STAFFING REQUIREMENTS FOR FUTURE SMALL & MEDIUM REACTORS

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Abstract

As power generators around the world grapple with the challenges of the environment, deregulation, competitions and changing prices of fuels, the economics of running a future power plant are influenced significantly by the component of labour costs. These costs, from plant staff, corporate support and purchased services will affect the overall plant economics. To achieve improved efficiency and effectiveness of organization structures and staff, vendors and utilities are working jointly to apply lessons learned for future designs. This paper will examine the experience gained to date with Canadian CANDU 6 type reactors both in Canada and abroad. The strategies which have been very successful will be reviewed, together with the results of collaboration between Atomic Energy of Canada and the utilities. An assessment of the staffing numbers is provided as a comparison between current number at a Canadian utility and the projected number from a future plant with the improvements in the design. The influence to the overall plant economics are discussed with some broad generalities that look at the effects of increasing and reducing staff levels showing the probable impact on capacity factor. The lessons from other plants can contribute significantly to the performance improvement process. The paper points to the need for a balanced approach in the future for the distribution of operating maintenance and administration (OM & A) cost between nuclear safety studies; maintenance programs and staff training. In the future, utilities, together with the designers will have to greatly improve plant maintenance and training. The improved design features detailed in the paper will support this strategy by utilizing operational experience.

1. INTRODUCTION

The paper reflects the experience gained over 29 years on various CANDU reactors in Canada. Emphasis is placed on the experience of Ontario Hydro and New Brunswick Utilities from the following nuclear power plants (NPP); Nuclear Power Development Plant, Rolphton, 25 MW(e); demonstration Plant Douglas Point, 200 MW; first commercial plant, Pickering 'A', 4 × 540 MW and Point Lepreau 668 MW. Ontario Hydro and New Brunswick Power models are suitable for consideration for small and medium reactors as they reflect a significant history of operation between 1964 and 1998.

These utilities modelled their stations to operate independent of outside resources and services, by training developing staff to perform the majority of plant activities. In order to meet the planned nuclear expansion program, additional staff were included in the initial station staff complement. Each station had a dedicated planning and technical support group on site.

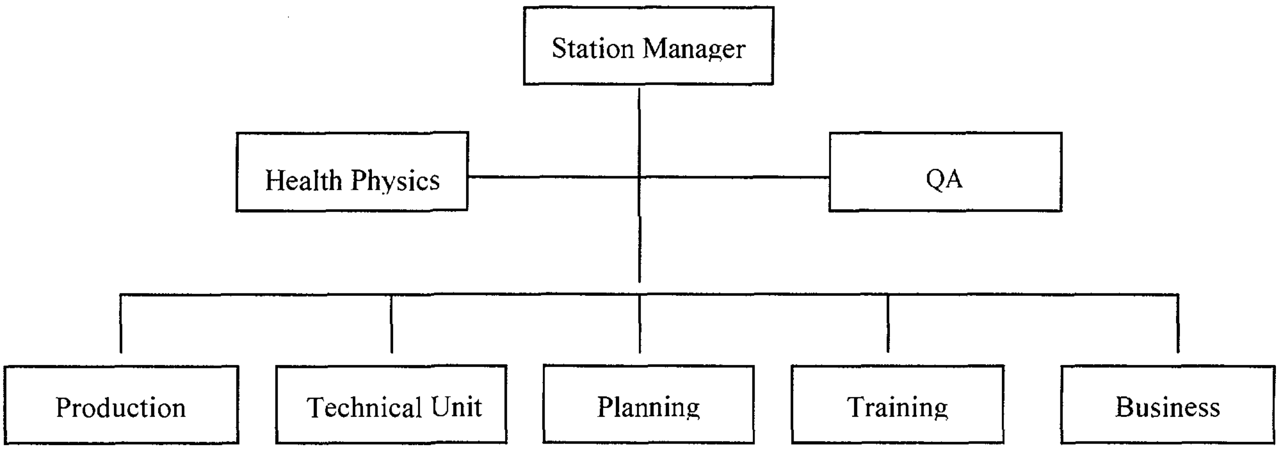
The major off site services were for design, analysis and highly specialized work e.g. nuclear reactor/piping in-service inspections, boiler metallurgical inspections, and specific turbine generation specialty work.

There was a co-operative effort between the utilities of Ontario Hydro and New Brunswick Power; where Ontario Hydro agreed to support New Brunswick Power by providing staff, training and documentation. New Brunswick Power planned to follow the successful Ontario Hydro model for a second planned unit (to date not yet committed).

2.1. Experience of small and medium reactors (SMR) operation

2.1.1. Current organization, qualification & staff by function

For this discussion a single CANDU 6 700 MW unit will be described. The basic organization is as shown.



