AECL'S SUPPORT TO OPERATING PLANTS WORLD WIDE

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ABSTRACT

Through their operating records, CANDU® reactors have established themselves as a successful and cost-effective source of electricity in Canada and abroad. They have proven to be safe, reliable and economical. A variety of factors have contributed to the enviable CANDU record, such as a sound design based on proven principles supported by effective development programs, along with dedicated plant owners committed to excellence in safely maintaining and operating their plants.

Atomic Energy of Canada Limited (AECL), the CANDU designer, has continuously maintained a close relationship with owners/operators of the plants in Canada, Argentina, Romania and South Korea. AECL and the plant operators have all benefited from this strengthening relationship by sharing experience and information.

CANDU plant operators have been required to respond decisively to the economic realities of downward cost pressures and deregulation. Operating, Maintenance and Administration (OM&A) costs are being given a new focus as plant owners review each cost element to improve the economic returns from their investments. Amongst the three main OM&A constituents, plant maintenance costs are the most variable and have the largest influence on effective plant operations. The correlation between effective plant maintenance and high capacity factors shows clearly the importance of proactive maintenance planning to reduce the frequency and duration of forced plant outages and their negative impacts on plant economics.

This paper describes the management processes and organizational structures in AECL that support plant operations and maintenance in operating CANDU plants with cost effective products and services.

INTRODUCTION

CANDU reactors have been operating commercially for over 30 years providing a safe and reliable source of electricity. Following the success of the Nuclear Power Demonstration (NPD) project that was commissioned in 1962, the prototype of CANDU's Commercialization - Douglas Point - started in 1967. This was followed by the Pickering Units 1 and 2 entering in-service in 1971, by units 3 and 4 in 1972 and 1973 respectively and, later, by additional units at Bruce, Pickering and Darlington. The first CANDU 6 at Pt. Lepreau began commercial operation in 1983. Today, in 1998, there are nineteen CANDU units operated by Ontario Hydro, and six CANDU 6 plants operating worldwide. Two CANDU 6's,Wolsong 3 and Wolsong 4, are expected to begin commercial operations in 1998 and 1999 respectively, and two CANDU 6 units under construction at Quinshan, in China, are scheduled to be in-service by the year 2003.

AECL is a turnkey supplier for the full scope of CANDU projects and AECL's capabilities cover the entire spectrum of the plant's life cycle, i.e. from design to commissioning through operations and decommissioning. Depending on the specific contractual agreements, once the in-service plant is turned over to the owner, the owner takes full responsibility for the operation of the plant. Within AECL, the responsibility for supporting the operating plants is then transferred from the Projects Division to AECL's Services Division. This paper describes AECL's strategy to support the operating CANDU plants through a dedicated Services Division that is mandated to supply cost effective products and services required by the plants.

CONTRIBUTORS TO GOOD ECONOMICS

For operating plants the key contributors to good plant economics include:

- Low fuel costs,
- High plant availability factors, and
- Low OM&A costs.

Two features of the CANDU design - use of natural uranium as the fuel and on-line refueling - provide automatic economic gains through low fuel costs and the elimination of refueling outages. From a plant maintenance perspective on-line refueling provides significant flexibility in the scheduling of outages and simplifies the planning and execution of the activities to be carried out. The contribution of fuel costs and on-line refueling benefits are fixed by design and are known up front. This leaves the OM&A component as the major variable in the cost equation for operating CANDU plants.

OM&A Costs

Three elements comprise OM&A costs:

- Operating costs,
- Maintenance costs, and
- Administration costs.

Administration costs are generally the smallest of these, constituting about 5% of the total OM&A costs. Depending on the organization's requirements and practices, these costs can vary somewhat. The two larger elements of the OM&A costs are operating costs and maintenance costs. Operating costs are a function of a number of variables including the organizational structure, design features, practices and regulatory requirements. For example, the number of licensed positions to support the plant can vary from plant to plant depending on specific requirements identified by the Regulator. Once a plant is in operation and staffed to its full complement, operating costs are largely set by the payroll burden and are not a major variable. Limited savings in operating costs may be achieved through approaches such as more automation, computerized testing, etc., to reduce the labor requirements at the plants. The third variable in the OM&A cost equation is maintenance cost which has the largest variability and range. Maintenance costs could vary more than 100% from year to year on the same plant, and similar variations can exist from utility to utility. Other factors that can influence maintenance costs include the age of the plant, previous history of maintenance, the frequency of forced outages and the utility's planning approach to inspection and preventive maintenance.

