities is to organize their efforts so as to respond to change in a structured manner, rather than in a chaotic way. In addition to the changes resulting from the initiation of open energy markets, technological advancement has resulted in major changes in NPP activities. Information technology has been widely adopted within the nuclear industry in areas of work management, materials management, financial systems, human resource management, outage management, and document control. The pace of such technological changes is likely to continue at present levels or even increase. The challenge created by information technology advances is to organize work to take full advantage of its potential.

The following are considerations when responding to such changes:

1. **Establish an environment where change is looked upon as a normal state of affairs, and continuous self-assessment is encouraged.** Change is a natural part of life. It is unreasonable to expect that one way of organizing work will be the most effective for all circumstances throughout the life cycle of an NPP.

2. **Confirm the need for change and communicate the need to all affected persons.** If item one is achieved, then change will be expected, and even embraced, if it has clear advantages over current practices. Those people who perceive that they have something to lose through reorganization will need particular attention in this respect.

3. **Make a realistic assessment of the situation, and identify the best integrated, overall approach.** An assessment of the situation can either be made by professional organizations, through self-assessment, or both. Based on this assessment, various options are identified for further discussion. The strengths and weaknesses of these options should be investigated from different aspects, e.g., cost/benefit, influence on safety, number of people, number of layers of management, and conformance with functional processes. Also, an implementation strategy should be prepared with the optimal date, duration, and detailed time schedule of the structural change. An integrated, overall approach is needed.

4. **Establish an experience feedback program and associated indicators to monitor progress**. It is important to establish measures which can be monitored in order to determine whether the objectives of reorganization are achieved.

5. **Consider human related aspects**. During preparations for an organizational change, communications with affected staff should be carried out. Strategies for looking after people who are leaving, remaining or considered for promotion should be identified. The role of trade unions should be identified. A viable process for selecting managers and other key personnel should be clearly communicated.

6. **Manage the change process**. There will be a transition period between the past and the future structure which needs very careful management. The main criterion is that safety must not be compromised.

7. **Measure results**. Continuous monitoring and evaluation of the change process is needed. The organization must be candid enough to admit if a change has not been effective, and be willing, after a suitable time to acknowledge that a modified approach is needed. Managers have been found to develop more realistic and reliable proposals for change when they know that implementation will include evaluation of the achievement of their goals.

2.4. LESSON LEARNED No. 4: DESIGN THE ORGANIZATION TO AID IN ACHIEVING THE PRODUCTION POTENTIAL OF THE PLANT

For those NPPs that are not operating near their potential in terms of capacity factor, it is likely that improving plant performance will have a greater economic impact than reducing the costs that are controllable by plant management. The high capital investment in nuclear power, means that typically the staffing cost represents 5–15% of the cost of production. Thus, even a 50% reduction in staffing costs would have less economic effect than a 10% increase in capacity factor (all other factors remaining the same). This statement is not meant to suggest that reducing costs are unimportant, only to emphasize the economic importance of achieving the availability potential of the plant.

The main ways in which the plant organization can influence plant operational performance is through:

- Controlling the duration and frequency of planned outages through better planning, conduct and evaluation of maintenance activities.
- Reducing the frequency and duration of forced outages, or power reductions due to errors or inadequate maintenance.
- Improving plant material condition so that components and systems continue to perform their design function.
- Measures for increasing thermal/electrical power and efficiency.

The following are proven approaches related to organization to address these issues:

Maintenance management and organization. Some of the reductions in planned outage duration have been directly the result of reorganizing preventive and corrective maintenance programmes. These improvements have included: the increased use of on-line maintenance, and avoiding unnecessary preventive maintenance based on diagnostics and equipment history data. IAEA-TECDOC-928, *Good Practices for Cost Effective Maintenance of Nuclear Power Plants*, and IAEA-TECDOC-621, *Good Practices for Outage Management in Nuclear Power Plants* provide details concerning maintenance and outage management improvements discussed in the paragraphs below.

Outage planning and organization. Significant reductions in the duration of planned outages while maintaining high quality results in terms of both safety and operational performance have been achieved by utilities in a number of Member States. Careful consideration should be given to the organization of both outage planning and execution. Many utilities have found it to be a good practice for the outage organization to be a team based on a project organization approach. The establishment of a full time outage manager has proven beneficial. The outage manager should lead the outage planning team, which should consist of team members having experience in operation, maintenance, radiation protection, quality assurance and modification planning. Also, it is a good practice to include a person qualified as shift supervisor in the outage planning team. It has been found to be a good practice during an outage to have some shift operations personnel who are dedicated to monitoring plant systems and configuration control. Other operators are dedicated to support outage activities such as isolation of equipment for maintenance and post-maintenance testing. For major projects, such as major component replacement or refurbishment, partnering with suppliers/contractors should be considered. Annex F provides an example of the project organization for a major project in the Czech Republic.

Increasing individual employee ownership and responsibility for the results of their work. Employees should be encouraged/expected to correct deficiencies when they find them (within the limits of safety rules). Shift operations personnel should take responsibility for minor maintenance in their areas (within clearly defined bounds to avoid potential compromises in safety).

Standardize activities. Work should be planned, and performed, using a standardized approach (for example, only doing maintenance work on one train of a system at any time).

Challenge past practices. Organizations have reviewed their work practices asking two basic questions of each activity: "Why do we do it?" (i.e., what value is there in the work?) and, "How could we do it better?" With respect to the first question, it is not enough to respond, "Because we've always done it that way." Rather, the response should specifically identify the result of the activity (e.g., for an activity such as, "provide radiation protection technicians at entry points to contamination control areas," the reason it is done is to prevent the spread of contamination. However, properly trained workers have been successfully given this responsibility at some NPPs).

Involve all NPP personnel. The details of work processes for an organization are generally not well known to NPP managers. Only through involvement of staff from all levels of the organization will the best solutions be identified.

Use activity based costing. Activity based costing is a reorganization of cost accounting of NPP work based on activities instead of organizational groups and units. The activity supervisor determines the needed resources, then costs associated with these activities are identified and monitored. Cost accounting data is used to:

- Reveal problem areas
- Show results of business process improvement efforts
- Determine standard costs for planning
- Acquire a better knowledge of costs for future planning.

Methods of accounting for improvements permit management to balance required resources with the associated benefits. In this way, the risks associated with change can be controlled.

Increase productivity. Eliminate non-value added work (e.g., large number of review and approval signatures dilutes responsibility). Maintain an internal customer orientation. Reduce the number of interfaces and assign full responsibility. Transfer interfaces from the organizational level to the expert level (process-based and team oriented solutions). Identify appropriate measures to monitor performance.

Annexes G and H provide examples of ways in which utilities are finding more effective ways to work. Annex G provides information on how the Olkiluoto NPP in Finland has been successful at achieving essentially all of the production potential available, given the plant design, using several of the methods outlined above.

2.5. LESSON LEARNED No. 5: ENCOURAGE TEAM WORK TO IMPROVE PERFORMANCE

Teamwork is one of the most important aspects of any group and in particular within an NPP organization which has to organize many different aspects and disciplines. Multi-discipline teams, by virtue of their organization and make up, are able to apply the necessary skills as one cohesive group. The following are details with respect to efficiencies that can potentially be realized through multi-discipline teams.

Reduce interfaces and hand-offs. Often situations and problems arise during NPP operation and maintenance that start off with one discipline and end up with a solution involving another discipline. Typically a mechanical vibration problem may be monitored by an electronic condition monitoring system. Where separate discipline groups are involved, the individual groups have different priorities and concerns. Consequently interface and hand-off issues often arise which reduce the effective consideration of an overall issue. Where individuals have easy access within their team to personnel with all the skills needed to complete a task, greater productivity of both the individuals and their teams results.

Form multi-disciplined teams. When forming multi-disciplined teams, a balance needs to be made between the flexibility of the team being able to address any plant problem and the need for ownership of a particular plant item or system. In deciding the best organization a compromise is often required, balancing ownership with flexibility. For example, task based teams allocated and working within general plant areas like the turbine building and reactor building provide a suitable compromise. It is recommended that the above aspects be fully considered and the balance required for a particular location and organization be determined.

Increase ownership of tasks and/or systems. As multi-discipline teams develop they inevitably become more closely associated with particular tasks and plant systems. This ownership improves the quality of the maintenance as a greater degree of ownership, understanding of plant history, and plant performance develops. Work areas or functions may be assigned to groups to reinforce this ownership. Where groups or individuals are task based rather than plant or system based the same advantages apply to the task.

Increase job satisfaction and provide skill broadening. As individuals recognize the efficiencies, flexibility and improvements that can result from multi-disciplined teams, increased job satisfaction and motivation often result. Also, individuals have opportunities to broaden their skills to cover more than one aspect of a job or task.

Reduce costs and increase flexibility. The increased flexibility brought about from multi-disciplined teams leads to reduced costs. Individuals are able to identify opportunities for cost reductions. Within an NPP organization a practical and achievable approach is to employ skill broadened individuals working within a multi-discipline team. In this way individuals are able to retain a high degree of skill in a particular area yet at the same time have sufficient skills to maintain complete plant items. This enables tasks to be performed by a single person, encourages greater ownership of plant items or tasks, and reduces interface/communication problems. When all of these arrangements are linked with a suitable reward and recognition policy it can improve the motivation and efficiency of individuals and groups.

Team planning/empowerment. Within the framework of an overall plant programme the team itself is often best equipped to plan and direct the work to be performed. Self directed teams feel empowered and motivated. This also has the advantage of pushing decision making down to the lowest appropriate level.

2.6. LESSON LEARNED No. 6: SHARE HUMAN AND OTHER RESOURCES AMONG UTILITIES/NPPs

The principal motivation for sharing of resources is to provide more efficient, effective and lower cost ways to accomplish needed work. Sharing of human resources can be beneficial not only for the utility/NPP but also for the employee. From the viewpoint of management, sharing of human resources will improve efficiency, while plant staff gain knowledge and career growth. At the same time, however, there remain some issues to be resolved for the effective sharing of human resources, including: scheduling, control, training and qualification. Heightened competition has the potential to negatively affect the continued sharing of information to help NPPs operate safely and efficiently. However, this potential for reduction in sharing must be overcome.

Multi-site utilities. Sharing of human resources among units of similar designs at the same site can be most easily and effectively conducted because of common characteristics in terms of the facility, equipment and experience, as well as no additional costs due to travel expenses. However, sharing of human resources among other sites, or from a utility headquarters organization has also been demonstrated to be effective. One of the biggest issues in such sharing is the difference in procedures and configuration between sites. Accordingly, it is important to enhance similarity among sites as much as possible by standardizing procedures and work practices. In addition, standardization such as preparation of a common training program may contribute to a solution of these issues. Standardization of radiation protection measures, equipment names/designations and computer systems may also be useful measures.

Single unit utilities. Some single unit nuclear stations have formed alliances to co-ordinate procurement, resource sharing and consolidation of internal functions. Members benefit by sharing existing resources, such as helping each other during outages through exchange of workers. Rather than each unit maintaining its own spare parts, one common facility serves all the members of the alliance. Benefits include lower unit costs due to volume purchases, lower inventory costs, and fewer resources required to staff the facilities. It is often not efficient for each site to have their own personnel with specialized skills, particularly those skills that are infrequently used. Thus, it is necessary to identify employees with specialized skills who may be assigned to a site when needed. This method may also apply to those who have gained expertise in large scale modification projects.

Consolidate research and development (R&D) and other support. Particularly in a competitive market, R&D and other needed industry support activities need to be focused on the most important industry needs. Unnecessary redundancy needs to be avoided and results need to be communicated clearly to all interested parties.

Identify the value of information sharing. It is generally recognized that safety problems and poor operating performance of NPPs anywhere in the world have the potential for large negative impacts on all NPPs. Thus, in the nuclear safety area, the need for co-operation and information sharing far outweighs the consequences of helping a potential competitor. Safety concerns at any NPP impact every plant. A decision for early shut-down of an NPP based on economic considerations casts a shadow across all the rest. Therefore, it is in the interest of the industry for every nuclear unit to be operated safely and economically. Activities such as bilateral assistance efforts between Member States, and WANO "twinning" arrangements among utilities have been particularly effective.

2.7. LESSON LEARNED No. 7: ESTABLISH PARTNERSHIPS WITH CONTRACTORS/SUPPLIERS

Contractors provide essential resources for the conduct of planned outages. For many utilities, particularly those with only a few NPPs, the size of plant maintenance organizations is based on maintenance needed for routine operations. During outages, the maintenance workforce increases to several times this size (from 500 to 2000 persons depending on utility practices and outage extent). For many utilities, during an outage, the majority of persons onsite are contractors. Also, as plants age, it is quite likely that there will be increasing difficulties in obtaining spare parts and replacement parts for plant equipment. In both of these cases a relationship of mutual co-operation can bring significant benefits to both NPPs and their contractors/suppliers.

Establishment of long term contractual relationships, and good working relationships between NPPs and their main contractors and suppliers has proven to be effective. Such contracts provide a mechanism for sharing the risks and rewards of improved plant performance. Partnerships are not about transferring jobs to contractors at the expense of plant staff, but about achieving mutually beneficial goals. There are significant benefits to be gained by improved working arrangements between NPPs and their contractors

In order to enhance quality and to optimize costs, it is a good practice to consider the following:

- Long term contracts (3 to 5 years) with main contractors
- Competition among contractors
- Fixed price contracts with quality bonuses given directly to the people doing the work
- Preplanning of activities together with contractors
- Contractor personnel being considered equal members with utility personnel in outage teams.

When utilities have identified ways to reduce staff sizes, a common issue is what to do with the personnel who are no longer needed. Many utilities, particularly those whose labour laws or union contracts preclude them from layoffs, have decided to take over some functions traditionally performed by contractors. It may instead be possible to transfer such personnel to the contractor. This may be a superior approach particularly if the contractor can do the work more efficiently and effectively.

Utilities should integrate contractors into their safety management system and their safety culture. This includes involving contractors in safety meetings, planning, preparing work procedures and instructions, incident analyses, training programs, and providing information concerning lessons learned and standards.

An important aspect of the use of contractors is that the utility must retain adequate control and supervision of the contractors in order to retain the responsibility and accountability for safety. Similarly, the utility must retain sufficient and suitably competent people to sanction and evaluate the work of contractors.

2.8. LESSON LEARNED No. 8: SPECIAL ORGANIZATIONAL CONSIDERATIONS FOR "INTERNATIONAL" PROJECTS

The types of projects addressed here are those where foreign vendors, in addition to providing systems and hardware, are also providing significant portions of the plant organization and staff, at least during startup and initial plant operation. The significance of these types of projects is that there is an overriding need to resolve differences in business practices and regulations among the international participants in such projects.

Establish business practices for the project and maintain these good practices after transfer of responsibilities. Areas of differences in business practices are often: standards of work performance, compliance with and use of written procedures, communication methods and practices, ownership, and productivity expectations. Managers representing all local and foreign organizations with significant involvement in the project first agree on the business practices that will be used for the project. Often their is a strong reliance on the practices of the major suppliers, particularly if the local organizations have little or no experience in nuclear power. These practices then need to become ingrained in the organization's culture, and plant personnel need to be convinced of the value of such practices.

Licensing/authorization of temporary, foreign NPP staff by the regulatory body. Special provisions in regulations and procedures have often been needed to accommodate licensing/authorization of foreign NPP personnel, who are sometimes used, on a temporary basis to augment/train local staff. Such considerations often include accepting the responsibilities and associated liabilities of such positions.

Establish one safety culture for the project. Because of cultural differences among the various organizations/countries involved, particular emphasis needs to be placed on establishing and communicating safety culture expectations. Training courses, meetings and team-related activities should be used in order to establish and reinforce expectations. Among the potential topics for such activities are establishing management expectations, self-assessment, and risk assessment.

Staffing and training of NPP personnel. Initial staffing of such projects will be significantly higher than that of similar plants in the supplier's country. There are several reasons for this; among them are: redundancy of personnel in key positions for purposes of training, significant periods of training time at similar plants, training staff for subsequent units, and finally, the services that are provided in the supplier's country by outside organisations are not available in the local economy, and thus the plant must provide its own capabilities. Additionally, in order to attract and retain staff for an NPP, particularly at a remote location, it may be necessary for the utility to provide and maintain support services such as hotels and restaurants, apartments, houses, schools and recreation facilities.

Laws and regulations. Particularly for the first NPP in the country, it is quite likely that existing rules and regulations will not address all of the unique characteristics of an NPP. The design and organizational structure of the NPP in the supplier's country have been based on a certain set of rules and regulations. If there are significant differences between the rules and regulations of the two (or more) countries then costly revisions in plant systems and/or organization can be the result. The affected laws and regulations are certainly those related to nuclear safety, but others are also of concern (financial, procurement, environmental, industrial safety and fire safety

Transfer of operational responsibilities and authority. Both legal and organizational issues are involved in such a transfer. In some cases, a consortium has been established which has the legal and operational responsibility for startup and initial operation of the plant. Procedures need to be established for a gradual and well structured transfer of responsibility and authority. Methods to ensure that experience is transferred also need to be established.

Organizational structure reflects both local and supplier norms. Areas of particular emphasis should be quality assurance, configuration management, licensing, health and safety programs, materials management, and emergency preparedness. The licensing practices and requirements of the participant countries will also have an influence on the organization structure (e.g., separate turbine and reactor operator, or control room operators who are qualified for both positions).

Language(s) for communication. It is necessary to agree upon the language, or languages that will be used in areas such as plant documentation and training programs. It is quite common for such documents to be developed in both the languages of the host country and the supplier country.

Annex I provides an example of the organizational structure for the construction and commissioning of the Guangdong Daya Bay Nuclear Power Station in China.

Annex A

NPP ORGANIZATIONAL ANALYSIS CASE STUDY

This annex reproduces, as a case study, an organizational analysis conducted for a nuclear utility. In order to maintain the confidentiality of this utility, it is referred to in the case study as "Utility X." The case study is presented in the same format and style as if the results were being presented to the senior managers of Utility X. While the entire organizational analysis may be of interest to the readers of this publication, what may be of particular interest are pages 31–32, which relate organizational design principles to the implementation of a new organizational design for Utility X. The study was conducted by the US consulting firm of Tim D. Martin & Associates.

Our objective in this analysis was for Tim D. Martin & Associates to analyze the organization design of Utility X. To achieve this objective, we established a set of organizational design principles which build on the results of previous Utility X organizational work. We documented the structure and design principles used by other nuclear power plant operators, including those with combined nuclear, fossil and hydro generation groups.

Next, we reviewed the current Utility X Nuclear organization reporting structure. We proposed recommendations to improve Utility X's organizational structure based on our assessment of the current structure against the design principles and structures at other utilities.

Our approach, compared Utility X to other utilities and the design principles, is displayed graphically below.

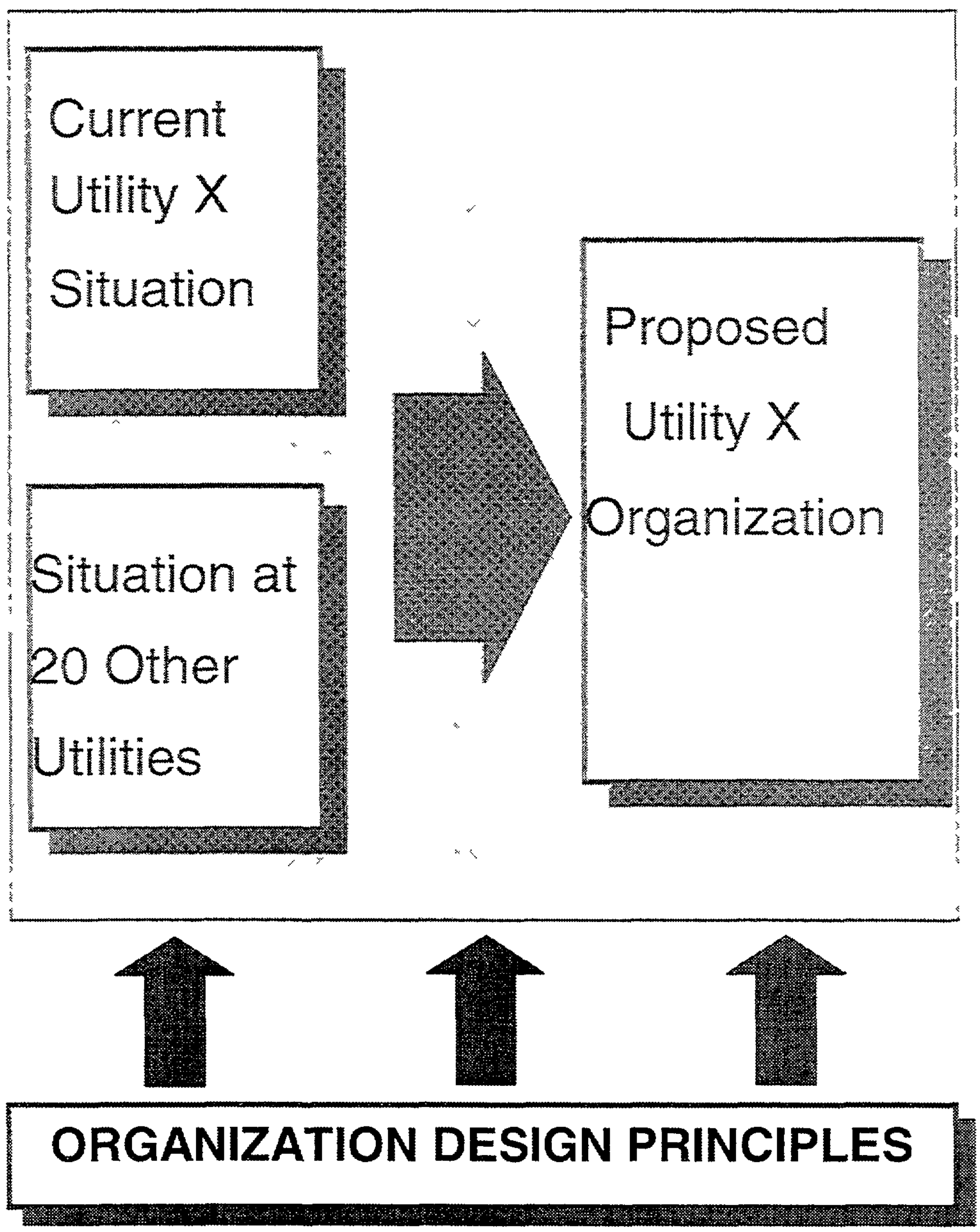


FIG. 1 Overall approach.