(a) Operate plant (b) Maintain equipment	(a) Technical support (b) Design interface	(a) Planning (b) Scheduling	(a) Training new staff (b) Co-ordinate training	(a) Materials management (b) Accounts
Function:				
– Fueling – Chemistry – Waste management	– Documentation production – Nuclear safety – Surveillance monitoring	– Monitoring work – Co-ordination work	– Manage simulator	– Budget – Clerical – Payroll – Personnel

The organization has 5 main groups: production, technical, planning, training and business with two support groups, QA and health physics. Table I gives a general account of the staff numbers and their respective function.

The main function and qualification of each group is as follows:

Production function

Operators to operate all systems; Trades staff for all maintenance; Fueling staff to fuel reactor and manage spent fuel; Chemistry group to run lab and monitor/maintain chemistry.

Qualifications

Operators — high school grade 12 minimum. Preferences to those with community college science courses beyond high school. Hired as trainee and developed to the various operator levels through the company training program.

TABLE I CANDU 6 SINGLE UNIT STAFFING AND FUNCTION

Staff designation	Staff level	Function
Management (includes VP nuclear)	6	Various corporate support
Station manager	1	Oversee entire plant operation.
Planning	8	Plan, schedule, monitor & coordinate all work.
Store (supply)	20	Material management, spare part storage.
Production manager	1	Manage operation, maintenance, fueling & chemistry.
Operations	89	Operate all plant equipment
Maintenance	151	Maintain all plant equipment
Fueling	28	Operate & maintain fuel handling systems
Chemistry	18	Sample, monitor, initiate action to maintain chemistry specs.
Technical manager	1	Manage technical unit to support production & ensure reactor safety.
Technical EC&I	33	Technical engineering specialist for electrical & instrumentation & control
Technical mechanical	31	Technical engineering specialist for mechanical & process systems
Technical specialists — Safety systems	14	Technical engineering specialist for 4 special safety systems
Technical engineering services	5	Technical engineering specialist for project management & contractor services
Nuclear safety manager	1	Maintain nuclear safety analysis & licensing
Nuclear safety analysis	11	Carry out safety evaluations & special analysis
Regulatory affairs (licensing)	3	Deal with all licensing & related issues
Nuclear safety reliability	4	Practical reliability model, monitor & evaluate plant performance.
Administration manager	1	Manages administration, material procurement, accounts, security etc.
Public affairs	1	Interface with plant and public, media, local community
Budget and cost control	1	Monitor budget and cost
Security	22	Provide plant security
Administrative support (clerical)	38	Services for typing, document management, procurement role.
Training	20	Coordinate & provide training for all staff.
Quality assurance	8	Support the station manager with QA activities.
Health physics	21	Define policy and develop procedures for radiation plant.
Health physics (laboratory)	3	Perform all lab work for dose monitoring programs.
Total staff	534	

Technical function

Provide technical support for the production group. Prepare operating, maintenance and training manuals. Interface with design support groups. Develop staff to become system specialists to carry out system surveillance, plant monitoring and evaluation. Ensure documents and systems provide the required level of nuclear safety. Prepare detailed work plans for plant outages and breakdowns. Prepare station performance reports. Provide computer, electronic, electrical and reactor physics specialists.

Qualifications

An engineering degree is required. Previous industrial experience may be an asset. All technical staff complete the station training program. Shift supervisors are drawn from this pool of technical staff.

Planning function

Manage the work program; to ensure maintenance is done during operation; prepare outage schedules and forced outage plans.

Qualifications

The senior who directs the group is an ex shift supervisor. The planners are selected from control room operators or capable trades staff.

Training function

The training group runs the training center and simulator, coordinates the preparation and delivery of all the required training.

Qualifications

Manager is an ex-shift supervisor. Other trainers are from technical control room operators and capable trades staff.

Business function

Provide all services to support the various station functions: for material management, clerical support, budget and accounting, personnel, payroll and security.

Qualifications

Manager is selected from utility organization. Business staff are from high school/college.

Quality assurance function

Carry out all quality assurance functions and audits for the plant manager.

Qualifications

Staff are ex shift supervisors. Other capable staff from various departments.

Health physics

Support to the station for radiation protection. Coordinate and prepare all procedures for plant emergencies and provide an interface for the various civil authorities. Provide training to all staff in scientific matters related to radiation and health.

Qualifications

Senior specialists with university degree. Support staff drawn from the ranks of station staff and given special training in health physics group.

2.1.2. *Experiences and strategies to optimize staff*

The strategy used for the CANDU reactors in Canada for staff optimization is one that focused on staff selection, training and development; using written procedures for most tasks. The aim was to develop staff to have a very broad understanding of the various attributes of Nuclear Power. The operations staff were responsible for commissioning all units. Interaction between the station staff and the major suppliers and manufacturers was actively encouraged to improve the understanding and relationship between the manufacturers and the users. Feedback processes were set up between the utility and the major supplies to ensure that operator and maintenance feedback was provided to improve future products. This proved to be very effective and was a major contribution to the early life high capacity factors.