PLANT OUTAGES

Plant outages that result in production losses can be classified by the initiating cause into the

following three categories (Reference 1).

- Equipment,
- Human factors, and
- External causes (including Regulatory).

The outages that can result from these initiators can either be forced or planned plant shutdowns. Planned maintenance outages affect the plant economics in several ways and the duration of the planned shutdown usually has the largest direct cost impact. Unforeseen events such as accelerated or anomalous degradation of equipment (discovered during inspection), human errors or availability of staff or parts can cause outages to last longer than planned with potentially significant and indeterminate economic penalties. Forced outages, on the other hand, can have even more severe economic penalties since they may occur during periods of peak electricity demand and highest cost. Forced outages acutely test a utility's capability to quickly determine the cause of the outage, to quickly obtain appropriate equipment such as tools, spare parts, etc., and to deploy the appropriate personnel.

The foregoing discussion indicates that in order to achieve good plant economics, attention must be focused on the various elements that make up the operating and maintenance costs and in particular to ensure that the frequency and duration of unplanned outages are minimized. The ensuing sections in this paper describe AECL's approach in helping operating plants to achieve this objective.

SERVICES SUPPORT ORGANIZATION

AECL's present organization is structured along two major functional lines - the Commercial Operations Division and the Research and Product Development Division. In its broadest form, the Commercial Operations Division consists of the Projects Groups that execute all work related to the 'build projects' and the Services Group that supports operating CANDU plants. The Services Group derives its mandate from AECL's Corporate mission that commits to support and service the operating CANDU plants. The organizational structure of the Services Group has evolved to the current state shown in Figure 1:

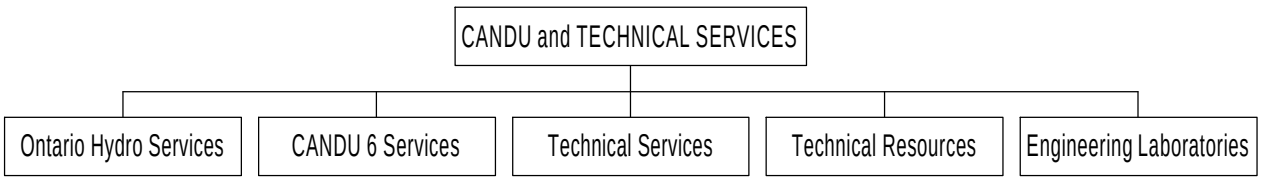

Figure 1

Figure 1The Services Group is split into three distinct and separate operating units along client based lines and is led by a General Manager. The Ontario Hydro Services unit is dedicated to support all nuclear plants operated by Ontario Hydro. The CANDU 6 Services unit provides services support to operating CANDU plants in Canada, Argentina, South Korea and Romania. The Technical Services unit provides services and products to non CANDU clients. In addition, two other support units provide technical resources (staff) and manufacturing/laboratory services to these three client based units. Key features of AECL's services support organization are described below.

Accountability

Each of the units shown in Figure 1 is led by a Director who has full responsibility to manage its operations and is accountable for its commercial objectives. Each unit is further sub-divided to support individual clients or plants as shown below (in Figure 2) for the CANDU 6 Services unit (as an example).