For our approach, we used interviews and written materials to document the Utility X organization structure. Interviews were conducted with key managers and knowledgeable persons, including: Senior Vice President, Vice President, Plant Manager, Nuclear Engineering Manager,15 functional unit managers and HR consultant. Written materials we reviewed included organization charts, nuclear department procedures, and past organizational design and strategy documents.

Organizational design principles were an important part of the analysis. The principles we developed were comprehensive and fundamental statements of design philosophy that have proven useful in structuring top performing organizations. Design good practices describe alternatives for how a specific principle can be implemented.

Principles were developed primarily from our experience working with senior managers at electric utilities. In addition, we used principles established by leading management development theorists including Peter Drucker, Geary Rummler, and David Nadler. We also reviewed design principles developed in past studies performed for Utility X Nuclear Department.

We identified 6 principles for nuclear organization design:

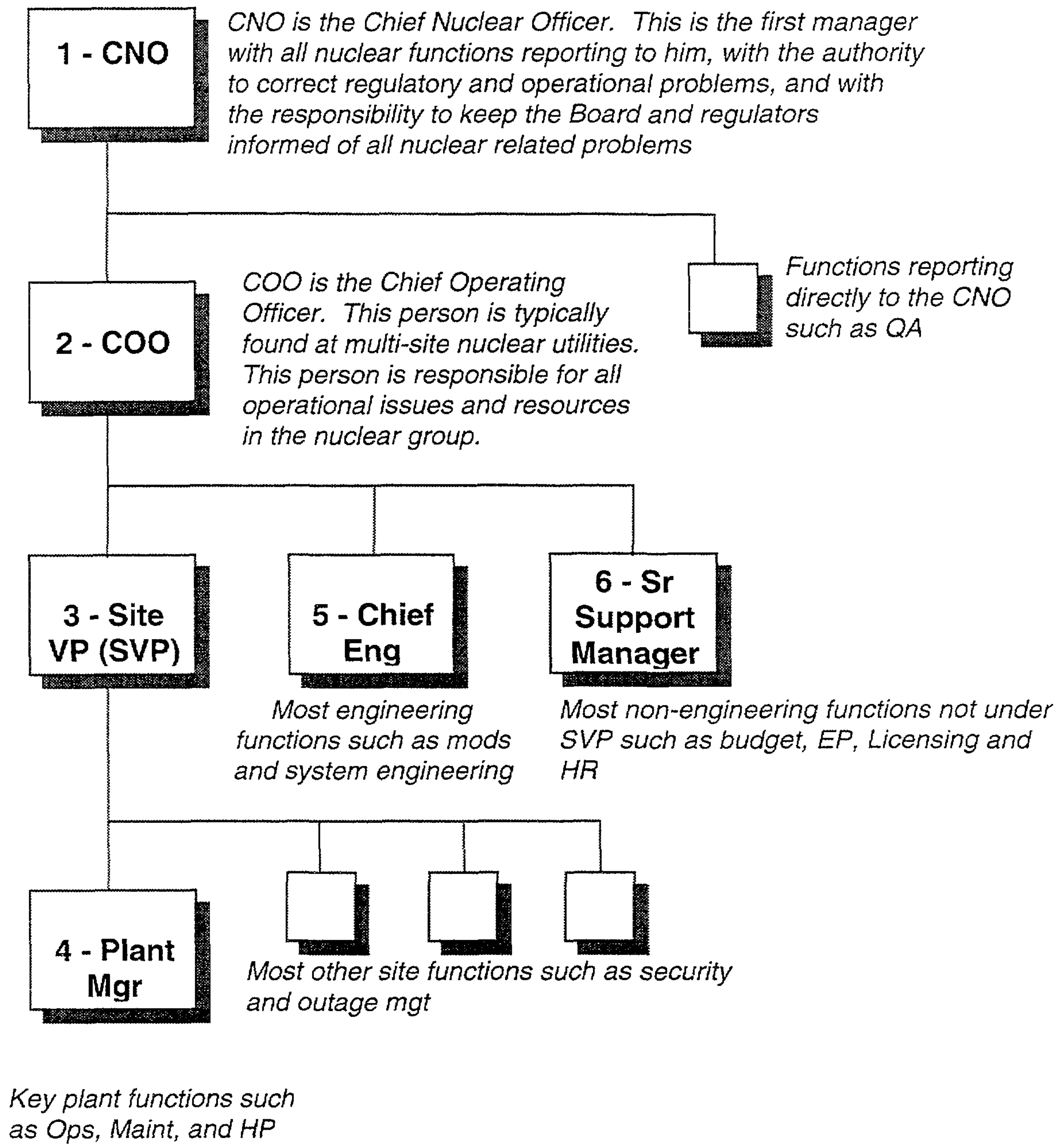
1. Design the organization based on the company's vision,
2. Organize work functions to enhance interfaces among work groups,
3. Increase spans of control and minimize layers of management,
4. Minimize the number and size of staff organizations,
5. Design the organization to be flexible, and
6. Change the organization design only when needed to meet objectives.

Each principle and the specific practices used to implement the principle at good performing utilities are discussed further at the end of this Annex. Organizational design principles were used in our analysis to identify existing organizational design problems, and understand the linkage between organizational design deficiencies and issues discussed with us by managers. Three parts of a nuclear department's organizational structure were analyzed in-depth. We analyzed the senior manager organizational structure, the arrangement of work functions within the senior manager organizational structure, and the organizational structure of each work function. Each of these is discussed on the following pages.

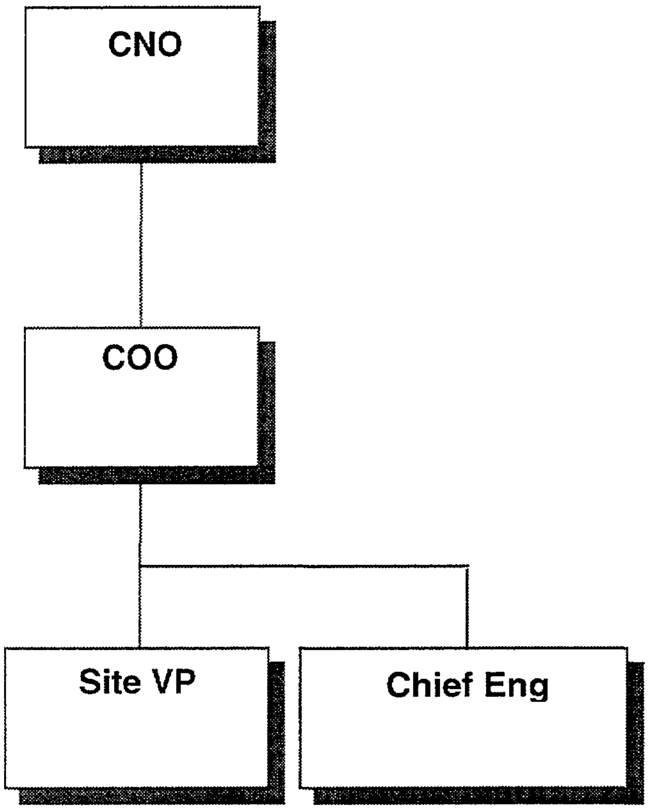
On the following pages, several abbreviations are used:

EP = energy planning
HP = health physics
HR = human resources
NSR = nuclear safety review
QA = quality assurance
QC = quality control
STA = shift technical advisor

We found that the senior management structure at a nuclear utility has 6 possible positions.



However, the current Utility X organization currently uses only 4 of these manager positions.



At Utility X:

There are three layers of management above key nuclear functions such as operations, maintenance and system engineering.

Site VP is currently titled Plant Manager. He has the responsibilities of, and is functioning as, a site vice president.

There are no Senior Support Manager that are peers of the Site VP or COO.

Operations	System engineering
Maintenance	Mod engineering
Other site functions	Other engineering and support functions

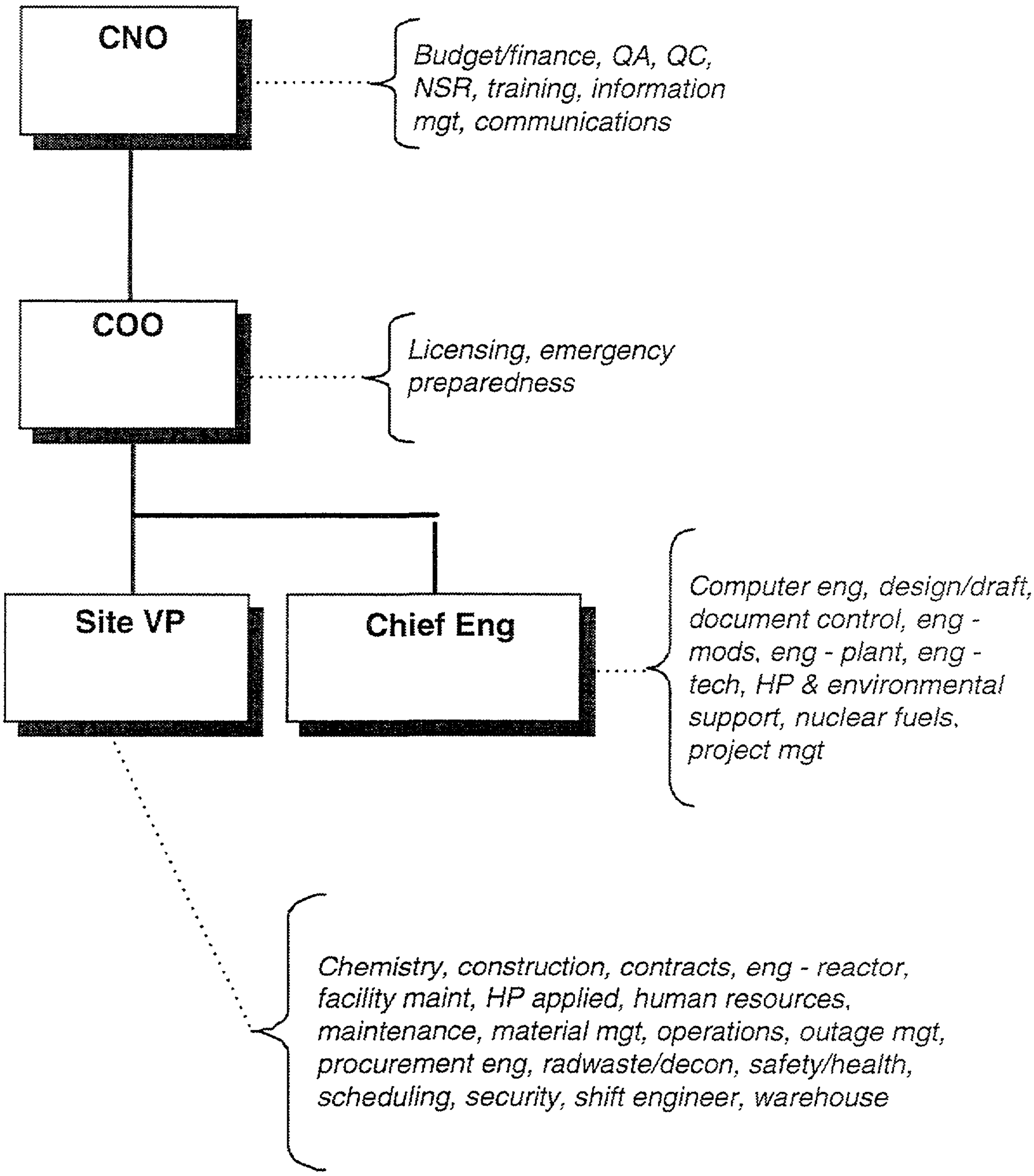
This organization structure at Utility X is different from that used at many utilities. At most other utilities, there is both a Plant Manager and a Site VP. The plant manager is more narrowly focused on plant operations and maintenance which allows the Site VP to balance plant internal and external demands.

Utility X is the only good performing utility with no Senior Support Manager positions. With these positions the CNO/COO directly manage fewer functions which provides positions for senior manager rotations. Utility X is also the only single site utility with both a COO and Site VP position. At these other utilities a Site VP reports directly to the CNO. Utilities with a generation group also do not have both positions.

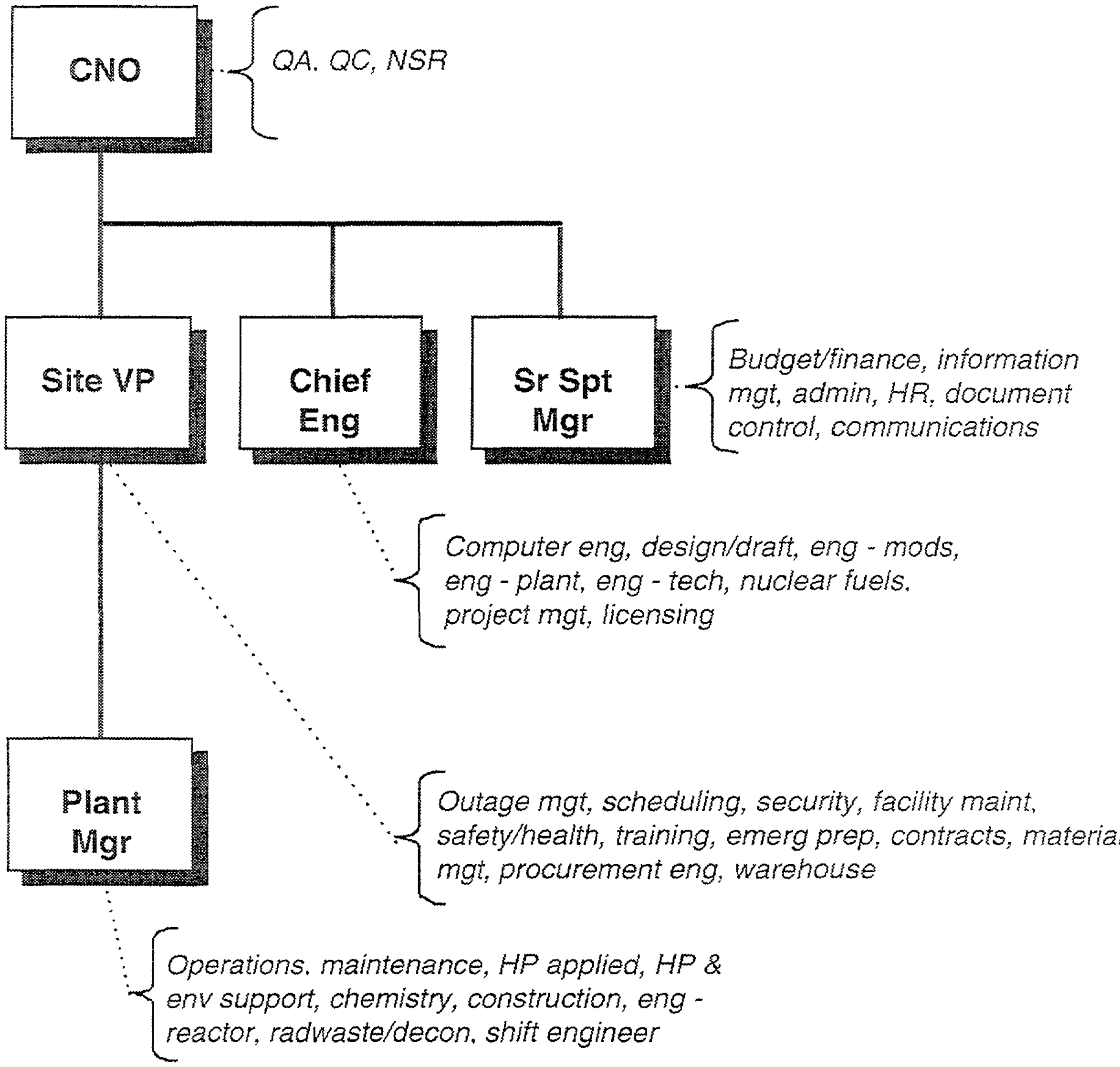
In the industry, 37 functions are grouped among managers in a nuclear department. These functions are listed below.

Admin	Document Control	HP & Env Support	Operations	Scheduling
Budget/fin	Emerg Planning	Human Resources	Outage Mgt	Security
Chemistry	Engr – Mods	Information Mgt	Procurement Eng	Shift Engineer
Communications	Engr – Plant	Licensing	Project Mgt	Training
Computer Engr	Engr – Reactor	Maintenance	Quality Assurance	Warehouse
Construction	Engr – Technical	Material Mgt	Quality Control	
Contracts	Facility Maint	Nuclear Fuels	Radwaste/decon	
Design/drafting	HP Applied	NucSafety Review	Safety/health	

Current Utility X organization assigns functional management responsibilities to 4 senior managers in 3 levels.



Other single site utilities assign management responsibilities to 5 managers in 3 different levels.



As a result of these differences, functions are arranged differently at Utility X than at many good performing utilities. At most utilities, the CNO and COO, if one exists, do not directly supervise functional managers. Functions that report directly to the Utility X CNO and COO report to different managers at other utilities. These include: Information management, training, budget/finance, emergency planning, and licensing. Site functions at other utilities are split between the Site VP and the Plant Manager.

Next, we analyzed the 4 parameters which describe the organizational structure of each function. They are: Average span of control of managers and supervisors performing the function, title of senior functional manager, number of layers below the CNO of the senior functional manager, and number of organizations performing the function.

The functional organization design at Utility X is similar to other utilities in most areas. The number of organizations responsible for each function at Utility X is similar to the number of organizations at other utilities. There are a few instances where there is more than one organization responsible for a function at Utility X. This is because of the off-site location of more staff at Utility X than at most utilities.

There are also a few differences in functional design between Utility X and other good performing utilities. These differences are in 3 areas and are shown in the following tables: There are more layers of management in some functions, span of control is narrower in some functions, and the title of some managers is different.

Several Utility X functions have more layers of management than many utilities:

FUNCTION	LAYERS AT UTILITY X	LAYERS AT BEST UTILITIES
Maintenance	4	3
HP applied	4	2 – 3
Security	4	2 – 3
Plant engr	3	2
Chemistry	3	2
Radwaste/decon	3	2
Nuc safety review	3	1 – 2
Nuclear fuels	3	1 – 2

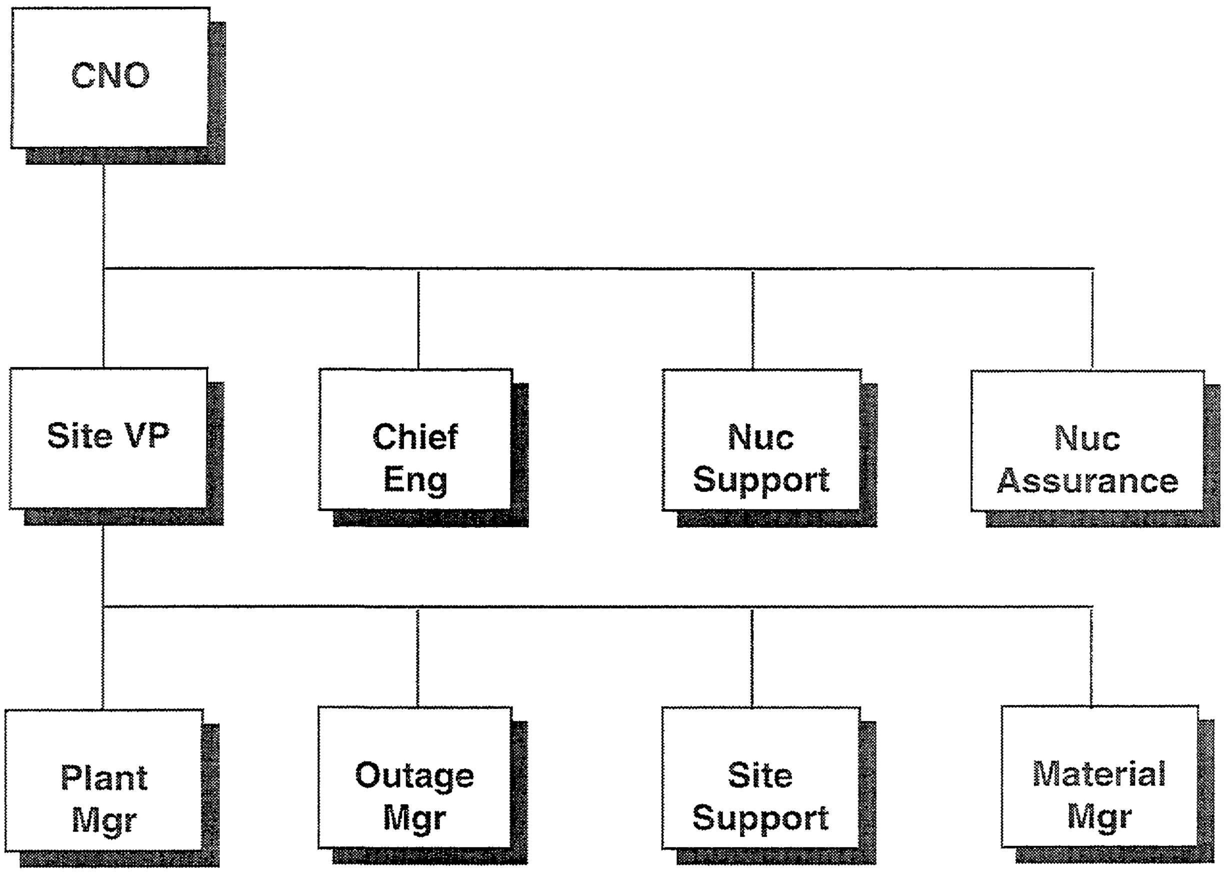
Several Utility X functions have relatively narrow spans of control:

FUNCTION	SPAN AT UTILITY X	SPAN AT BEST UTILITIES
Chemistry	7	12
Engineering – Plant	4	11
Engineering – Tech	6	9
Nuclear Fuels	3	7
Nuclear Safety Rvw	4	7
Security	6	9
Training	4	9

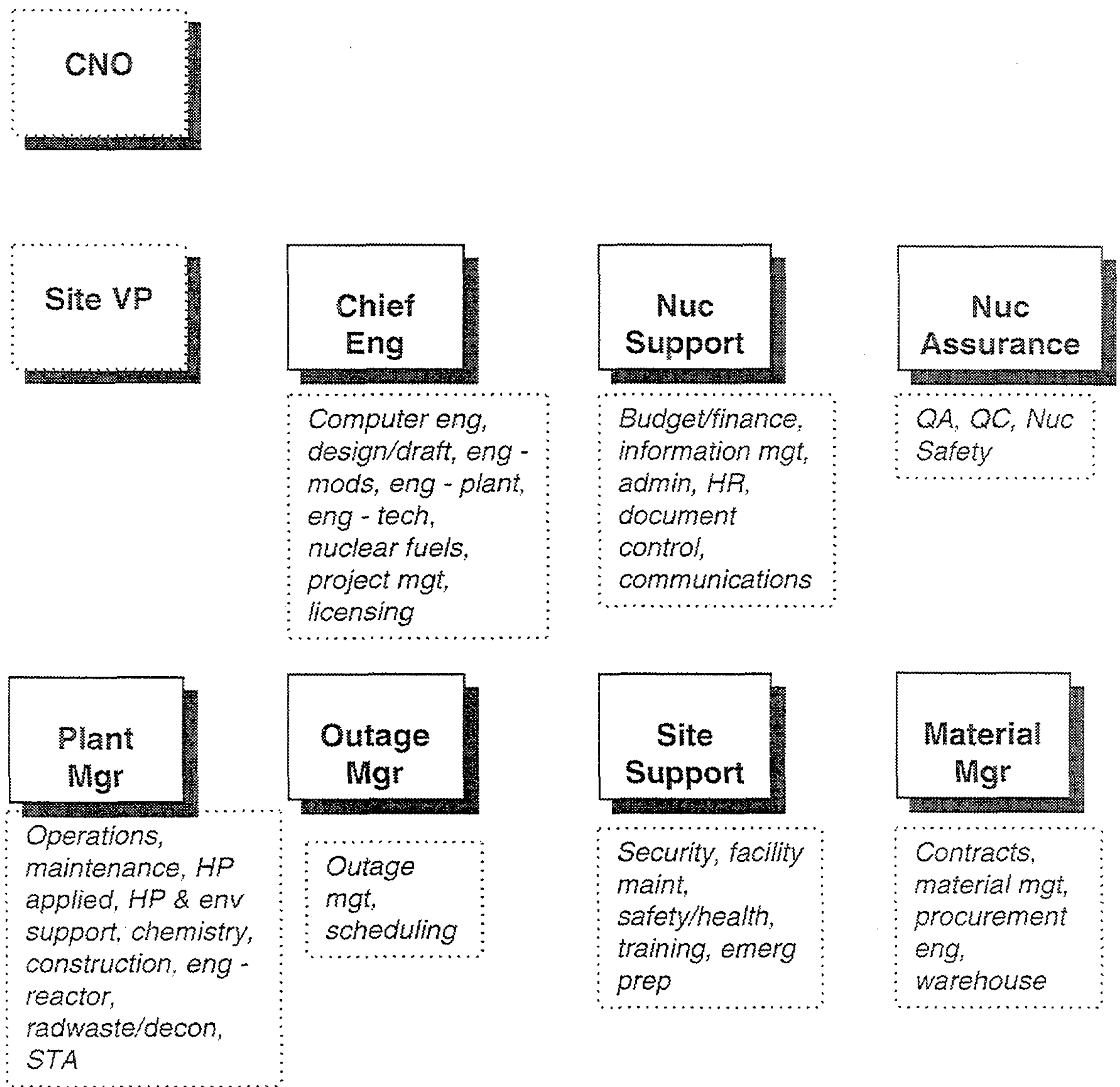
Titles of some Utility X functional managers are different from those at many utilities

FUNCTION	TITLE AT UTILITY X	TITLE AT OTHER UTILITIES
Licensing	Supervisor	Manager
HP Applied	Supervisor	Superintendent
HP & Env Support	Supervisor	Superintendent
Document Control	Supervisor	Manager

Based on these findings, a new organization design is recommended for Utility X:



Functional responsibilities in the new organization would be split among seven managers.



The transition to this new organization would involve several key steps. The Senior Vice President, Generation would transition out of the CNO role which would mean all functional nuclear groups would be placed under the control of the Vice President, Nuclear Operations. This position and the CNO designation would be retained in the Vice President, Nuclear Operations position.

A new senior support manager position would be created and be responsible for many of the functions currently reporting directly to the Senior Vice President and Vice President. Key plant functions would be placed under the control of a new manager position. Position would be focused on operations, maintenance and health physics, and position would report to the current Plant Manager position.

Several other changes are recommended based on differences between Utility X and other good utilities. First, reduce one layer of management in several functions: Maintenance, HP

Applied, Security, Plant Engineering, Chemistry, Radwaste/Decon, Nuclear Safety Review and Nuclear Fuels. Next, increase spans of control in several functions including: Chemistry, Plant Engineering, and Training. Finally, change the title of the Licensing Supervisor to Manager.

SUMMARY OF ORGANIZATION DESIGN PRINCIPLES UPON WHICH THE RECOMMENDATIONS HAVE BEEN MADE

PRINCIPLE	APPLICATION IN NEW ORGANIZATION
1. Design based on vision	Added Plant Manager focus on ops, maint and HP; unburdened Plant Manager of Site support activities and place those under a Site VO; decrease day to day activities of COO/CNO
2. Organize to enhance interfaces	Improves interfaces by moving licensing to engineering; training, emergency planning and HP & environmental support move to the site organization; and document control move to a new Nuclear Support Manager
3. Increase spans and minimize layers	Increases spans and reduces layers where different from other best performing utilities; reduces layers in many functions as the CNO moves down one layer
4. Minimize staff organizations	Support functions grouped together into one group and one site group and one site group
5. Design to be flexible	Spans increased and layers decreased which allows more functions to be grouped under a common manager
6. Change only to meet performance objectives	Only areas where Utility X is different from other good utilities ***and*** changes will help meet objectives are recommended for changes; will provide more oversight on key performance and cost areas.

The following discusses different ways to implement the design principles:

Principle 1: Design the organization based on the company's vision. Companies where cost is central to their vision will increase the importance of the maintenance process (scheduling, outage management and maintenance) in the organizational design. Companies emphasizing high system availability will increase the importance of system engineering in the organizational design. Companies with a conservative approach to operations will increase the importance of quality assurance, nuclear safety review and engineering in the organizational design.

Principle 2: Organize work functions to enhance interfaces among work groups. To implement this principle, combine functions to reduce the number of interfaces needed to accomplish work (e.g., communications, approvals, task coordination and hand-offs). For example, place plant functions in one organization, engineering functions in one organization and oversight functions in one organization. Organize by process where appropriate. Where it is impractical to organize by work process, and where there are numerous interfaces between work groups, proactively manage the interfaces. This can be achieved using positions such as system engineers or work week managers

Principle 3: Increase spans of control and minimize layers of management where possible. At senior manager levels, balance fewer layers and broader spans with capabilities of managers, and management oversight needed for a group of functions. Within a function, customize the layers and spans by taking into consideration technical complexity of the function, amount of coordination needed for work process, and capabilities of workers, supervisors and managers.

Principle 4: Minimize the number and size of staff organizations. Combine all staff groups under 1 or 2 managers. When staff groups are combined into a few organizations, there is less tendency for their responsibilities to increase, and staff manager positions can be filled by line managers as rotational assignments. Assign staff functions as collateral, part time responsibilities of line organizations. The alternative is to create a specialized group to perform a staff function but this approach often results in extra resources and attention devoted to a function.

Principle 5: Design the organization to be flexible. This can be achieved by increased use of teams and multi-skill workers. Reduce the number of job titles and worker classifications. Place more responsibility under fewer managers. Improve the ability of managers to move people as resource needs change.

Principle 6: Change the organization design only when needed to meet performance objectives. Organization redesign is required when the structure no longer supports 1 or more strategic objectives. Organization redesign is typically not the best solution to personnel issues. It results in "quick fixes" which negatively impacts other parts of the organization. Relationships are disturbed with each organizational change which can disrupt work flow.

Annex B

MAINTAIN A FOCUS ON SAFETY

Deregulation may create economic stresses that have the potential to negatively affect safety performance. Nuclear regulators are becoming increasingly interested in the economics of the restructuring of the electric industry. In the future, NPPs will be finding more efficient ways to maintain current levels of safety, or even improve upon them. Many of these changes will be achieved through more efficient use of human resources, and reorganization. These changes will mean that the mechanisms that nuclear regulators have relied upon in the past to confirm safety performance will, in some cases, need to be replaced with other measures that provide an equivalent level of confidence in performance.

A feature of successful organizations is that safety is given a high priority and is integrated into their management systems. A good safety record also gives confidence to an organization's employees, regulatory authorities, the public and other stakeholders. This in turn leads to employee commitment and loyalty, less regulatory intervention, fewer public objections and market confidence. Another way to state this relationship is that good safety is good business.

Economics are vitally important — but NPP managers have to be sure that the message they are sending to their employees and the public is that nothing is more important than safety. The only way that NPP managers can consistently send that message is to continue to believe it — and to consistently take actions that reflect their commitment to safely operating their plants. One proven way to link safety and economics in a positive way is to convince employees that operating safely is the only way to long term economic security. Thus, doing things right the first time, which always include safety as a consideration, is necessary for success in the future. From an organizational perspective, this means that employees at all levels of the organization have the responsibility and the authority to take the actions needed to correct errors and to avoid unnecessary or unsafe actions.

Nuclear regulators are understandably reluctant to give up the bases upon which they ascertain the safety level of an NPP, particularly in an environment in which many aspects of NPP operation are changing. Thus it will be even more important than it has been in the past that the utility and the NPP be organized in such a way that decisions made which affect the safety of the plant are transparent to the nuclear regulator. This has the dual advantage of also addressing the point above, concerning visible demonstration to employees of the importance of safety. If savings are to be realized, then inefficient methods need to be improved, and unnecessary work stopped. The burden is on the utility to provide objective bases to demonstrate that necessary levels of safety are being maintained or even improved through new, more efficient processes. A number of utilities have found that the use of information technology and risk-based decision making tools to both improve efficiency and confirm the safety of alternative approaches have provided assurances to nuclear regulators that new approaches are acceptable. Having a transparent organization with respect to safety decision making also means that the regulator is encouraged to interject questions and issues into the decision making process along the way, rather than at the end, when the consequences and costs of resolving such questions/issues are higher.

It is important for many reasons to: maintain safety standards, good safety management systems and safety culture to ensure efficient and effective interaction with the regulator. One of these reasons is that extensive intervention by a regulator is inefficient and expensive.

Furthermore, punitive and prescriptive regulation can undermine a safety culture by creating controlled communications and removing initiative and ownership. Regulating intervention can be minimized by fostering good communications, sharing information on initiatives and any incidents which have occurred, and demonstrating continuous improvement through learning and self-regulation.

Annex C

STAFFING SURVEY METHODOLOGY

A survey approach was used to collect staffing data to be used in the proven approaches to staffing section of this report. The survey approach had four steps:

1. Determine the information to be collected.
2. Identify the plants to be included in the collection process.
3. Develop a survey form which was then sent to each participating utility.
4. Collect survey results and transcribe them to this section of the report.

This survey is meant to provide an initial, approximate review as to the staffing strategies of plants of different design and in different countries. It was not the intent of this report to perform an exhaustive staffing review or analysis, or to conduct any type of benchmarking. Annex D discusses the methodology for conducting a formal staffing benchmarking of an NPP and Annex E provides a case study of the results of a formal benchmarking at an NPP.

The information collected for NPP staffing data was the total staffing levels at, and supporting, each nuclear power plant including:

- Plant staff
- Nuclear headquarters staff (fully apportioned to all NPPs operated by the company)
- Non-nuclear headquarters staff (any staff directly supporting the NPPs).

Also included was all vendor support for the plant, including:

- Long term on-site contractors (e.g., security guards)
- Short term on-site contractors (e.g., outage support)
- Long term off-site contractors (e.g., engineering vendors)
- Short term off-site contractors (e.g., equipment manufacturer technical representatives).

Data for these staff resources was divided into six staffing areas:

1. Operations
2. Maintenance
3. Engineering
4. Safety
5. Support
6. Site services

Typical functions performed in each of these staffing areas are indicated on the following page, which is an excerpt from the staffing survey that was used to collect this data. The staffing survey was compiled from using data from 54 plants in 19 countries:

Brazil	Bulgaria	Canada
Czech Republic	China	Finland
Germany	Hungary	India
Japan	Lithuania	Republic of Korea
Romania	Russian Federation	Slovakia
Slovenia	South Africa	United Kingdom
United States of America		

EXCERPT FROM NPP STAFFING SURVEY

STAFFING LEVELS

Show staffing levels of plant staff and **supporting staff from the site, headquarters and corporate. Include on-site and off-site contractors and vendors.**

UTILITY	
PLANT NAME	
NUMBER OF UNITS	
3-YR CAPACITY FACTOR (WANO DEFINITION)	
STAFFING AREA	STAFFING LEVEL
Operations	
Maintenance	
Engineering	
Safety	
Support	
Site Services	
TOTAL	

Descriptions of Staffing Areas:

Operations: operations

Maintenance: construction support, maintenance, planning, outage craft, outage management, scheduling

Engineering: computer engineering, drafting, engineering design, plant engineering, engineering programs, technical engineering, nuclear fuels, procurement engineering, project management, reactor engineering

Safety: ALARA, chemistry, emergency preparedness, environmental, HP applied, HP support, licensing, nuclear safety, QA, QC/NDE, Radwaste/decon/ plant cleaning, safety/health

Support: Administration, budget/ finance, clerical, communications, contracts, document control, human resources, information systems, management, management assistance, materials management, purchasing, training, warehouse

Site Services: Civil/community services, employee housing, facility maintenance/non-plant cleaning, fire protection, offsite high and low level waste disposal, security

Annex D

STAFFING BENCHMARKING METHODOLOGY

Staffing benchmarking is the comparison of staffing levels of one plant to those of one or several other plants. The process for conducting the benchmarking consists of a formal, quantitative methodology which includes:

- Selecting the appropriate group of plants against which to benchmark.
- Determining the staffing areas to be benchmarked.
- Normalizing or adjusting the data to take into account differences among plants such as plant design, size, age and location.
- Identifying the factors which cause any differences in staffing in an area.
- Deciding whether any actions should be taken because of the differences.

Benchmarking staffing is, in many ways, a method of benchmarking economic performance. Benchmarking NPP economic performance is a way for utility management to determine how well their NPPs are performing compared to other well run, efficient plants. Plant economic performance is often measured using non-fuel production costs per MW·h generated, or non-fuel operating and maintenance (O&M) costs per kw of installed capacity. However the usefulness of these indicators for benchmarking is limited by questions about currency conversion, cost accounting differences among utilities, validity of comparisons of data among plants of different design, age and size, and the inability to make consistent comparisons in subcategories of costs. Many of these limitations can be overcome by using staffing as a measure to compare the economic performance of NPPs. Staffing serves as a good substitute for costs because it can rather easily and consistently be quantified and assigned to categories or functions of interest to management. "Heads" are often easier to consistently count and categorize than marks, pounds or yen.

Several specific benefits can be obtained from benchmarking staffing at NPPs. These include:

- Identifying areas or processes where **staffing may be insufficient** to safely and efficiently operate the NPP.
- Identifying areas or processes where it may be possible to **reduce staffing** while still safely and efficiently operating the plant. The staffing changes should only be made after changes to the plant, work processes, organizational design, work scope or staff capabilities have first been instituted.
- Establishing **staffing targets** for short term or long term manpower planning.
- Understanding **why staffing is different** among plants which provides insight into the actions that might be taken to reduce staff, and activities which are not being performed which could have an impact on continued safe and efficient operation of the NPP.
- Understanding how and why staffing of **plants at the same utility differs.**
- Determining the **total number of resources** (utility, corporate and vendor) which are being used to operate and maintain a NPP.

One methodology to benchmark staffing levels is described in this section. It has been successfully used by the US consulting company of Tim D. Martin & Associates to benchmark staffing levels at 40 NPPs. This discussion is not meant to imply that this is the only methodology which can be used. The methodology has eight steps:

1. Identify areas of work performed at NPPs.
2. Determine staffing areas to benchmark.
3. Determine plants to benchmark against.
4. Collect staffing and plant data.

5. Normalize staffing data.
6. Identify other factors influencing staffing.
7. Adjust benchmarks for factors beyond management's control.
8. Compare benchmarks to the actual staffing.

Each of these steps is discussed below:

The first step in the benchmarking process is to **divide all work into a number of categories** from which the areas to be benchmarked can be chosen. These areas should be generally consistent with how work is performed and organized to facilitate data collection. They should also distinguish any work areas of special interest for benchmarking..

The staffing **areas to be benchmarked** should then be determined from this list. Benchmarking can be conducted for some or all activities performed at a NPP. Benchmarking only a few areas will require less overall data collection and analysis. However, benchmarking all areas at one time has several advantages:

- It is more efficient to collect and analyze all data at one time than to start, stop and then restart the data collection and analysis process if the scope of benchmarking is changed at a later date.
- Accuracy of staffing data collection is increased because all staff and vendors are accounted for at one time and assigned to a process.
- Management participation and buy-in of the results is often greater because all organizations are treated equally (i.e., they are included in the analysis).

Next, the **plants to be included** in the benchmarking should be established. Three considerations are important when selecting the plants to be included:

- Aggressiveness of benchmarks. Plant staffing benchmarks can be developed for various performance levels such as industry average, best quartile or best decile. Most typically, the benchmark will be for plants performing at levels better than the average. However, the plants in this category must first be established, often using currently available data.
- Ease of collection. Plants should be selected with some expectation that they will be willing to share data. This may mean providing reciprocal information to the participating plants. In some cases there may already be relationships among plants, such as users groups, which can be used to help achieve the data collection.
- Within the constraints of these first two considerations, the more plants included in the benchmarking sample size, the more representative will be the benchmarks. The accuracy of the statistical processes used to normalize the data, the understanding of the causes of differences, and the likelihood of including the most efficient performer in an area will increase as more plants are included in the benchmarking process.

Collect staffing and plant data. Staffing data must be collected consistently and completely from each plant participating in the benchmarking. Generally, two methods can be used to collect the data: surveys or interviews. Surveys are easier but less accurate. Using the survey method, a form is prepared and sent to a contact at each plant and nuclear corporate office for the participating utilities. These forms should include information about the processes being benchmarked, activities included in each process, and instructions for how to assign plant, nuclear headquarters and non-nuclear corporate staff to a process. They should also address how to account for vacancies and various categories of contractors:

- On-site vendors (long term and short term)
- Off-site vendors and vendor services (long term and short term).

The interview method is more manpower intensive but usually results in more accurate and consistent data collection. This is because a few (one or two) people can collect all the data from all participants rather than having a different person at each plant or utility collect data. The on-site interviews allow for more extensive questions and answers by the managers providing the data for their plants. In addition, questions about organization structure, work processes and practices, and management and regulatory decisions can be asked which will provide information about why there may be differences in staffing levels between plants.

Regardless of the method used for data collection, plant data must also be collected. The plant data will be used to normalize the staffing data from each plant so that the benchmarks can be developed. Typical plant data which should be collected includes plant design, NSSS, size, age, number of units, constructor, turbine manufacturer, geographic area, cooling tower type, distance from salt water, and number of nuclear units, plants and sites operated by the utility.

Next, the **staffing data is normalized**, by function, on a plant or unit basis, for the physical differences among plants. One method for performing the normalization is to use multivariate regression analysis. In this technique, staffing data for each function are the dependent variables, and the plant data (e.g., NSSS, size, cooling tower type, etc.) are the independent variables. The regression analysis correlates the impact of each independent variable on the dependent staffing data. The result is an equation, or model, for each staffing process, that can be used to predict the staffing level of a plant based on all the industry staffing data collected. For example, the equation derived from the regression analysis might show that the number of health physics technicians is equal to a factor times the plant size plus a factor times the plant age plus a factor times the number of units. The values for each factor are provided by the regression analysis, and the value for the actual plant parameters is provided by data collection at the plant being benchmarked. In effect the staffing at each plant participating in the survey is adjusted for the characteristics of the subject plant so that staffing levels are directly comparable from plant to plant.

Other factors influencing staffing at the plant being benchmarked must also be investigated. In addition to the independent variables, there will be other factors which may help explain why staffing is higher or lower than the benchmarks. These factors include:

- Physical plant characteristics which are unique to the plant such as additional safety trains or abnormally high levels of plant contamination.
- Management decisions about the organizational structure, work processes, use of automation or plant standards which are more or less manpower intensive than benchmark plants.
- Regulatory requirements and commitments which may be greater or less than those of the benchmark plants.

These factors should be identified during the data collection process through interviews or survey forms. Each factor should be classified in one of two categories: controllable and non-controllable. The controllable factors are those which impact staffing and are controllable by the utility in the long run. Non-controllable factors are not controllable by the utility in the long run. Care should be exercised in the classification because some factors which may not initially appear to be within the control of the utility such as regulatory requirements or union work rules can be influenced or changed in the long run with sufficient attention. The size of the impact of each of these factors can usually be estimated through a combination of interviews with selected plant managers or staff, and the experience of the staff conducting the benchmarking.