The operational strategy for the stations was to develop a very strong on-site technical and planning capability, to support operation and maintenance activities on a shift basis, 24 hr a day 7 days per week. This was to enable the stations to cope with most types of expected upsets and breakdowns. The technical group were able to secure additional specialized services as the need arose.

The concepts of composite trade was agreed to between management and the unions. The objective of the composite trade was to provide training to employees to expand the type of tasks they would be capable of performing. For example, in the Electrical I&C shop the staff are called control technicians and they each have a high skill level in electrical — instrumentation — controls — electronics. Each person had a main strength in one discipline and the appropriate additional skills are select and developed for the individual.

The broad base training requirement was part of the initial staffing strategy and considerable effort was made at the onset to select candidates with the greatest potential for composite trades. This fundamental strategy is quite basic, but has proven very effective.

Experience has shown that by selecting competent people; providing well organized training; and providing staff with well prepared procedures, work is done well, safety is not compromised and capacity factors are high.

2.1.3. *Relations between staff cost and plant performance*

For the Canadian Utilities the various 'costs' for an NPP are shown on Table II. Operation maintenance and administration (OM & A) is the cost most influenced by staff numbers.

The detailed cost elements of OM & A are shown on Table III. Also shown, for clarification, are cost elements that are not included in OM & A costs.

The percentage contribution to the total OM & A is shown on Table IV.

Station staff costs are about 54% of total OM & A, while hired, contract and consulting services account for about 20%. Thus the total portion of OM & A costs related to manpower is about 74%. It is this portion of OM & A costs where organizations look to make 'Savings'.

The cost performance model on Figure 1 should be studied carefully when trying to optimize staff levels. The figure shows that the operating costs should be to the right of the lowest point. If OM&A costs are driven down to the extent that they are to the left of the lowest point, the impact on the overall cost of generation is dramatic. The overall cost will be extremely high and the possibility of nuclear shut down is also high. Recent experience in Canada attests to the validity of this conceptual model.

To examine the relationship between plant costs and plant performance, the 1995 data for two CANDU power plants was used to estimate the costs for a variety of capacity factors as shown on Table V.

The estimates were based on the actual performance to the end of 1995. The table is based on the assumption that if OM & A resources are reduced too much for too long, the capacity factor will drop off and the costs will actually increase by significant amounts. For the single 635 MW unit, the 'total cost' will increase by about 80% when the capacity factor drops to 50%.

The information shown on Table V illustrates that much care is needed and slow changes are required to establish the optimum OM&A for any particular utility. Changes made today will not start to show an effect for 3–5 years. Once it is recognized that excessive cuts have been made, it may take 5–7 years to show a real recovery.

TABLE II

A.	(i)	Operating Maintenance & Administration (OM&A)c/KWhr
	(ii)	Fuel (used to produce power)
	(iii)	Fuel management (spent fuel storage)
B.	(iv)	Production unit energy costs (PUEC) = (1) + (2) + (3) c/KWhr
	(v)	Interest, depreciation & provisions
	(vi)	Corporate and D_2O overhead
C.	(vii)	Total unit energy (TUEC) = (4) + (5) + (6) C/KWhr

TABLE III. OM&A COST ELEMENTS

INCLUDED	EXCLUDED
Operations	Heavy water capital recovery
Maintenance	Fuel
Administration	Fuel disposal
Utilities	Decommissioning
Building maintenance	Low level waste disposal
Security	Property tax
Insurance	Capital modifications
Regulatory fees	Interest on debt
Heavy water losses	Depreciation on debt
Purchased services	
Outage costs	
Consumables	
Corporate overhead	
Training	

TABLE IV. PT. LEPREAU OM&A COSTS 1994/95

Category	Description	Percent
Operating staff	regular staff wages and salaries	53.6%
Hired services	extra staff for outages or heavy work load	3.7%
Contracted services	principally COG membership, includes specialty contract work (e.g. SG cleaning)	8.7%
Consulting services	supplement to station technical staff	7.5%
Materials	consumables including D_2O	12.4%
Regulatory fees	licensing fees	4.0%
Tools and equipment	specialty tools and equipment	0.7%
Vehicles	cars, trucks, special vehicles	0.3%
Travel	expenses for staff travel and attached staff	0.7%
Communications	major element is telephone costs	0.7%
Properties	maintenance of grounds and buildings	0.8%
Insurance	larger utilities may 'self-insure'	5.5%
Other	training costs (other than salaries), public relations, etc.	1.3%
	Total	100.0%