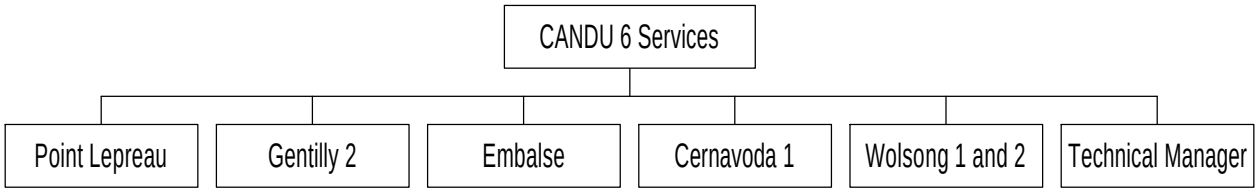

Figure 2

Client Interface

AECL has taken great care to organize its Services Group to provide the best support to the operating plants. To achieve this, AECL's representative, who interacts with the client, is located at the plant working alongside plant staff. This ensures frequent and immediate access to AECL for plant personnel and provides timely and effective AECL services to the utility.

Experience Sharing

AECL's representatives at CANDU sites are in close touch with colleagues elsewhere in AECL and at other sites. This communication provides immediate and detailed feedback among sites and has proven invaluable both in information sharing and in preventing the occurrence of similar incidents at more than one plant.

Cost Sharing

The Services Division organization encourages cost sharing of work among utilities in activities such as product development, generic problem resolution, procurement of spare parts, equipment and tool design, engineering assessments etc. The Technical Manager (Figure 2) assesses specific requirements from each utility and recommends to AECL's representatives at other sites investigations of the potential for cost sharing of the required tasks among the affected utilities.

Communication

AECL continues to design and build new CANDU plants and to incorporate continuous improvements in the CANDU products. AECL's representatives at each CANDU site help this process by feeding back operating experience to designers. Even more important to the operating utilities, the representatives also keep them informed of improvements and new features being incorporated in newer plants for possible retrofitting to existing plants. Similarly, AECL's Reactor and Product Development Division develops solutions and/or new products both in support of the CANDU ‘build projects’ and for other clients. These are communicated to the operating plants through AECL's site representatives.

Products and Services

AECL's support to the operating stations encompasses the following three broad areas:

- Design Support,
- Maintenance and Inspection Support, and
- Operations Support

In its CANDU vendor role, AECL usually carries out all work related to the Nuclear Island and sub-contracts work related to the Balance-of-Plant. AECL has a similar strategy in executing services work to support operating plants. AECL has developed numerous products and services that serve the operating CANDU utilities economically.

Design Support

Utility technical units that provide operating and maintenance support to CANDU plants vary in their expertise and capabilities. The problems and issues faced by the technical units can be broadly classified as Operations and Maintenance related, or Design related.

Most utilities maintain in-house capability for planning and execution of all operations and maintenance activities, but there are differences amongst them in their in-house design and analysis capabilities. This is particularly so for specialized work such as computer code development and application, assessments outside of the design envelope or problems involving multiple disciplines.

AECL has a close working relationship with the CANDU plant owners who need these kinds of specialized assistance. They are supported using one or more of the following approaches to complement the expertise staff.

Integrated Teams

To address occasional specialized and complex issues, AECL has provided technical experts to be integrated with teams from the plant. The joint teams can work out of either the site or AECL's offices. The integrated task team approach has worked very efficiently to resolve defined problems and issues. Recently, AECL utilized this approach to provide support to the utility in resolving a feeder pipe leaking and replacement problem at Point Lepreau.

Integrated teams have also worked well in resolving generic problems where teams are drawn from more than one utility. In 1994/95, the CANDU industry had a generic concern that required the re-engineering of the degasser condenser system and valves. A team of experts from Ontario Hydro, N.B. Power, Hydro Quebec and AECL successfully met all requirements. In such cases, a Steering Committee that oversees the strategy and implementation has proven to be very effective. A similar approach is currently being used to develop fitness-for-service guidelines for the CANDU outlet feeders.

Staff Secondments

In other instances the operating utility leads the work assisted by technical resources seconded to the team by AECL. The seconded staff have been at the expert level for short term durations or at the generalist level for longer terms. This concept has proven to be very cost effective for the utilities since it minimizes training requirements and accesses experts only for the exact durations for which they are required. AECL has used this approach extensively in its support to Ontario Hydro plants.