Next, the **benchmarks are adjusted** for the non-controllable factors. The regression analysis process will normalize the staffing benchmarks for many of the differences among plants. However, other factors identified in the previous step which are beyond the control of management and which impact staffing should also be taken into consideration. The size of the adjustment should be based on the added manpower expended on the activity as reported by the plant or the experience of the staff conducting the benchmarking.

Finally, actual and benchmark **staffing levels should be compared** for each process. Processes where the actual staffing levels are greater than the benchmarks should be the priority focus of management. These areas represent the best opportunities for staffing reduction. Many of the causes of the variance may have already been identified in the earlier step where the controllable and non-controllable factors were discussed. Further investigation should be conducted, as needed, such as through discussions and visits with good performing benchmark plants for the process. For areas where staffing is lower than the benchmark, management should ensure it is because of good performance or efficiency in the area, and not because inadequate resources are being devoted such as may be indicated by growing backlogs or deteriorating performance.

Although staffing benchmarking can provide a very useful tool to management to identify inefficiencies or areas not receiving sufficient resources, management must be aware of several issues associated with its use. First, it is important to recognize that differences between actual and benchmark staffing cannot be eliminated by only changing staffing levels. The benchmarking process can identify the areas for focus, the magnitude of the potential savings, and the causes for much of the variance. However, any decision to change staffing must be accompanied by related changes to the plant, organizational structure, work processes, use of automation, or regulatory or management expectations.

In addition, as with any staffing change, there may be decreases in performance because of direct or indirect affects of reducing staffing levels. Worker morale, experience levels and familiarity with new components, systems or structures will have an effect.

Because staffing benchmarking uses a statistical process to normalize for differences in plant parameters, there is an inherent uncertainty or error distribution in the benchmark. Larger sample sizes will reduce but not eliminate this uncertainty.

As can be seen from the description of the benchmarking process, it is a somewhat manpower intensive process. A utility can expect to devote about three to four man-months by capable staff and managers, per plant type benchmarked, to the conduct of the data collection and analysis. Care must be taken during the process to ensure the data is consistently and accurately collected.

Even if the benchmarking analysis is successful, the project will not be a success unless plant management understands and accepts the findings. They may not agree with the results, but they should acknowledge that the process was fair and the results reasonable. To achieve this buy-in, managers at each plant should be involved in the data collection and interview process. This will help ensure their understanding and acceptance of the project. These managers should also be allowed to comment on and modify the report before it is finalized.

Annex E provides a case study of the results of a formal benchmarking performed at a nuclear power plant. Review of this study will provide more information about the types of findings that can be expected to result from a benchmarking analysis.

Annex E

CASE STUDY OF AN NPP STAFFING BENCHMARKING

This annex reproduces, as a case study, a staffing benchmarking analysis performed for a nuclear utility. In order to maintain the confidentiality of this utility, it is referred to in the case study as "Utility X." The case study is presented in the same format and style as if the results were being presented to the senior managers of Utility X. While the entire staffing benchmarking analysis may be of interest to the readers of this publication, it is expected that utility and NPP managers would focus primarily on the methodology, rather than on the specific staffing numbers in this case study. The study was performed by the US consulting firm of Tim D. Martin & Associates.

The primary objective of our analysis was to determine an appropriate staff size for Utility X. Appropriate staff size is based on steady state, non-outage benchmark staffing levels. Two benchmarks were developed: best performer and lowest. Steady state staff includes full time plant staff, corporate employees and long term contractors. Steady state staffing levels do not include contractors providing outage or other non-recurring (i.e., one-time) short term (less than 6 months) support services or vacancies.

A secondary objective was to obtain detailed information about work practices at Utility X and to count all staffing as of September 1997. The staffing included in the analysis included Utility X employees, long term contractors and short term contractors.

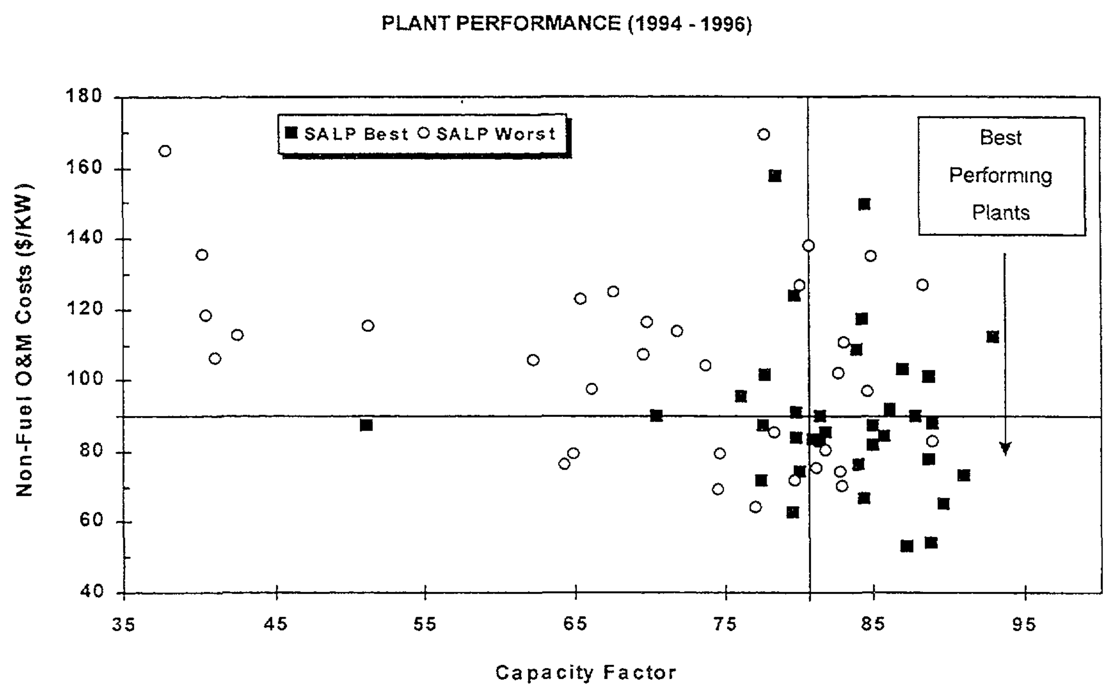
Other objectives of our analysis were to categorize staff into 46 job processes, and identify factors which explain variances between actual and benchmark staffing levels.

The staffing analysis was conducted in six steps.

We:

1. Held a kick-off meeting with utility management,
2. Distributed questionnaires and conducted interviews,
3. Analyzed data collected from the questionnaires and interviews,
4. Presented a draft report of our findings to management,
5. Obtained input from management about the draft report, and
6. Revised the report based on management input.

Benchmark staffing levels were developed using plants with the combination of better than median capacity factors, costs and regulatory performance. Two benchmarks from this data set were developed: Best and Lowest. The best benchmark represents the **average** staffing of the best performing plants. These plants are depicted below.



Source: TDM Analysis, August, 1997

Note: SALP is a measure in the US of plant safety performance

In addition to the best benchmarks, lowest benchmarks were also developed. Lowest staffing benchmarks are different from the best benchmarks. Whereas the best benchmarks are the average of the best performing plants; the lowest benchmarks are from the lowest staffed (not average) plant from the group of best performing plants. The lowest benchmarks are developed separately for each job function. Therefore the lowest benchmarks are based on different plants for each function (i.e., whichever plant is lowest for each function). No plant is the lowest staffed in all functions. Lowest benchmarks were determined by: identifying the plants with lowest staffing in each function, normalizing staffing to Utility X, and then adjusting staffing to account for differences in scope.

In addition to the staffing benchmarks, Utility X organizational design was compared to the benchmark plants. Two measures were used to compare the organizational design: Layers of management and span of control.

Layers of management are the number of levels in the chain of command up to the President. Comparison does not include individuals with supervisor or manager titles who do not directly supervise workers.

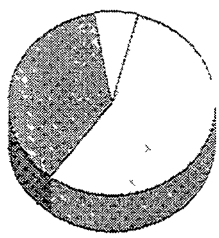
Span of control is the number of direct reports to a manager or supervisor excluding clerks. Percent of managers and supervisors with narrower or broader than typical spans of control were identified.

The benchmark staffing levels and models are based on several key assumptions. These assumptions are that the plant is considered to be in steady state operation, and short term outage contractors are excluded. Another key assumption is that no major initiatives (e.g., steam generator replacement) are being performed. For this analysis, Utility X employees are assumed to perform work with average productivity.

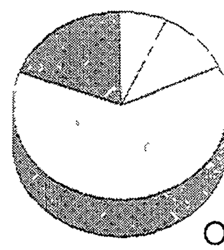
Two other aspects of the benchmarks are that staffing levels do not include vacancies, and engineering benchmarks are those needed to perform essentially all design engineering work in-house or with contractor personnel.

Our review showed that the number of people operating, maintaining, and supporting Utility X is 843 people. This staff consisted of utility employees, long term (LT) contractors and short term (ST) contractors. Four organizations were included in the analysis: Operations, licensing/engineering, financial/administration, and president/quality programs department & legal. The staff in each group are shown in the pie-charts below. Abbreviations in the pie charts refer to the organizations or the types of contractors mentioned in this paragraph.

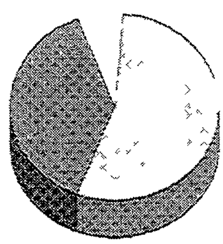
For the analysis, the short term contractors were excluded. Thus a total of 792 people (as shown in the bottom pie chart) were included in the remainder of the analysis.



TOTAL STAFF:
843

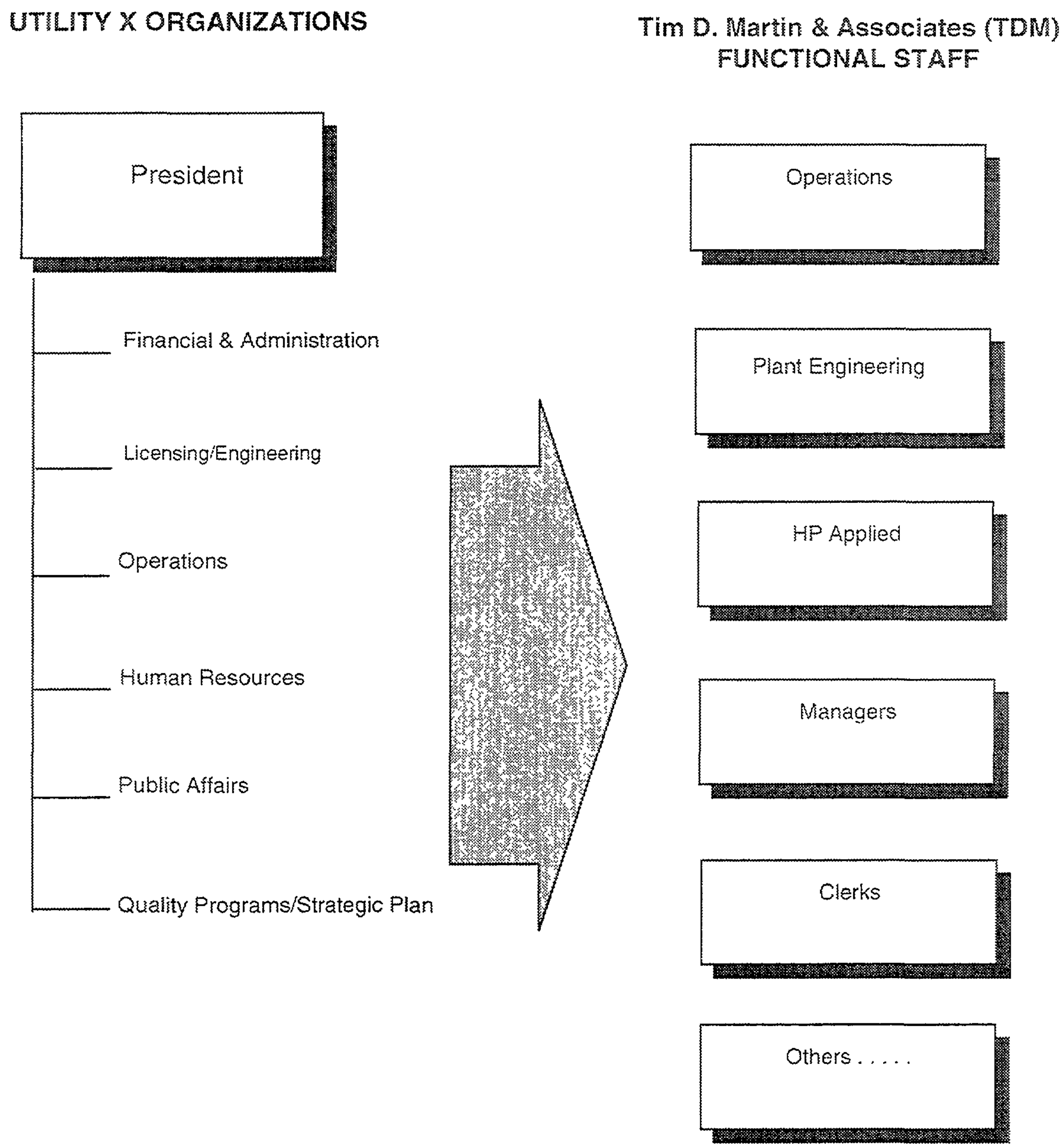


STAFF BY
ORGANIZATION



STAFF ANALYZED:
792

This staffing level of 792 people were categorized into 46 separate work processes.



Our benchmark findings are shown on the following pages. The 46 processes are combined into four groups as shown below. Findings for each grouping are then shown in a common format on one of the following pages.

Operations

- ALARA
- Chemistry
- Construction Craft
- Construction Mgt
- Environmental
- Facility Maintenance
- HP Applied
- HP Support
- Maintenance
- Operations
- Outage Mgt
- Radwaste/Decon
- Security
- Scheduling
- Shift Engineer
- Training

Licensing & Engineering

- Civil/Struct Engr
- Computer Engr
- Design/Drafting
- Elec/I&C Engr
- Emergency Plan
- Engr Programs
- Information Mgmt
- Licensing
- Mech Engr
- Nuclear Engr/Fuel
- Nuclear Safety Rev
- Plant Engr
- Procurement Engr
- Project Mgt
- Reactor Engr

Corporate/ Finance & Admin

- Communications
- Contracts
- Document Control
- Finance/Budget
- Human Resources
- Legal
- Materials Mgmt
- Purchasing
- Quality Assurance
- Quality Control
- Warehouse

Common Processes

- Admin/Tech Asst
- Clerks
- Fire/Safety/Health
- Management

A consistent format is used to show the findings for each process. The format is defined as follows:

PROCESS	TOTAL	MGR	CLRK	SHORT TERM	LONG TERM	UTIL X STAFF	FUNC STAFF	BENCHMARKS BEST	LOW
A	B	C	D	E	F	G	H	I	J

A - Process being analyzed (e.g. operations, training, etc.)

B - Total employees and contractors performing the process

C - Management (managers above first line supervisors)

D - Company clerks and long term contractor clerical staff (but not document control or dosimetry clerks)

E - Short term contractors (less than 6 months)

F - Long term contractors (more than 6 months or providing recurring non-outage services)

G - Utility X employees (excluding managers and clerks)

H - Functional staff is the sum of F plus G

I - TDM best performer benchmark for the work process

J - TDM lowest benchmark for the work process

As shown in the following table, our findings for the operations processes were that most of these processes are staffed below the best benchmarks.

FUNCTION	TOTAL	MGR	CLRK	SHORT TERM	LONG TERM	UTILITY X STAFF	FUNC STAFF	BENCHMARKS	
								BEST	LOW
ALARA	7	0	0	0	3	4	7	6	3
Chemistry	13	1	1	0	0	11	11	24	21
Construction Craft	11	0	0	6	5	0	5	5	3
Construction Mgt	6	0	1	0	5	0	5	6	3
Environmental	8	0	0	0	6	2	8	6	5
Facility Maintenance	28	0	0	1	17	10	27	27	22
HP Applied	23	0	1	0	8	14	22	28	20
HP Support	16	0	1	0	9	6	15	15	11
Maintenance	124	5	4	2	45	68	113	142	131
Operations	74	2	2	0	0	70	70	78	75
Outage Management	4	1	1	0	0	2	2	6	4
Radwaste/Decon	14	0	0	0	7	7	14	19	13
Security	84	2	3	0	76	3	79	72	66
Scheduling	2	0	0	0	0	2	2	10	5
Shift Engineers	8	0	0	0	0	8	8	6	5
Training	46	2	2	0	4	38	42	39	37

Greater than benchmark ALARA staffing reflects high plant radiation levels.

Lower than benchmark chemistry staffing may be due, in part, to work scope differences with other plants because at Utility X, unlike other plants, plant engineering, not chemistry, performs some soil analyses, and Quality Programs supports some X-ray work.

Greater than benchmark environmental staffing may reflect organizational arrangement of the process into three groups.

Lower than benchmark maintenance staffing may be due to high non-outage maintenance backlog and greater use of outage contractors.

Operations staffing below the benchmark reflects one fewer operator per shift than benchmark plants.

Higher than benchmark staffing in security is due to Utility X's use of guard towers versus cameras and not having a fence-line warehouse.

Training staffing above the benchmark appears to be in the area of operations.

Almost all licensing & engineering processes are staffed below the best benchmarks.

FUNCTION	TOTAL	MGR	CLRK	SHORT TERM	LONG TERM	UTILITY X STAFF	FUNC STAFF	BENCHMARKS BEST	LOW
Civil Engineering	4	0	0	0	3	1	4	6	4
Computer Engineering	8	0	0	2	4	2	6	7	4
Design/Drafting	5	0	0	0	1	4	5	10	8
Electrical Engineering	10	0	0	0	4	6	10	13	10
Emergency Planning	6	0	0	0	3	3	6	6	4
Engineering Programs	24	0	0	0	14	10	24	29	26
Information Management	17	0	0	0	7	10	17	23	20
Licensing	12	0	0	3	5	4	9	10	8
Mechanical Engineering	11	0	0	0	8	3	11	15	13
Nuclear Eng/Fuel	24	0	0	0	23	1	24	18	15
Nuclear Safety Review	8	0	0	2	0	6	6	7	6
Plant Engineering	33	0	0	7	7	19	26	37	34
Procurement Engineering	7	1	0	1	1	4	5	6	4
Project Management	9	1	0	0	5	3	8	6	3
Reactor Engineering	6	1	1	0	0	4	4	4	3

More than typical overtime levels and high backlog may, in part, explain the lower than benchmark staffing in mechanical and electrical engineering.

Greater than benchmark staffing in nuclear engineering/fuels reflects that Utility X is performing more licensed reload activities in-house than other utilities for the number of units supported, and more design work with nuclear engineering/fuels staff.

Plant engineering staffing below the benchmark results, in part, from not having formal systems engineers, and higher than typical overtime.

Higher than benchmark project management staffing may be due to using more utility staff for oversight of vendor activities than other utilities that use architectural/engineering firms for outside engineers.

Most corporate/finance & admin processes are staffed at or below the lowest benchmark levels.

FUNCTION	TOTAL	MGR	CLRK	SHORT TERM	LONG TERM	UTILITY X STAFF	FUNC STAFF	BENCHMARKS BEST	LOW
Communications	11	1	2	0	0	8	8	6	4
Contracts	2	0	0	0	0	2	2	4	3
Document Control	9	0	0	1	1	7	8	17	12
Finance/Budget	20	3	1	0	2	14	16	31	26
Human Resources	13	1	3	0	1	8	9	12	11
Legal	3	0	1	0	0	2	2	2	2
Materials Management	3	0	0	0	0	3	3	6	5
Purchasing	7	0	1	0	0	6	6	8	6
Quality Assurance	9	0	0	0	4	5	9	15	10
Quality Control	11	0	0	1	4	6	10	14	10
Warehouse	10	0	0	0	0	10	10	15	11

Greater than benchmark communications staffing reflects efforts devoted to public education and public relations, including print/media advertising and lobbying.

Lower than benchmark finance and budget staffing reflects recent efforts to reduce resources in this area.