Packaged Work

When the required work is complex or cannot be well defined, AECL may support the operating utilities by carrying out such work on a turnkey basis. Examples of such work include:

- Complex multidisciplinary analytical studies that involve code development and/or modifications,
- Safety System performance assessments and analysis,
- Plant Life Management studies, and
- Software development and support.

Maintenance and Inspection Support

AECL employs specialists who can assist the utilities on a variety of maintenance and operations support activities. Such expert teams generally work at sites during outages and support plant personnel on activities that range from training to operating specialized equipment and tools supplied by AECL. This approach is cost effective since it does not require utility personnel to be trained on activities which could be specialized but infrequent. The development, training and maintenance of such expert teams poses a number of challenges to AECL. To have the right numbers of staff with the appropriate mix of skills and expertise requires ongoing interaction with operating plant staff. Prevention of potential schedule conflicts between the outages of two or more operating plants requires careful planning and organization. The lead responsibility for outage management and activities rests with each utility, but AECL, has been contracted to undertake turn-key maintenance projects that have included the deployment of other organizations/suppliers and integration of their activities.

The organization of AECL's Services Division shown in Figure 1 has been designed to respond to these requirements. The Technical Resources group, resident in the same division, arranges for the timely availability of staff for outage support. Staff development and training activities are planned and customized to respond to specific client requirements through good communication within the division.

As noted earlier in the paper, an operating plant's economics can be degraded if response to unplanned outages is delayed by limitations of technical resources, experts, equipment or tools. AECL's Services organization, through its resident representative at each site, assists plants in addressing such needs as soon as they become issues that could affect the operation of a plant. Appropriate contracts are always in place with each utility to permit immediate emergency deployment of experts. AECL also arranges emergency supply of equipment and tools for planned and unplanned outages from other plants, suppliers or AECL's own inventory.

AECL has trained its own staff to understand the cost impact of outage extensions. AECL also consults closely with plant staff to ensure that AECL staff have detailed understanding of both the overall outage activities and all AECL commitments to supply staff, equipment and tools. These activities are planned in detail to guarantee timely availability of AECL's products and services. For off-shore utilities, other factors such as shipping details and export/import permits introduce additional elements to the plans.

Products and services offered by AECL include:

- Fuel Channel replacement equipment tools and services,
- Spacer location and repositioning (SLAR) tools and services,
- Reactor maintenance and emergency services,
- Safety Analysis and design assessments,

- Steam Generator maintenance/Inspection tools and services,
- Site training,
- Environmental Qualification calculations, assessments and tests,
- Configuration Management services, and
- System and equipment surveillance programs and processes

OPERATIONS SUPPORT

As discussed earlier, operating costs are a major component of the OM&A equation and payroll costs are in turn a large part of the operating costs (in addition to consumables and fuel). When a plant has been operating for several years, as is the case with most CANDU plants, these costs do not have major variability from year to year. Savings in these costs are hard to achieve without significant effort to reduce labour intensive activities such as inspection, monitoring and testing of components/systems by computerizing or automating such activities.

AECL has continued to enhance automation of the CANDU reactors which from the very onset had digital plant control provided by two redundant control computers. A number of products have been developed by AECL to simplify or replace labour intensive activities including:

- Remote computerized testing of safety systems,
- Online equipment monitoring systems,
- Fuel channel inspection systems,
- Robotic tooling, and
- Configuration management.

Most of these products have been developed by AECL, in consultation with the operating plants, and in response to specific needs. In addition to reducing costs, these products help to reduce radiation doses and improve safety. AECL continues to work with the operating utilities to assist plant operations and to improve economics.

CONCLUSIONS

AECL is fully committed to support operating CANDU plants to run economically at high capacity. To achieve this objective, AECL's Services Division has been organized to provide cost effective products and services to the operating plants. The Services Division maintains key links with CANDU utilities through an AECL representative at each site for liaison and timely actions.

REFERENCES

1. Desbiens & P. Lafrenière: "Maintenance Contributors to Gentilly 2 NGS Incapability Factor". Paper presented at 4th International CNS Conference on CANDU Maintenance, Toronto, Canada, 1997 November 16-18.