Lower than benchmark staffing in materials management is reflected, in part, by lower than typical warehouse inventory which is $16 million at Utility X compared to $20 million at many good performing low staffed plants

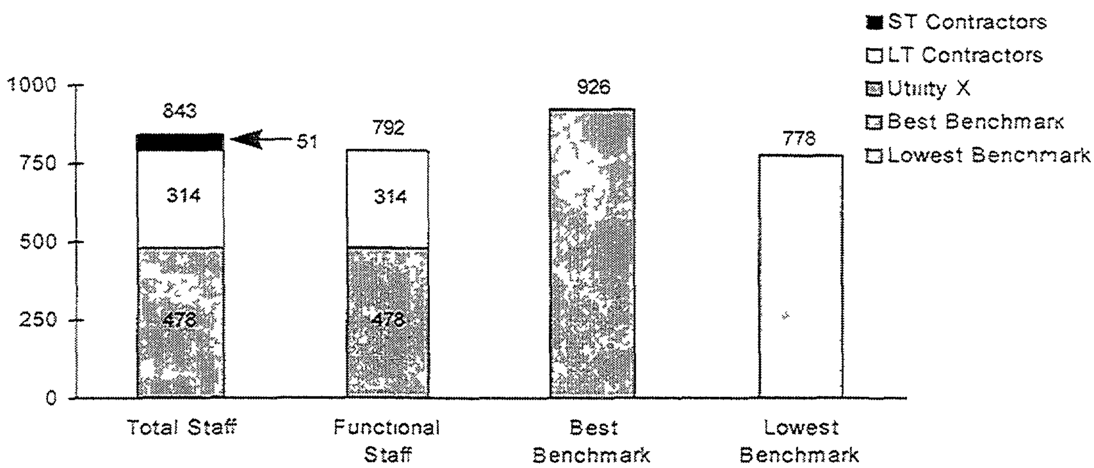
Half of the common processes are staffed above the best benchmarks

FUNCTION	TOTAL	MGR	CLRK	SHORT TERM	LONG TERM	UTILITY X STAFF	FUNC STAFF	BENCHMARKS BEST	LOW
Admin/Tech Assist	23	0	7	5	3	8	11	7	5
Clerks	58	-	-	3	21	34	55	63	53
Fire/Safety/Health	25	0	0	20	0	5	5	6	4
Management	43	-	-	0	8	35	43	34	30

Admin/tech assistant staffing above the benchmark may be due to management approaches at Utility X such as no consolidated action tracking system and the Learning Process organization with dedicated re-engineering staff

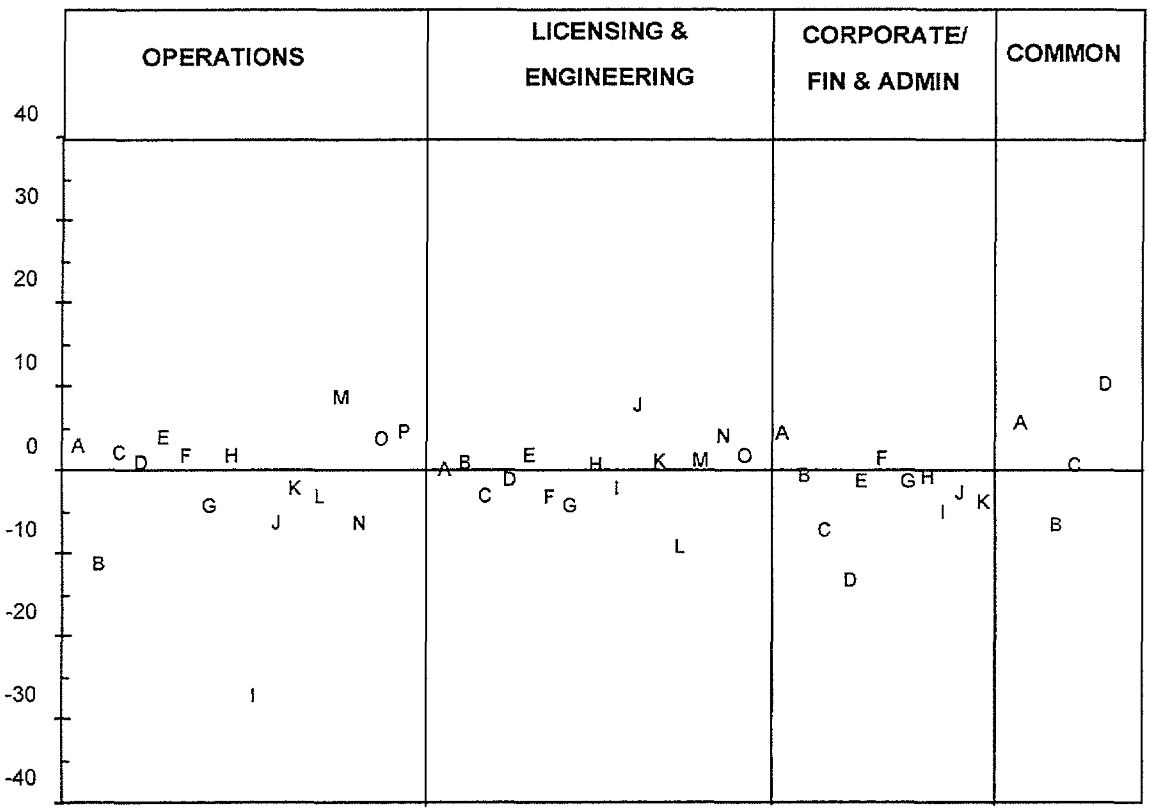
Management staffing above the benchmark reflects Utility X's approach to a more vertical organization structure This results in more layers of management than good performing, low staffed plants, and narrower spans of control

Overall, our findings show that Utility X staffing is 17% lower than the best benchmark and 2% greater than the lowest benchmark



The following chart shows for each process the differences between actual and best benchmark staffing. Processes that plot above the horizontal line have staffing above the best benchmark. The chart shows that several processes are staffed above the best benchmark and are good candidates for reduction.

FUNCTIONAL STAFFING BEST BENCHMARK - UTILITY X



Operations

- A - ALARA
- B - Chemistry
- C - Const Craft
- D - Const Mgt
- E - Environ
- F - Facility Maint
- G - HP Applied
- H - HP Support
- I - Maintenance
- J - Operations
- K - Outage Mgt
- L - Radwaste/Decon
- M - Security
- N - Scheduling
- O - Shift Engineer
- P - Training

Licensing & Engineering

- A - Civil/Struc Engr
- B - Computer Engr
- C - Design/Draft
- D - Elec/I&C Engr
- E - Emergency Plan
- F - Engr Pgms
- G - Information Mgmt
- H - Licensing
- I - Mech Engr
- J - Nuclear Engr/Fuel
- K - Nuclear Safety Rev
- L - Plant Engr
- M - Procurement Engr
- N - Project Mgt
- O - Reactor Engr

Corporate/Fin & Admin

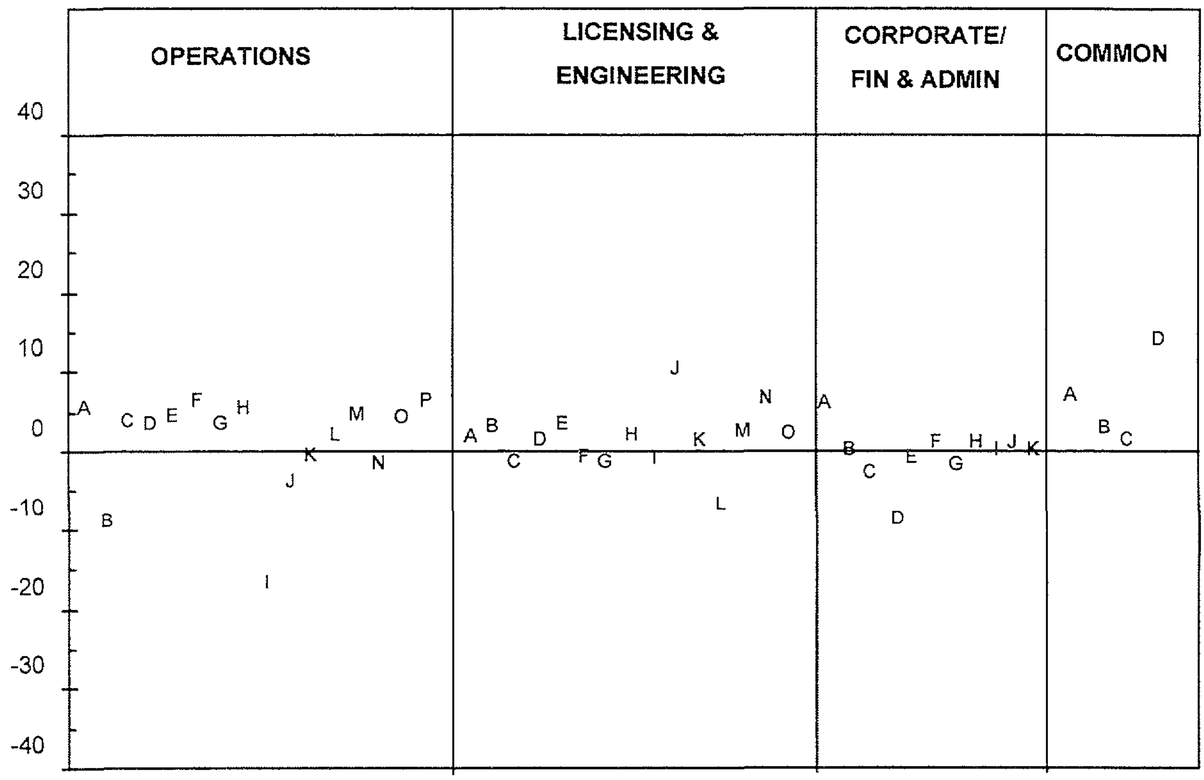
- A - Comms
- B - Contracts
- C - Doc Control
- D - Finance/Budget
- E - Human Res
- F - Legal
- G - Material Mgt
- H - Purchasing
- I - Quality Assur
- J - Quality Control
- K - Warehouse

Common

- A - Admin/Tech
- B - Clerks
- C - Fire/Safe/Hlth
- D - Management

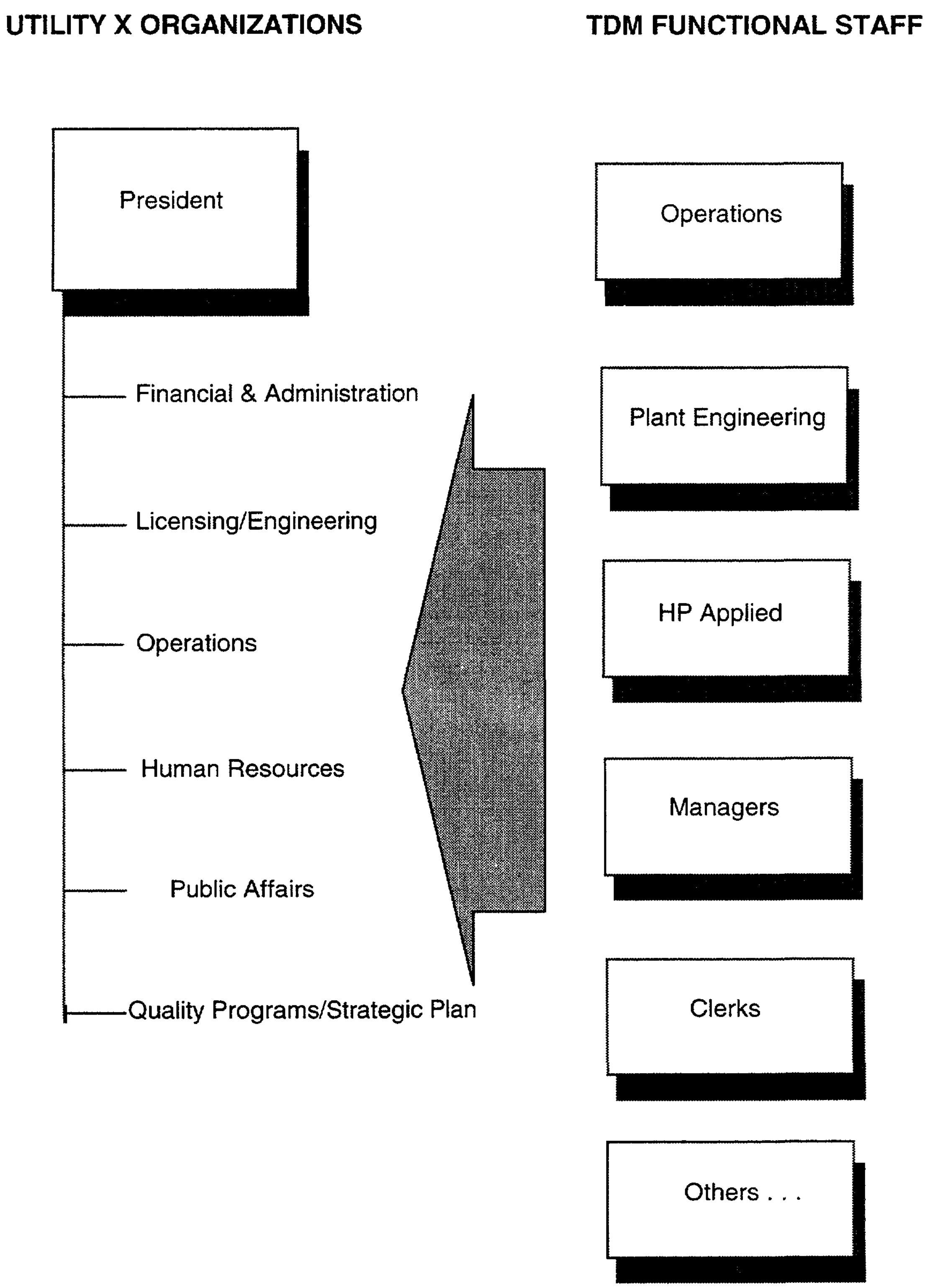
This chart shows the variance between the actual and lowest benchmark staffing for each process. It shows that many processes are staffed above the lowest benchmark and are good candidates for staffing reduction.

FUNCTIONAL STAFFING LOWEST BENCHMARK - UTILITY X

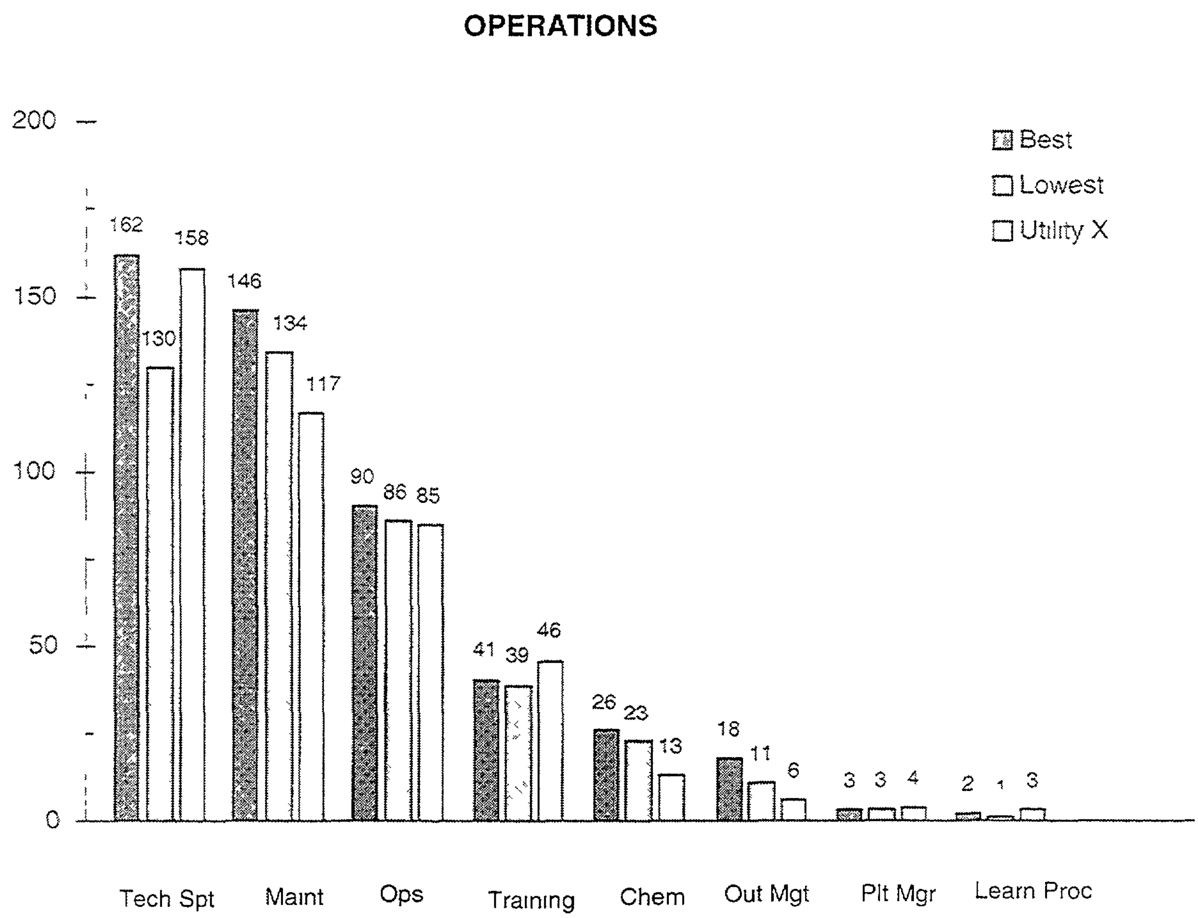


OPERATIONS	LICENSING & ENGINEERING	CORPORATE/ FIN & ADMIN	COMMON
A - ALARA	A - Civil/Struc Engr	A - Comms	A - Admin/Tech
B - Chemistry	B - Computer Engr	B - Contracts	B - Clerks
C - Const Craft	C - Design/Draft	C - Doc Control	C - Fire/Safe/Hlth
D - Const Mgt	D - Elec/I&C Engr	D - Finance/Budget	D - Management
E - Environ	E - Emergency Plan	E - Human Res	
F - Facility Maint	F - Engr Pgms	F - Legal	
G - HP Applied	G - Information Mgmt	G - Material Mgt	
H - HP Support	H - Licensing	H - Purchasing	
I - Maintenance	I - Mech Engr	I - Quality Assur	
J - Operations	J - Nuclear Engr/Fuel	J - Quality Control	
K - Outage Mgt	K - Nuclear Safety Rev	K - Warehouse	
L - Radwaste/Decon	L - Plant Engr		
M - Security	M - Procurement Engr		
N - Scheduling	N - Project Mgt		
O - Shift Engineer	O - Reactor Engr		
P - Training			

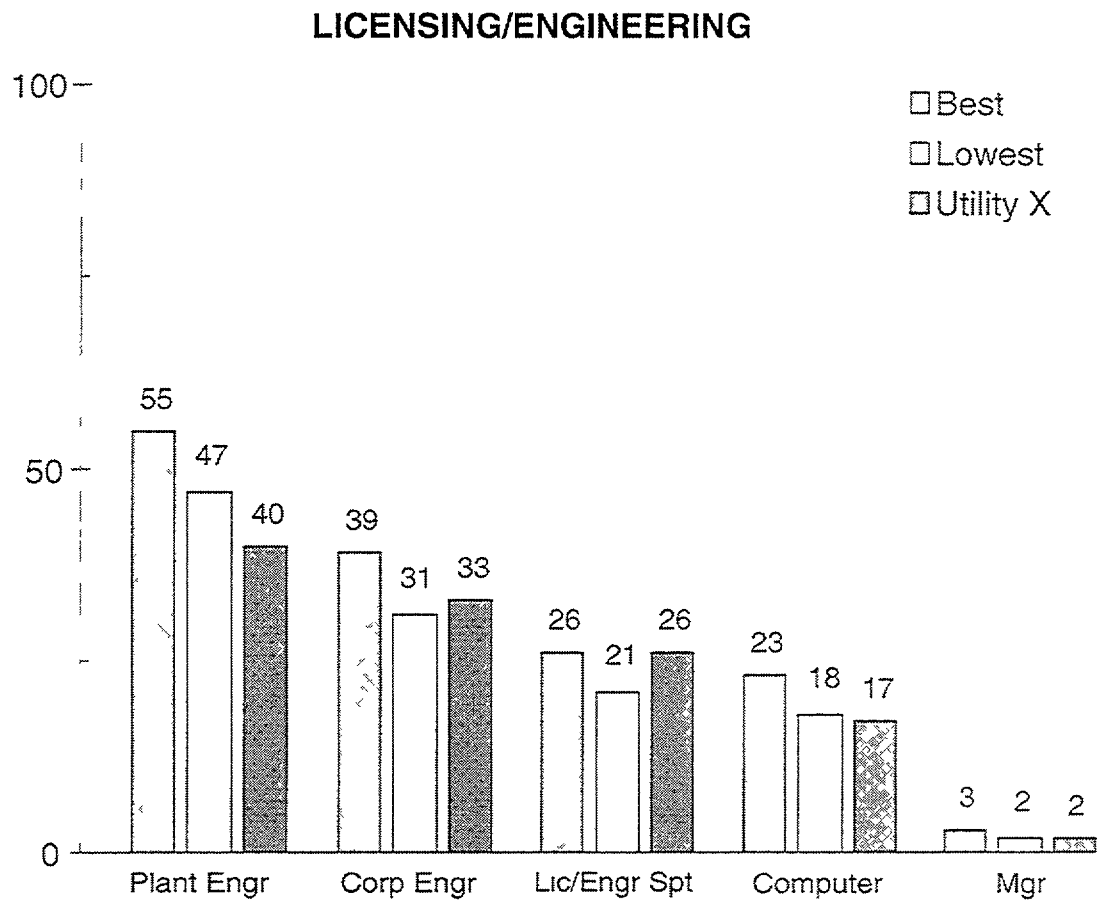
We also analyzed staffing variances in each organization which required that we redistribute functional staffing into Utility X organizations.



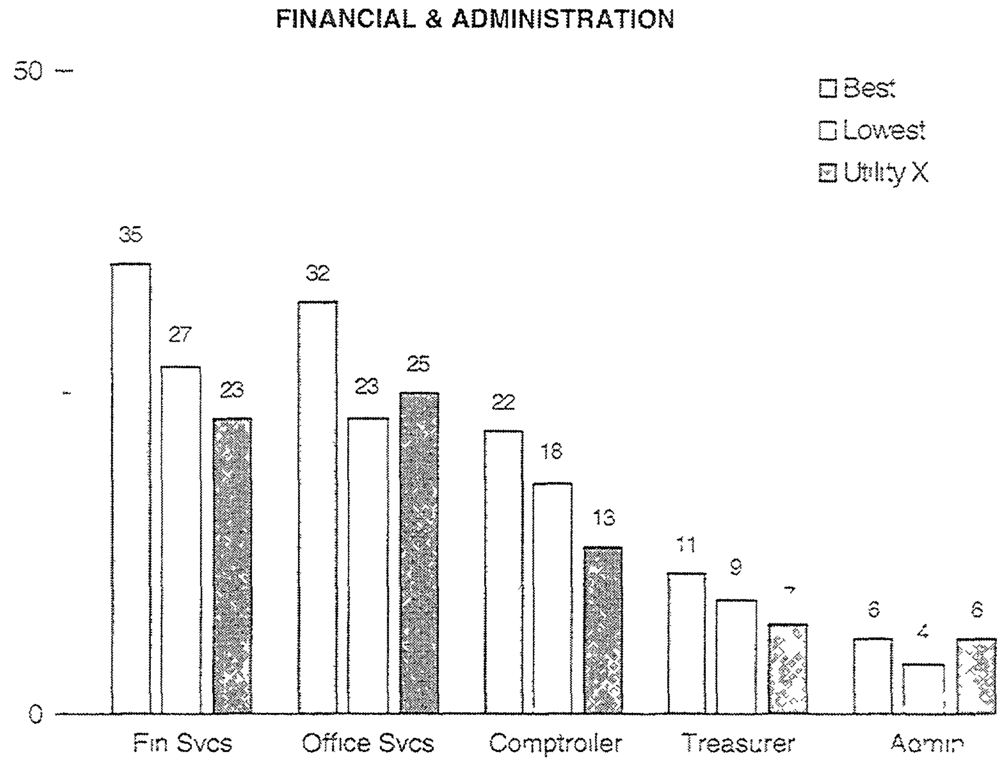
Lowest benchmark staffing for operations was found to be 427 people. Each of the bars in the graph below represents one of the departments in the operations organization at Utility X.



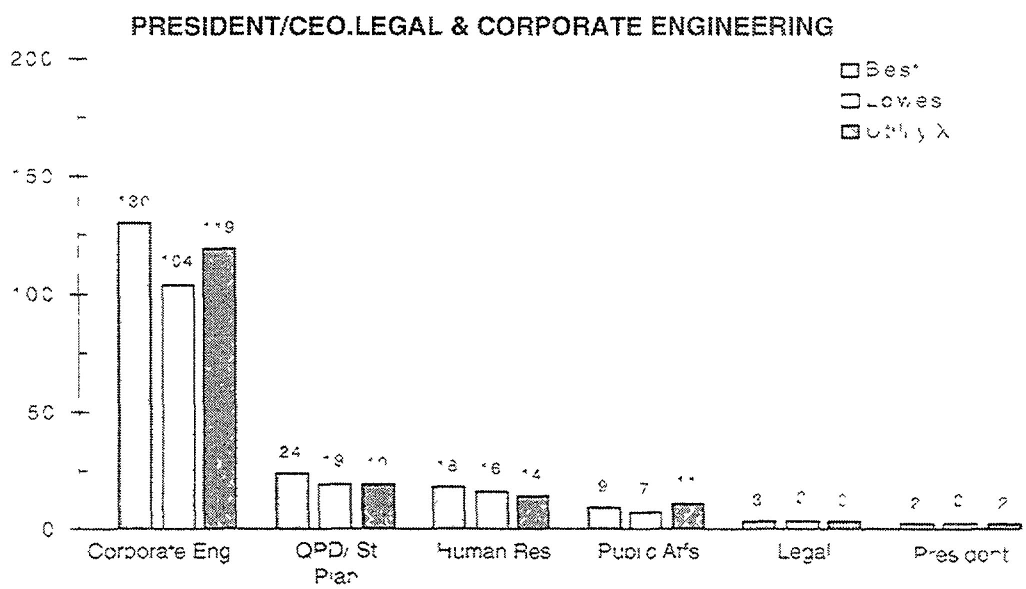
Lowest benchmark staffing for licensing & engineering was found to be 119



Lowest benchmark staffing for finance and administration was 81 people



Lowest benchmark staffing for corporate organizations was 151.



Although there are several opportunities for staffing reductions, management must be careful in implementing staffing changes. Any decision to adjust staffing levels must be accompanied by a rationalizing process. If staff are to be reduced then either work must be reduced, eliminated or completed, or productivity must be increased such as through work system changes or technology improvements.

In addition, it is important that senior management "buy-in" and accept any risks associated with staffing reductions.

If there are to be any staffing increases in areas where staffing is below the benchmarks, then the specific activities to be improved must be identified, and time requirements established for new staff achieving agreed on performance improvement goals.

Annex F

ORGANIZATION OF A PROJECT FOR INTERIM SPENT FUEL STORAGE

1. INTRODUCTION

The Czech Republic is one of the few countries that has put into operation an Interim Spent Fuel Storage (ISFS) Facility. The following is a brief description of the organization of this project, emphasizing, in particular, the team approach used.

2. BACKGROUND

Fundamental changes in the policy and economic systems of the Czech Republic began in 1989. In the political environment, the collapse of the communist regime with subsequent transfer to a pluralistic democracy. In the economic environment, collapse of a planned economy with transfer to a market economy. In the legal system, new environmental protection including a law concerning assessment of environment of proposed projects.

All these changes permitted a release of forces which had been suppressed in the former system. Among these forces were various environmental organizations. These organisations began with sharp attacks against nuclear power. In the previous regime, information concerning nuclear issues was absolutely omitted. Thus, these anti- nuclear groups easily gained a new audience, particularly in the immediate surroundings of nuclear power plants.

In 1991 the negotiation was commenced at the government level concerning division of Czechoslovakia into the Czech Republic and the Slovak Republic. This division was carried out in 1992.

At that time, the interim storage of spent fuel for the Dukovany NPP (in the Czech Republic) had been provided in the interim storage pools of the Bohunice NPP situated in the Slovak Republic.

In Jaslovské Bohunice, the interim storage for all former the Czechoslovakia NPPs had been built. From 1989 to 1992 about 140 tons of spent fuel from Dukovany NPP was transported to Bohunice.

This spent fuel, according to the original concept, was to be transported for reprocessing to the Russian Federation. However, in 1991, the Russian Parliament adopted a law by which the transport of spent fuel from foreign countries to the Russian Federation was prohibited. Therefore the spent fuel from Dukovany NPP remained in the Jaslovské Bohunice interim storage pool, which was suddenly on the territory of a foreign country. To address this situation, an agreement between Slovak Energetic Enterprise and the company CEZ a.s. was concluded. This agreement indicated that between 1995 and 1996 this spent fuel would be transported back to the Czech Republic. These changes were sudden and unexpected, and did not provide an opportunity to prolong the storage in the Slovak Republic.

The capacity for storage of spent fuel in the fuel storage pools at the Dukovany NPP allowed operation through 1993. Through reconstruction of these spent fuel storage pools in 1993 and 1994 to provide more compact storage, about 2,5 years of additional spent fuel storage was provided. In parallel, plans for construction of an interim spent fuel storage were initiated. This work required incorporation of ISFS into the existing Dukovany NPP systems of safety protection, health physics measurement and control, electric power supply and railway transport. Co-operation among several departments of the Dukovany NPP was necessary.

3. DECISION ON THE TYPE OF SPENT FUEL STORAGE

In 1991 the tender for spent fuel storage was announced. Eleven companies responded to the tender. Various types of dry, wet and deep storage were proposed by these companies. In 1992 four company's proposals were selected for further discussion; Skoda Plzen (wet storage similar to storage in Jaslovské Bohunice); NAC, Nukem (dry storage in containers); Alsthom (dry storage in "chimney").

The dry storage approach proposed by the consortium of companies GNS and Nukem was selected. This method is based on dry storage in cast-iron containers.

The ISFS facility for Dukovany was the first facility whose environmental impact was negotiated with the Government in compliance with the new environmental impact law. This method of negotiation was agreed upon between the ÈEZ company and Ministry of Environment, appropriate regional authorities and the villages of Dukovany and Rouchovany, which are in close proximity of Dukovany NPP. Even though this new law was not mandatory for the ISFS facility, a decision was made to comply with its requirements. This review confirmed that neither the construction of the interim spent fuel storage facility, nor its operation would have significant impacts on the environment.

The design team for the ISFS facility was established from the Dukovany NPP employees who had implemented the design modification of the spent fuel storage pools to increase their capacity. This team commenced its work in September 1992. Upon its establishment, significant effort was needed by all members of team in order to submit documents to the regulatory body which could lead to the issue of appropriate approvals.

These administrative proceedings were complicated because after each step in the approval process opponents of the project immediately appealed. The necessary permits for the project were obtained on 3 July 1994 and construction was immediately commenced.

4. IMPLEMENTATION OF INTERIM SPENT FUEL STORAGE CONSTRUCTION AND ARRANGEMENT OF TEAM WORK

Given the complexity of relationships with external groups, whose objective was to prevent ISFS construction, it was decided in September 1992 that development as well as construction of this facility would be the responsibility of a design team which will be provided the necessary authority in order to allow flexible co-operation.

The following task was assigned to the team:

to manage the preparation, design and implementation of the Dukovany NPP interim spent fuel storage. In particular for achievement of required technical parameters, for budget observance, and for observance of terms of construction.

A design team leader with many years of experience was appointed.

The design team structure

- Team leader.

- Members of team: two technicians from machinery and civil building department, one technician from the nuclear fuel handling department, two technicians from the quality assurance department and one technician from Health Physics Department.

- The team leader was subordinated directly to the power plant's Technical Director, whom team leader submitted a report about the course of the construction of the intermediate spent fuel storage facility once a month.

The authority and duties of team leader as well as members of team were established as follows :

Authority of the design team leader

Final authority to decide about substantial questions relating to the management of project, in particular:

- To determine the objectives and schedule of design preparation and implementation and Partial Quality Assurance Programme in compliance with General Quality Assurance Programme.
- To determine potential suppliers from which the consultant services, design work and component delivery will be ordered.
- To evaluate offers and on the basis of evaluation results to decide about the choice of supplier.
- To sign contracts for consultant services, design work and other deliveries (up to 10 million CZK).
- To approve payments (e.g., advance payments, part payments and final invoices).
- To accept Dukovany NPP obligations resulting from administrative and other public-law decisions or appeals of Dukovany NPP against these conditions.
- To submit annual payments from the total budget into Investment Programme of Dukovany NPP.
- To decide about rewards for individual members of the design team.

Duties of design team leader

- To perform the work in compliance with:
  – valid laws and other regulative and standards of the Czech Republic
  – internal control standards of CEZ a.s.
- To assign tasks to individual design team members.
- To monitor technical and cost performance of the project.

Duties of team members

- Responsibility for control, preparation and implementation of that portion of the project assigned him by the design team leader.
- To maintain, in his task fulfilment in particular the following:
  – valid laws and other regulative and standards of the Czech Republic
  – internal control standards of ÈEZ a.s.

- To monitor the technical and cost performance of that portion of the project assigned to him.

Team meetings were held at least weekly. Once construction commenced, the meetings were organised daily. In order to support the facility environmental assessment team members solved problems as they arose concerning construction, design and quality assurance for the facility and the storage containers.

The team was divided into two parts:

- the part which focused on the facility, and
- the part which addressed issues with respect to the storage containers.

The team was effective because each team member had the authority needed to carry out all of their responsibilities. All issues were solved by the system of task assignment and subsequently by the transfer of tasks to team members. Team members, together with suppliers and designers solved problems as they were identified. In this way, the day following identification of a problem/issue team members were able to present accurate information concerning the process of solution of assigned task.

The use of daily work meetings make it unnecessary to have additional meetings to provide information. Work was organized such that the facility was prepared in advance of the arrival onsite of the storage containers.

Teamwork between the Dukovany team and the vendor

The exchange of information and co-operation between the power plant's team and contractors was ensured by means of two-stage meetings. An operative meeting, which took place once a week, was the first stage. The content of the meeting was to solve all the problems connected with the construction. The head of the power plant's team or a deputy appointed by him chaired the meeting, other participants of the meeting were representatives of contractors and sub-contractors (construction heads, foremen, and the like).

A monthly meeting was the second stage. This meeting was also chaired by the head of the power plant's team, participants were the statutory representatives of contractors and sub-contractors. The problems whose solution went beyond the framework of the operative meetings were the content of this meeting.

Teamwork between the regulatory personnel and the Dukovany team

To prevent problems which arise during approval of the safety documentation when submitted to the State Office it was agreed to have an informal phone and fax communication with the responsible workers of the State Office for Nuclear Safety (SONS). A meeting with SONS concerning evaluation of the safety documents was held approximately once a month.

5. CONSTRUCTION COMPLETION AND SUCCESSFUL TRIAL OPERATION

The storage containers were delivered by the consortium of German companies, GNS and Nukem. The container had been subjected to the earlier licence approval in Germany for both storage and transport of spent fuel. In the Czech Republic the licence proceedings were carried out by the State Office for Nuclear Safety.

In September 1995 the construction of the Interim Spent Fuel Storage facility was completed. In December 1995 the first container of spent fuel was transported to the ISFS and the equipment was putted into trial operation. The trial operation of ISFS was performed according to a programme which was approved by SONS. Monthly, a status report about monitoring of trial operation of Interim Spent Fuel Storage was submitted to SONS. After one year, the operation of the ISFS was assessed and it was determined that as of that day (December 5, 1996) normal operation of the ISFS would begin.

6. CONCLUSION

In conclusion it can be stated that this form of team co-operation was successful because under very difficult conditions the team was quickly able to provide an appropriate solution. Thus the continued operation of Dukovany NPP was enabled.

Annex G

DESCRIPTION OF THE ORGANIZATION AND STAFFING APPROACH OF TVO (FINLAND)

INTRODUCTION

Teollisuuden Voima Oy (TVO) has for 17 years operated two identical BWRs of 710 MWe (OL1 and OL2) at Olkiluoto on the western coast of Finland. In 1998 the reactor power was uprated to 850 MWe. On the plant site we have OL1 and OL2 plant units, the interim storage of spent fuel, the final repository for low- and medium-level reactor waste excavated in the bedrock and the training centre including a full-scope simulator. The company takes care of all the functions needed to operate two nuclear power plant units "uranium from uranium mines to bedrock".

The production policy of the Olkiluoto plant is a safe, disturbance-free operation and keeping our plant continuously modern so that collective doses are kept low and environmental impacts small.

Our two units generate at full power throughout the year, producing energy mainly for the Finnish pulp and paper industry. The annual capacity factors have been over 90 percent since 1990, the average value being 94.0 percentage. The annual outages constitute our main loss of production — about 5 percent of the total production. Reactor trips from the full power play a minor role, on the average one trip per plant unit annually. Outages are carried out in the shortest possible time in the spring when there is a lot of hydropower available in Finland.

By keeping the personal doses low we increase the acceptance of nuclear power and can be sure of getting the most qualified and experienced contractor personnel to work in our outages now and in the future.

PLANT ORGANIZATION

TVO's staffing policy is to: keep its own staff small (totally less than 490 persons); maintain effective contacts with vendor and consulting companies as well as to research institutes; keep key experts in its own staff; have challenging projects always in progress; and maintain open and pro-active relations with the Regulatory Body.

TVO plant organization is divided into three departments: production, engineering and finance. Departments are divided into different offices. TVO has no separate head office, all main functions are centralized in Olkiluoto. For the management of spent fuel TVO has the joint company, Posiva Oy, with Imatran Voima Oy (IVO) which owns the Loviisa NPP. TVO's organization and maintenance resources are presented in Figs1–3.

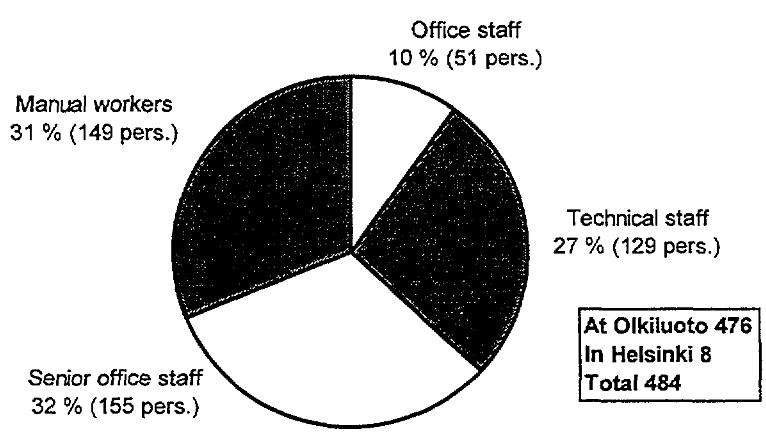


FIG. 1. Permanent staff. Breakdown in various staff groups 1997.

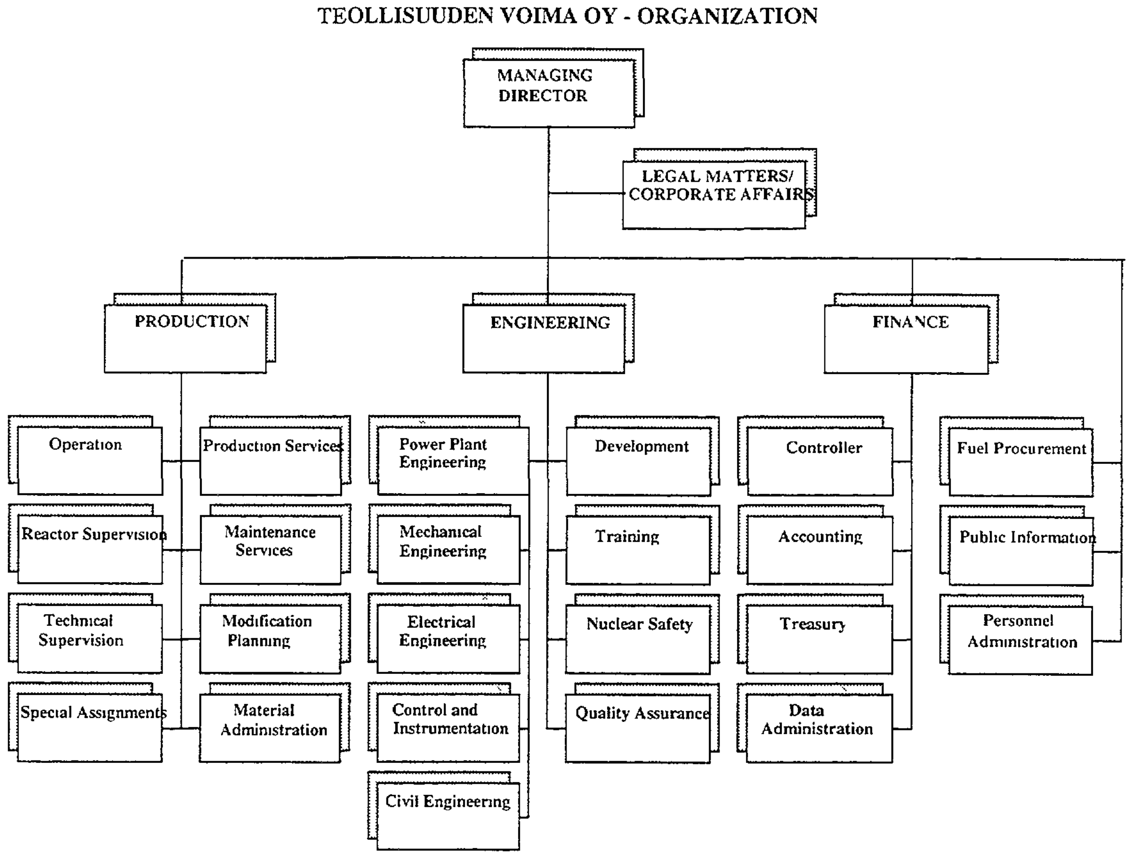


FIG. 2. TVO organization.

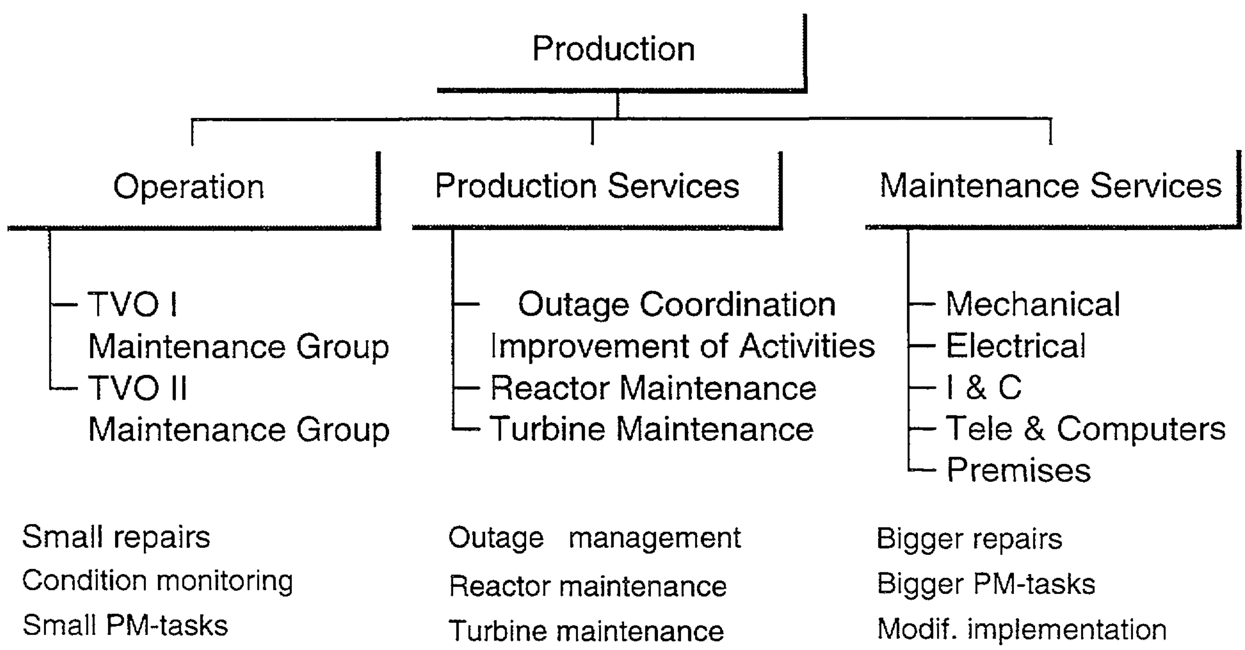


FIG. 3. TVO maintenance resources.

Quality assurance (QA) and quality control (QC) are placed in the engineering department. The task of QA is to ensure that the organization follows the company's quality assurance programme and instructions. QA has the right to intervene in all company functions if needed. QC is placed in the engineering department to ensure the independence of technical quality control measures (e.g., NDT) from the organization which makes the daily maintenance work on the plant units.

Reactor safety and training have special functions on the engineering department. There are also many other special groups and meetings with participants from different organization units (plant safety, training, information, outage management, technical meeting etc.) where plant matters are handled.

MAINTENANCE RESOURCES

The production department has the responsibility for daily plant maintenance. The responsibility for long term maintenance is shared with the engineering department, which also takes care of modification and improvement projects. TVO had a separate maintenance organization but now the maintenance is partly combined with operations.

Since 1994 the maintenance staff has been divided into three organizations: operations, production services and maintenance services. The maintenance groups in operations (one group per unit) have the responsibility for daily repairs, condition monitoring and minor preventive maintenance (PM) tasks. Major repairs and PM tasks and also the implementation of modifications and improvements are conducted by maintenance services (divided into mechanical, electrical, I&C, telecommunication and premises maintenance sections). Production services has the responsibility for outage co-ordination and reactor and turbine maintenance.

A major reason for the organization change in 1994 was to minimize overlaps between operations and maintenance activities and to fully utilize the operations maintenance staff at all the times. In this way services from other maintenance staffs can be offered to outside companies during normal operations when the work load is not so high.

MAINTENANCE RESPONSIBILITIES

There are two critical areas of responsibilities in maintenance and operation management: maintenance domains (equipment responsibility) and maintenance activities. Yearly planning and budgeting is done for three years ahead.

Plant units are divided into maintenance domains based on process functions and technological expertise (reactor internals, turbine, reactor valves, pumps etc.) where responsible persons are nominated. These persons are "the owners" of components. They have the responsibility of planning, executing and controlling maintenance for a given domain. They are responsible for fulfilling the defined safety and availability requirements and cost targets. They plan the scope of the preventive maintenance, analyze failures and operational disturbances, take care of spare parts needed, suggest improvements and modifications needed, etc. A three year action plan is prepared for every maintenance domain. The action plan is prepared by the responsible person of the domain. The action plan includes planned maintenance tasks, estimates of the workload for activities, sparepart consumption and costs. This work is done in co-operation with the persons of the engineering department.

Maintenance activities are a combination of people, technologies and methods which produce a certain maintenance service. They are sustained by defined organization units (for example mechanical maintenance, I&E maintenance, etc.). Every maintenance activity has a nominated person who is responsible for the quality and effectiveness of its execution.

TECHNICAL SUPPORT

Maintenance support is provided by key experts in TVO's own staff and by having effective contacts with main vendors, consulting companies and research institutes.

The company management has established permanent advisory and supervisory groups for co-ordination, review and supervision of important activities having interdepartmental inferfaces (e.g., ALARA, training, cost control development, information, data management, safety review). A system of temporary working groups and project groups is used to manage large and important tasks and projects having interdepartmental interfaces.

There are also permanent interdepartmental technical groups working on different technical areas (e.g., reactor internals, valves, pumps) to support plant maintenance.

THE USE OF EXTERNAL SERVICES

TVO is using external services in several areas including technical support, research, planning, spare parts and materials, and labour services. The material and service must meet quality requirements and co-operate well with maintenance and other organizations. TVO is using some one hundred external companies for these services.

Suppliers of spare parts, materials and new components for safety related systems are qualified by TVO and the Regulatory Body according to quality assurance requirements. Approval of manufacturers is not limited to specific companies. Any domestic or foreign manufacturer can be qualified if it demonstrates adequate capability and QA.

Planning and design of modifications and other major projects are often ordered from the plant vendors or other competent consulting companies. However, they must always be approved by TVO according to the company's quality assurance requirements.

In addition to about 500 TVO people on site in Olkiluoto during normal operation there are about 150 external contactor persons (e.g., security guards, house keepers/cleaners, maintainers). Canteens are maintained by a private company (with some support from TVO personnel). During annual outages the number of contractor personnel on site increases by 800-1200 persons. During outages there are totally about 100 different contractor companies working on site (including about 20 foreign companies).

Long-term co-operation with the plant vendors and other affiliated important companies is ensured by long-term agreements to provide competent technical support and services when needed. To maintain competition TVO is using more than one contractor on all important service areas if possible. TVO has also given special training to Finnish contractors on some key areas.

TECHNICAL AND ADMINISTRATIVE SYSTEMS

Because of its own very small organization, good co-operation with contractors and good support of administrative and technical systems is needed by TVO. TVO is continually developing administrative and technical systems to support plant maintenance. For example systems for plant equipment data, spare parts, plant and equipment history are essential.

OUTAGE PLANNING

Outage planning is done on three levels simultaneously: long-term planning covering ten years, mid-term planning covering three years and short-term planning of the forthcoming outage.

Long-term planning is used to fit together the planned maintenance, repairs and inspections with major modifications and plant improvements in the shortest possible time. The plant life extension program is also taken into consideration in the long-term planning.

Short-term planning of the forthcoming outage starts immediately when the ongoing outage is over. Special emphasis is put on the careful study of the critical path activities. For example, each foreman has his own detailed schedule for his jobs. Also each maintenance, repair, inspection and modification group has its own schedules. Generally speaking, each task has its place on the schedule. Purchasing spare parts and hiring contractor people so that they will be available when needed are especially important.

To optimize the outage costs and production losses, there are two different kind of outages; a refuelling outage and a service outage. These two outage types mainly follow each other in sequence. The estimated minimum length of a refuelling outage is 10 days. That 10 day period includes refuelling, annual tests and inspections according to the technical specifications, and corrective and preventive maintenance. In short, everything that must be done annually.

A service outage lasts from two to three weeks. During service outages, in addition to the work which is done for a refuelling outage, major overhauls, system modifications and improvements, all servicing and inspections are performed.

The personnel planning the outage must be well acquainted with operation and maintenance. TVO's outage planning organization consists of only three full time persons; the Outage Manager and two Outage Co-ordinators. They all are former shift supervisors. The Outage Manager has a permanent function in the organization but the two Outage Co-ordinators are chosen annually among shift supervisors. Every year two new shift supervisors will gain experience from outage supervision.

The Outage Planning Group is supervised by the Outage Manager. This group consists of supervisors from different maintenance areas, from operation, from engineering and from radiation protection. The group supervises the outages. It has, for example, the following tasks:

- to decide the duration and timing of the outage
- to plan all time schedules
- to make short- and long-term outage programmes
- to develop budgets and to control costs
- to handle problems and to take them to the Plant Meeting for decision making
- to take into consideration the experiences from earlier outages
- to look after purchasing of spare parts and materials
- to look after hiring of contractor people.

The Plant Meeting chaired by the Production Director and participated in by the managers of operations, maintenance, engineering, QA, safety and technical supervision holds the final authority in all outage matters.

Personnel make the result. That is why it is necessary to have the best possible personnel in the outages. The Finnish collective agreement makes it possible to order contractor personnel by name. In this way we can get well trained and experienced personnel. About 80 % of the personnel are the same from year to year. This 80 percent know in advance all our rules, instructions and ways of working.

The availability of professional personnel is assured by continuous training of contractor personnel and by long-term contracts with important contractor companies. Certain companies have a salary premium which they get if the quality of work has been exceptionally good and they have done their work on schedule. This kind of premium system is normally used with companies who work on the critical path.

We have paid particular attention to the living conditions of the contractor personnel on the Olkiluoto plant site. We want it to be a pleasure for them to return to Olkiluoto from year to year and to live and work there. Salary alone is not a sufficient incentive.

TVO's own personnel have a bonus salary system during both normal operation and outages. During outages this bonus depends on the realized schedule and on the total working hours of contractors. While we are trying to minimize the length of outages, we also want that the number of contractor personnel as small as possible.

There is a certain basic bonus, which is always paid, but if the outage length is on schedule or even shorter, the bonus will be higher. In the same way, the bonus will be higher, if the number of total working hours is smaller than planned. This bonus can be up to 25% of the salary of outage period. During operation, the bonus depends on the produced energy, production costs, cleanliness of plant units, effectiveness of personnel and on organisation specific pre-set goals. This bonus can, at the maximum, give an extra 130 hours salary annually.

REGULATORY BODY

The Finnish Centre for Radiation and Nuclear Safety (STUK) issues NPP-guides for outage supervision. Outage plans, outage execution and all safety-related outage activities must be approved by the Regulatory Body according to the instructions in the NPP-guides.

Before outages there are meetings where all outage activities are presented to the Regulatory Body's inspectors. The aim is to tell too much rather than too little. After the outage, directors and managers of the Regulatory Body and TVO have a meeting where all problems arisen during outages are discussed.

During outages up to 10 inspectors are working on the plant units. They are available 24 hours per day if necessary. The inspectors do their work honestly and to the letter but still in very good collaboration with the TVO personnel. The inspectors are very responsive and no work is delayed because of them. Inspectors can make individual decisions at the plant site without any bureaucracy of the Regulatory Body's headquarters.

HOW CAN THE NUMBER OF PEOPLE BE FURTHER REDUCED?

Individual responsibility. Given the chance, a worker will look for the most efficient method of doing his work. There is no need to have a very strict supervision of workers by foreman. If workers are well trained, experienced and skilled they certainly do their work in the best possible way without any continuous supervision. In this way the number of foremen and even the number of organizational levels can be reduced.

Multi-skilled workers can do more. By teaching people to do a series of operations rather than just one special task, the number of people can be reduced. For example, a mechanic can insulate components, make simple scaffoldings and take care of the cleanliness of his work site in addition to his mechanical work. Doing the work in this way, it will become more flexible and also more interesting and more challenging for the worker. A motivated worker also takes good care of his own radiation protection.

Multi-disciplined teams are effective and independent. By organizing teams of people with several professions in such a way that a team can carry out a job from beginning to the end, working will be very flexible and effective. Combining these multi-disciplined teams with multi-skilled people, the result will be even better.

TRENDS IN MAINTENANCE ORGANIZATIONS IN FINLAND

Traditionally maintenance work in Finland, including work at NPPs, has been organized through a strong centralized organization; one organization unit has taken care of all maintenance functions. Today's tendency is to combine the daily maintenance with operation and have a separate maintenance organization which concentrates on key functions. General and also some special services are purchased outside the company. Maintenance staff, especially in operations, should work as a team and have multi-skilled members.

Extreme care is to taken in procuring all maintenance services. In this case the company must have persons with broad knowledge to plan, purchase and supervise the work. This kind of organization is used for example in the paper industry and some conventional new power plants.

COOPERATION WITH OTHER POWER PLANTS

TVO has very wide co-operation and information exchange especially with Swedish NPPs and the Finnish Loviisa NPP. Meetings on different levels and topics (operation, outages, reactor, turbine, generator, diesel generators etc) are held at regular intervals.

TVO has partnership relations and experience exchange also with other NPPs around the world (for example with Japanese NPPs).

OPERATING EXPERIENCE

Operating experiences of plant units are followed up carefully. All disturbances on the plant units are reviewed by a special analysis group and are analyzed in more detailed by specialists if needed. This group analyzes also information from EURATOM, WANO, INPO, and the IAEA. This work has lead to improvements in some TVO systems and routines.

TVO reports component failures to a common data bank (TUD) with Swedish NPPs. This data is used by TVO to analyse problems of Swedish NPPs that have the same types of equipment and components as does TVO and for updating of PSA analyses.

The long-term agreements with the main plant vendors include also reporting problems from other power plant units supplied by the vendor.

THE FOLLOW-UP OF MAINTENANCE FUNCTIONS

How can sufficient quality and productivity of maintenance works be maintained? The main responsibility for quality lies with the worker, it is not reached by controlling. Good quality requires good preplanning, correct execution, verification by supervisors, inspections and good documentation so that also the quality can be verified afterwards (who made, how it was made and with what results).

The follow-up and development of the maintenance functions need performance indicators that point to trends and give us sufficient lead time to develop our activities.

THE FUTURE

The tendency in Finland is to have small NPP staffs and purchase a variety of services. This includes much of the maintenance of nuclear power plants. However, nuclear power plants have critical functions where NPPs must have their own competent resources to ensure a high level of safety and operational performance in the future.

We must continually improve and develop our business processes to meet future challenges and to keep the nuclear power competitive. The job is never complete.

Annex H

RESTRUCTURING OF PREUSSEN ELEKTRA'S POWER PLANT ORGANIZATION

Preussen Elektra AG is one of the largest German utilities, supplying electric power to the North of Germany. The installed power amounts to 12 000 MW, of which about 60% is supplied by nuclear power plants.

Due to the changes in the European electricity market, a paradigmatic change has begun in the field of nuclear power generation.

Formerly, the two principal priorities in the field of nuclear power generation were:

- safety
- availability

A third priority now has now been added to these:

- economic efficiency

This means that the existing safety and availability standards must be fulfilled under the growing pressure of costs.

A reorganisation of structures was decided, in order to prepare nuclear power plants for these changed overall operating conditions.

This reorganisation has two main objectives:

- making more flexible the staff and the organisation (transition from a hierarchical/facultative oriented to a process/team oriented organisation);
- increase productivity (optimisation of resources).

After strategic ideas were completed, a decision had to be made concerning the form of implementation of the concepts.

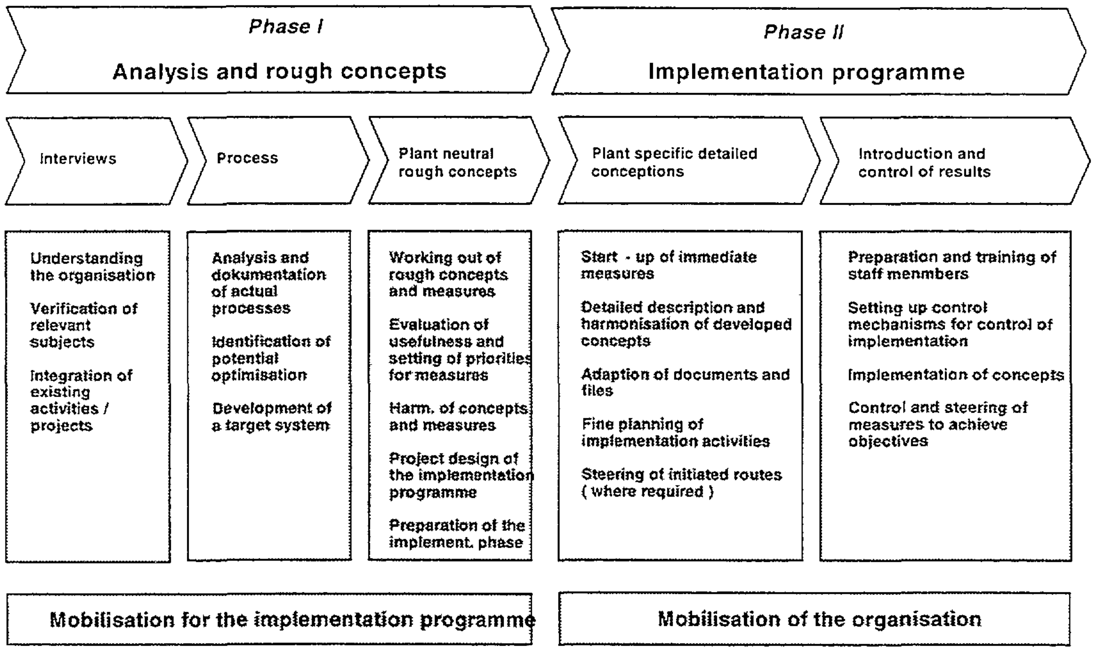
In the past, reorganisations mostly were carried out in top-down form, that is, the staff was informed about foreseen changes without being consulted in the matter.

This approach had yielded practically no satisfactory results.

This is why a modern route was chosen for the organisational restructuring of nuclear power plants.

This route provides for the largest possible number of persons involved in the process to participate directly in the reorganisation of their work and duties.

This participation is implemented by means of interviews, workshops, brown-paper sessions, etc.



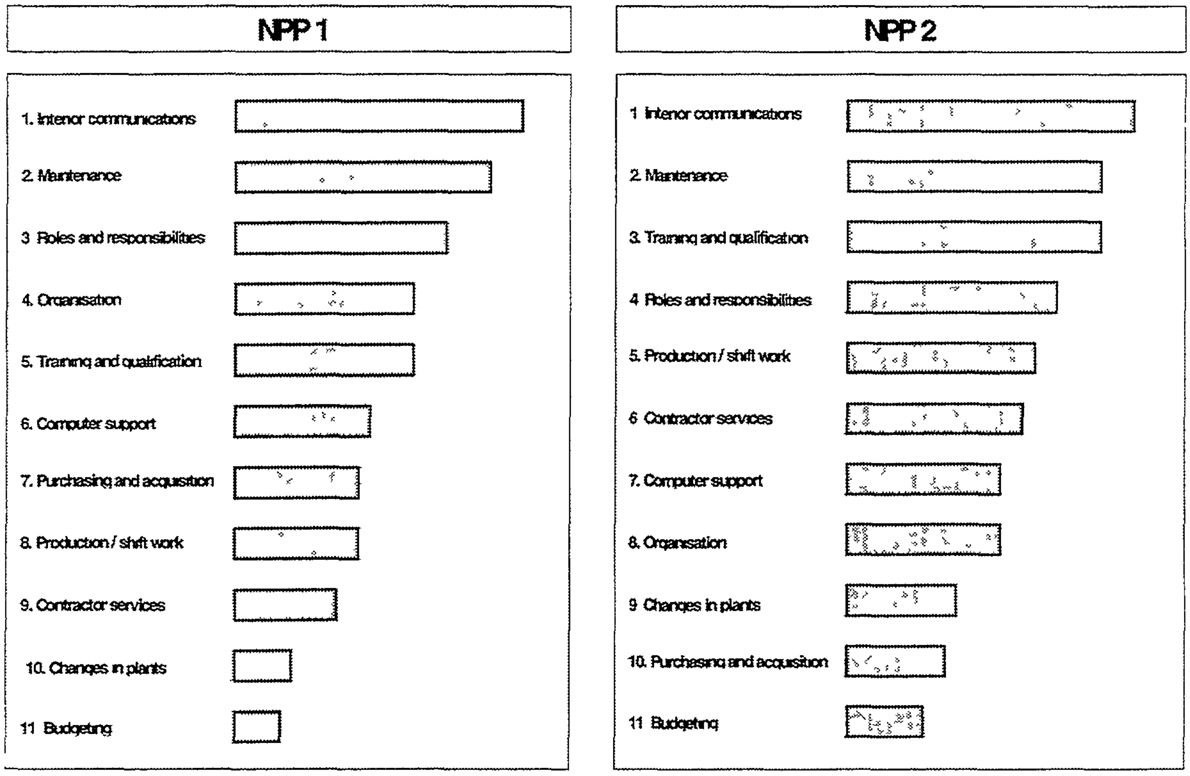
Shown above is the gradual process used to mobilise the staff and the organisation. The objective of the analysis and rough conception phase was to analyse the advantages and the potential improvement, as well as to work out rough concepts

To start with, organisation analyses cover the following fields:

- maintenance
- work in shifts
- changes in plants
- industrial economics.

After the first phase "Interviews and Process Analyses" was concluded in some of plants, preliminary results were available.

The NPP staff was questioned about their opinion of the most important points for the improvement on the effectiveness.



Frequency of mentions among the most important topics

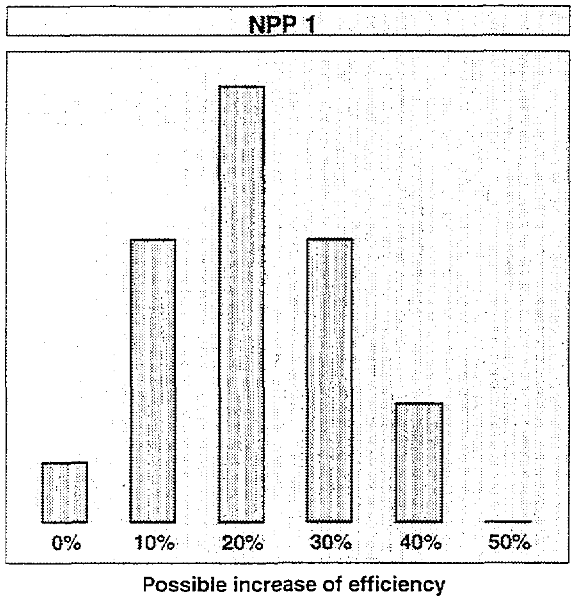
Shown above are the perspectived of NPP staff. These results show that internal communications and maintenance are main points of improvement in both powerplants. In the opinion of the staff, the topics budgeting, changes in plants and purchasing and acquisition were of considerably lesser importance.

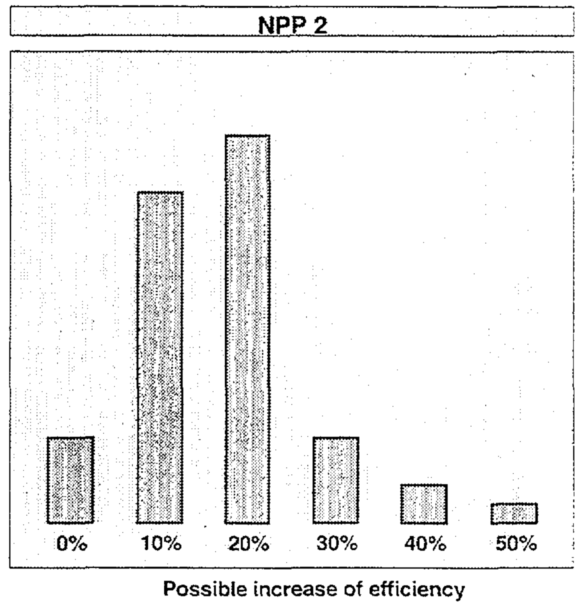
The following question was asked among other things to the staff:

"Assuming the potential improvements discussed during the interviews can be implemented, how high do you estimate the potential increase in efficiency ?"

Most responses concerning this free capacity estimated between 10 and 30%.

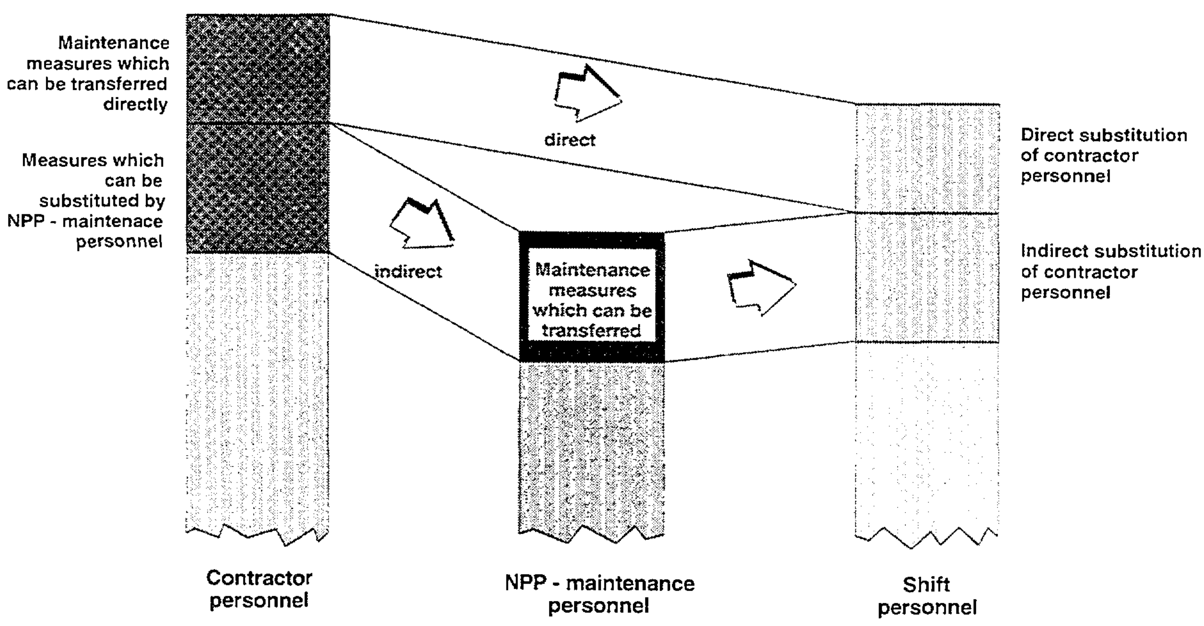
The evaluation of the answers is represented in the following illustration:





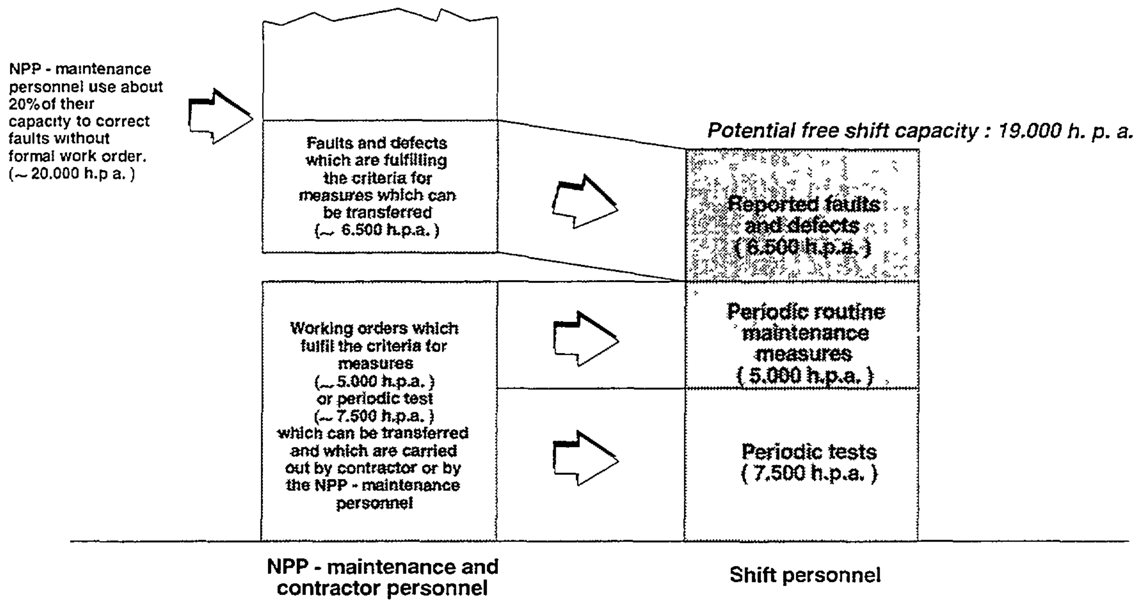
Shown above are the potential increase in efficiency which the NPP staffs consider to be realistic. The NPP staffs consider there still is a large potential for increased effeciency.

It was decided that to achieve the increase of the effectiveness a part of the simple maintenance work should be transferred to on the shift personnel.



The objective within the field of shift operation is the quantification of possibilities for direct and indirect substitution of contractors.

Free labour capacities in shift operation can be occupied with 12.500 hours per annum (h.p.a.) for recurrent tests and periodic maintenance tasks. The rest of potential free shift capacity can be occupied with reported faults and defects.



Occupied free labour capacities in shift operation

Shown above are the first concrete results obtained by the project team responsible for the shift operations area. The free labour capacities in shift operations are occupied with 6500 h.p.a "Reported Faults and defects", 5000 h.p.a. with "Periodic Routine Maintenance Measures" and 7500 h.p.a. „Periodic Tests"

Preussen Elektra NPPs expect clear reductions (20 to 30%) in these areas "Contractor and own Personnel Costs" once the restructuring measures become effective.

Annex I

GNPS PROJECT MANAGEMENT ORGANIZATION DURING CONSTRUCTION

1. INTRODUCTION

Guangdong Daya Bay Nuclear Power Station (GNPS) is the first large commercial nuclear power station in China (apart from Taiwan). GNPS comprises two Pressurized Water Reactors of 984 MWe each unit. Guangdong Nuclear Power Joint Venture Co., Ltd (GNPJVC) is responsible for the project construction and subsequent operations management upon completion of the construction programme. The nuclear island equipment is imported from France and the conventional island equipment supplied by the Anglo-French Company GEC-Alsthom. The balance of plant was independently procured by the owner. On August 7, 1987, the project was formally authorized to proceed (ATP). GNPS Units 1 and 2 entered into commercial operation on February 1, 1994 and May 6, 1994, respectively.

2. GUANGDONG DAYA BAY NUCLEAR POWER PLANT — INTERNATIONAL PROJECT

GNPS is an "international project". During the construction period, there were thousands of expatriates from supplier and contractor organizations who worked closely with their Chinese counterparts in designing, civil works, erection and commissioning activities.

GNPS project is characterized by its well-designed work schedule. It took about 7 years from ATP to the commercial operations of Unit 1 and 4 years or so from erection to the first criticality of Unit 1. This achievement demonstrated that the Chinese have the ability to organize and manage a large "international project" and the talent to overcome the communication difficulties and cultural differences in implementing such a complex project with expatriates. There were no insurmountable obstacles in the project up to the pre-operation tests and full-load operations. This demonstrates that Chinese parties have been successful in respecting the principal of the 'safety first, quality first' in the GNPS construction process. Since commercial operation, the good operating record of the plant shows that GNPS has reached the requirements of the original design.

3. PROJECT CONSTRUCTION MANAGEMENT OF GNPS

The GNPS project adopted a non-turn-key-subcontracting management approach. Non-turn-key means that GNPJVC took full responsibility for project construction by exerting control on the quality, progress and cost of the project. Subcontracting was divided into nuclear island, conventional island and balance of the plant. Each part was undertaken by a contractor for design and interface management. Meanwhile, GNPJVC had expert advice on quality assurance from an American engineering company, Bechtel. Additionally, GNPJVC signed a project service contract with EDF who had overall technical responsibility for the project and provided project management assistance.

As GNPJVC had no experience in designing and constructing large-scale commercial nuclear power plants, this management approach minimized the risk of project construction and helped GNPJVC and Chinese design institutes gain as much management and design expertise as possible in the project. The project's success demonstrates that this management approach was appropriate.

4. ORGANIZATION OF THE GNPJVC PROJECT DEPARTMENT

Figure 1 shows the organization of the Project Department during GNPS construction. The Project Department was headed by a Project Manager, who was an expatriate employed by GNPJVC, who had considerable experience in Nuclear Power Station project management. The Project Manager was responsible to the GNPJVC General Management for all project management activities of GNPS. He was assisted by two deputies from GNPJVC with experience in nuclear and electricity industries respectively. The management of the Project Department has the responsibilities as follows:

- Technical management,
- Engineering management,
- Planning and contract management,
- Administration and supply management.

As shown in Figure 1, the Project Department consists of two divisions; the Technical Management Division and the Contract & Administration Management Division.

The Contract and Administration Management Division had 5 branches; Construction Contract & Cost Control, Supply Contracts, Equipment, Import Management Office and Project Department Office. All heads of the branches were Chinese employees. The Contracts & Administration Division Manager was nominated by GNPJVC. His responsibilities were as follows:

In China:

- Planning supervision,
- Cost control,
- Provide administrative function,
- Coordinate delivery of components and materials to site and documentation to GNPJVC,
- Arrange other procurement activities outside the scope of the main contracts.

In Europe:

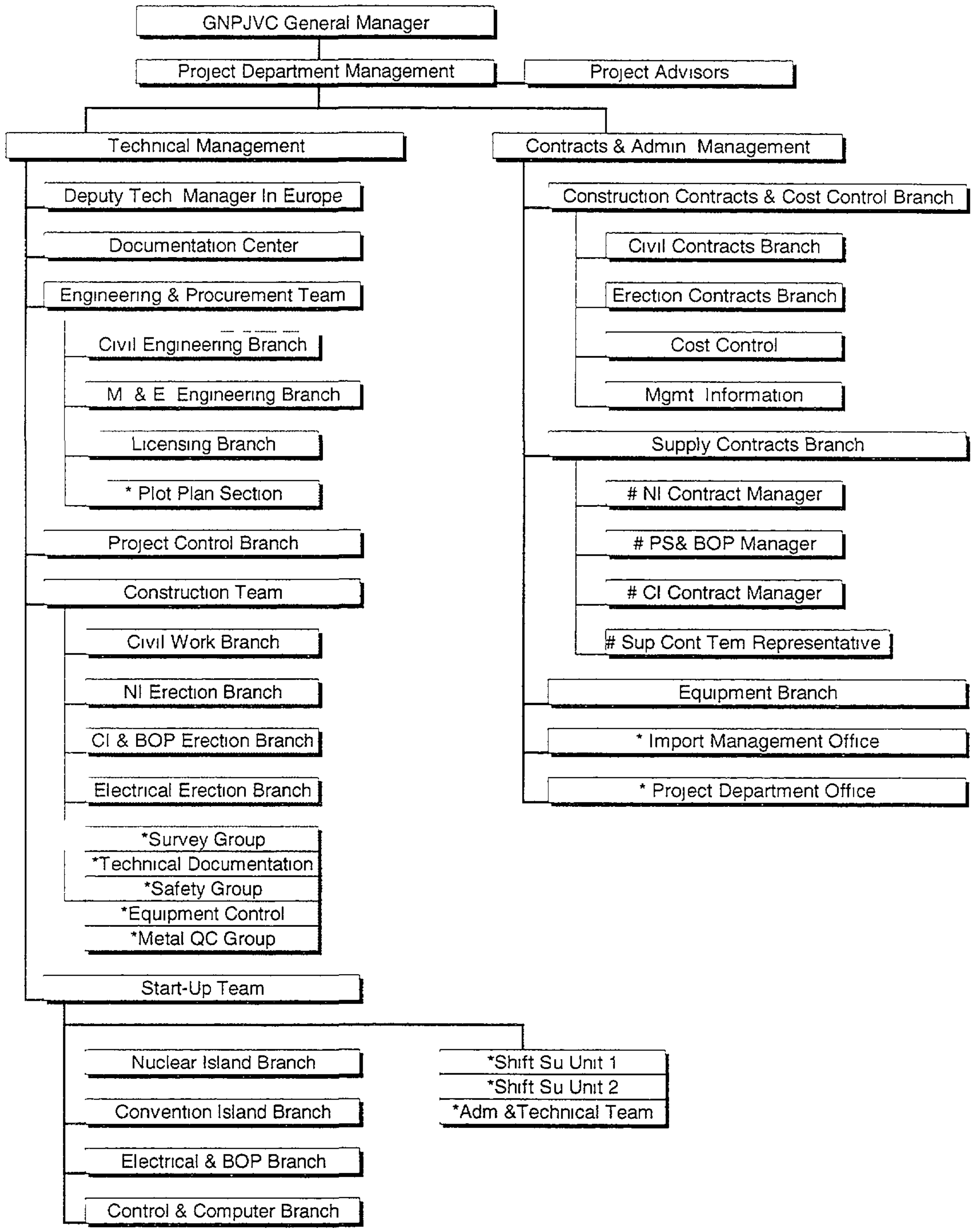
- Representative has to negotiate and implement contracts in commercial and legal respects, and issues not covered by technical management and resolve all issues of a contractual nature,
- Shipping,
- Administration.

The Technical Management Division consisted of an integrated team in Europe; Engineering & Procurement Team, Project Control Branch, Construction Team, Start-up Team and Documentation Center. All heads of the teams (branches) came from EDF staffs. The project services contract specified that managers and their deputies of these organizational units were seconded by EDF. An Assistant to the Manager was however seconded by GNPJVC.

Duties of the Technical Management Division were as follows:

In China:

- Coordinate the flow of equipment and documentation in accordance with site requirements, and manage the owner's technical liaison between site and the Europe team,



Note * Non Branch Setup # Deputy Branch Setup

FIG 1 GNPJVC Project Department Organization Structure

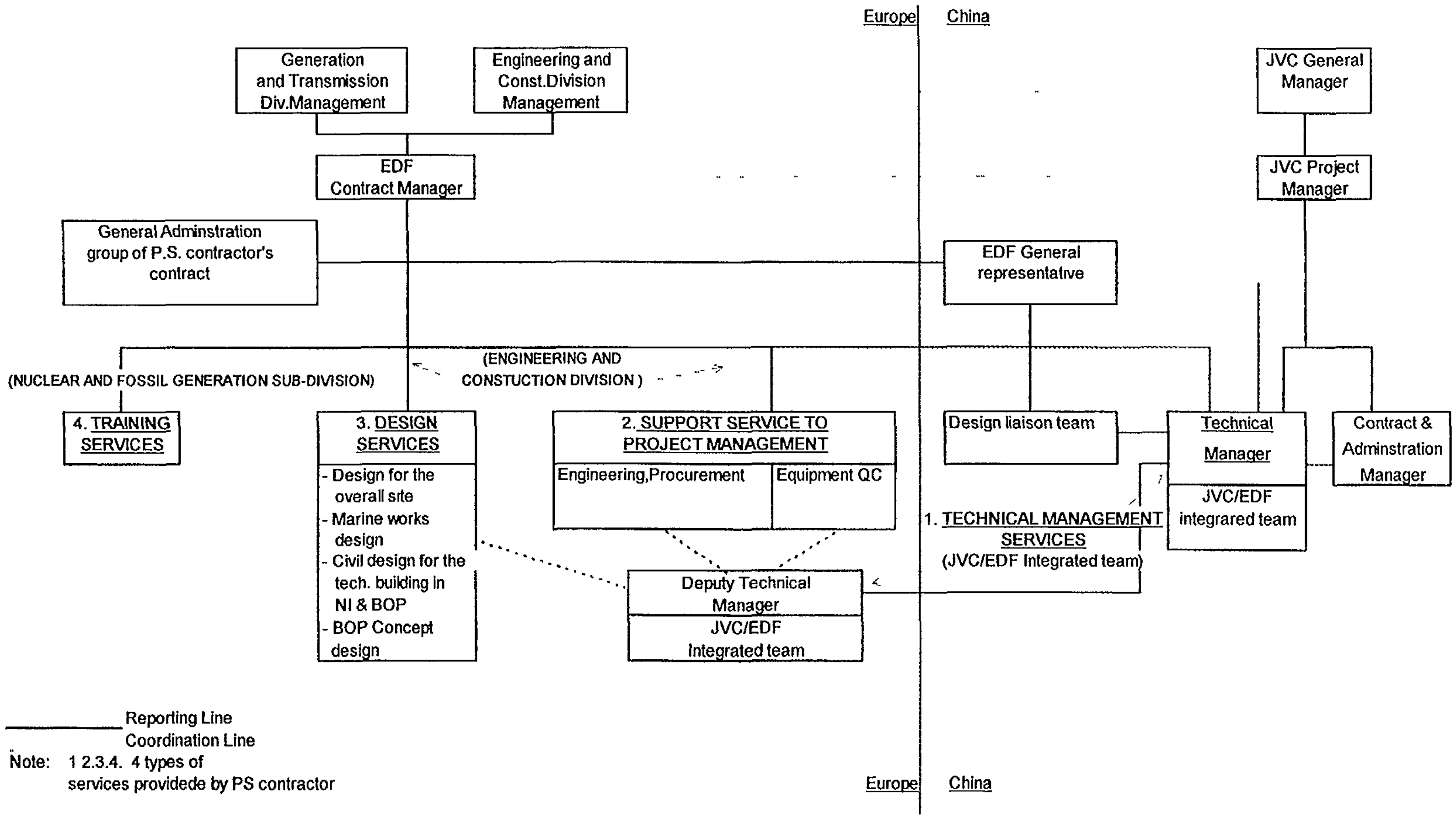


FIG. 2. GNPS Project Service Organization Structure.

- Coordinate and monitor site construction and erection activities, for which there was a Branch Manager reporting to the Technical Manager and led by an experienced construction manager,
- Manage the start-up tests, for which there was a Branch Manager reporting to the Technical Manager and led by an experienced Start-up Manager.

In Europe:

- Implement the project management procedures and engineering control documents,
- Coordinate and manage engineering activities, QC surveillance of manufacture and review of the design,
- Perform expediting and coordinate delivery schedules with site requirements.

5. GNPS PROJECT SERVICES ORGANIZATION

For the purpose of implementing the GNPS project smoothly, GNPJVC signed a project service contract with EDF who had knowledge of the technology and experience in project engineering, and in managing and operating large PWR type commercial nuclear power plants. The overall project services organization structure is shown in Figure 2. The responsibilities of the major participants involved in the contract are described below.

GNPJVC's responsibilities:

- Site selection and preparation, carrying out of earthworks and excavations,
- Awarding contracts for the procurement of components, equipment, systems and related services for the Nuclear Island, Conventional Island and Balance of Plant,
- Awarding contract for project services,
- Awarding contracts for:
  - construction of all buildings and civil structures,
  - transportation to the site, from the country of origin or from their arrival in China or Hong Kong, as the case may be, of material, equipment and components, and on-site handling and storage,
  - on-site erection of components, equipment and systems.
- Overall management and coordination of the Project, including:
  - obtaining from the appropriate authorities in China all required licenses, authorizations and permits to build and operate the GNPS,
  - monitoring of the various contracts either inside or outside China,
  - site management of GNPS,
  - coordination with local authorities,
- Operation of GNPS.

EDF's responsibilities:

- Technical Management Services (through a GNPJVC/EDF integrated team),
- Quality Assurance, Technical and Operation Management Assistance,
- Project Management Support Services,
- Engineering and Design Services,
- Training Services.

The GNPS's success was facilitated through effective organization and advanced management approach. The project progressed forward smoothly, while at the same time desired targets in terms of both quality and cost were also effectively achieved.

CONTRIBUTORS TO DRAFTING AND REVIEW

Bogomolov, I.	Kalinin NPP, Russian Federation
Diaz-Francisco, J.	International Atomic Energy Agency
Haferburg, M.	Preussen Elektra AG, Germany
Hamlin, K.	London Coordinating Center, WANO
Jeon, P. J-P	Korea Electric Power Company, Republic of Korea
Lipar, M.	Bohunice NPP, Slovakia
Mason, D.	Nuclear Safety Directorate, United Kingdom
Mazour, T.	International Atomic Energy Agency
Miller, K.	Nuclear Electric, Ltd, United Kingdom
Plavjanik, D.	Dukovany NPP, Czech Republic
Price, D.	Tim D. Martin & Associates, Inc., United States of America
Qiang, H.	GuangDong Nuclear Power JV Co, China
Sundell, R.	TVO, Finland
Trampus, P.	International Atomic Energy Agency
Xu, Y.	GuangDong Nuclear Power JV Co., China
Yanev, Y.	University of Sofia, Bulgaria
Yankov, M.	Kozloduy NPP, Bulgaria

Consultants Meeting
Vienna, Austria, 14–18 April 1997

Advisory Group Meeting
Vienna, Austria, 8–12 September 1997

Consultants Meeting
Vienna, Austria, 16–20 March 1998

IAEA PUBLICATIONS RELATED TO ORGANIZATION AND STAFFING OF NUCLEAR POWER PLANTS

SAFETY SERIES

50-C-O (Rev.1)	Code on the Safety of Nuclear Power Plants: Operation	1988
50-SG-09	Management of Nuclear Power Plants for Safe Operation	1984
75-INSAG-4	Safety Culture	1991
50-C/SG-Q	Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations	1996

TECHNICAL REPORTS SERIES

369	Management for Excellence in Nuclear Power Plant Performance	1994

IAEA-TECDOC SERIES

621	Good Practices for Outage Management in Nuclear Power Plants	1991
928	Good Practices for Cost Effective Maintenance of Nuclear Power Plants	1997

98-03216