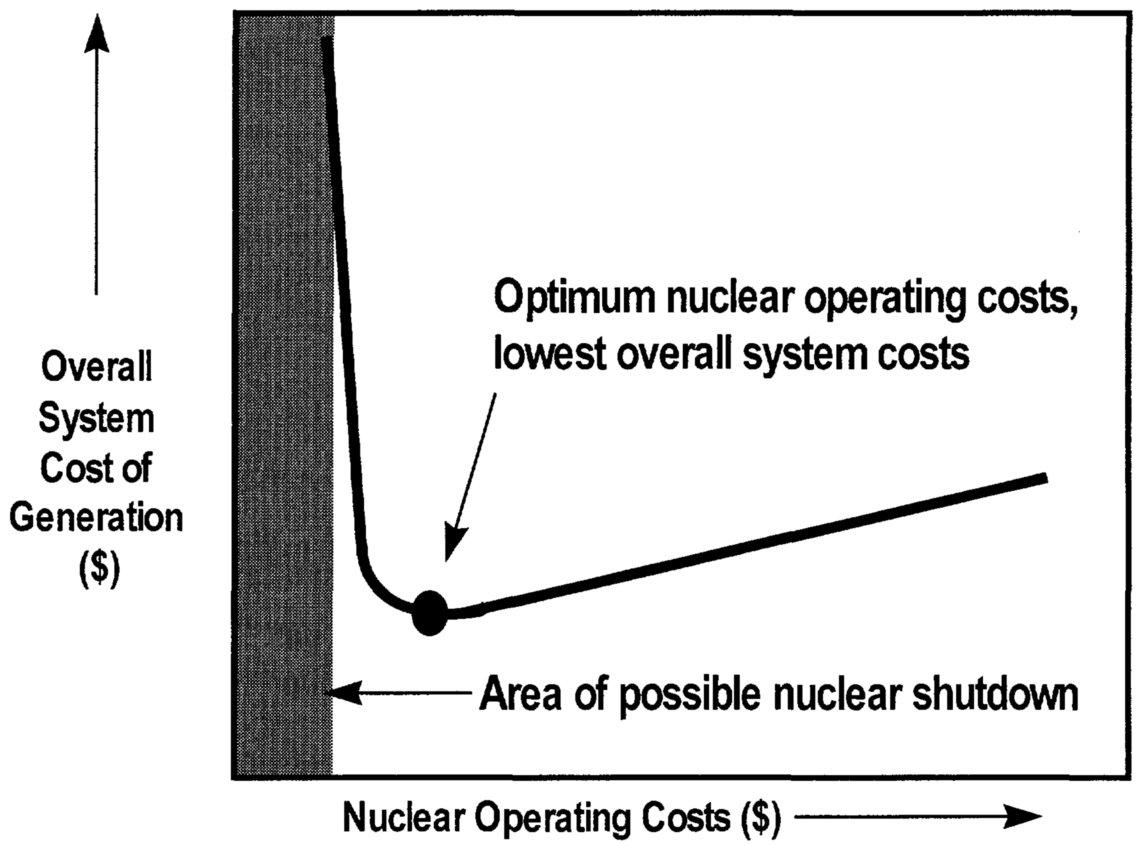


FIG. 1. OM&A cost optimization.[1]

[1] E. Horton and T.R. Sepa (OHN), presented at OECD/NEA International Symposium on Achievement of Good Performance in Nuclear Plants, Tokyo, Japan, April, 1989.

TABLE V. CAPACITY FACTOR IMPACT ON UNIT ENERGY COSTS, SHOWN AS %

	50% Capacity Factor	80% Capacity Factor	85% Capacity Factor	90% Capacity Factor	94% Capacity Factor	100% Capacity Factor
4 × 881 mw						
OM&A cost (c/KWhr Net)	60.7	12.3	5.5	1		– 19.7
PUEC cost (c/KWhr Net)	42.3	12.1	6.1	1		– 16.9
Total cost (c/KWhr Net)	67.9	12.5	5.8	1		– 12.3
1 × 635 mw						
OM&A cost (c/KWhr Net)	88.0	25.4	17.6	11.5	*1	– 6.0
PUEC cost (c/KWhr Net)	74.6	24.0	17.3	10.5	*1	– 6.0
Total cost (c/KWhr Net)	80.0	21.4	14.3	7.7	*1	– 6.0

*Actual performance to year end 1995 is base of 1

2.1.4. Recommendations to designer

The following is a general list of basic recommendations and suggestions:

(i) Provide mature well proven design — little need for modification;

(ii) Fully analyzed for all conceivable eventualities and clearly identify all assumptions made relating to operators and maintenance — little ongoing analysis;

(iii) Completed P.S.A. prior to construction completion — little need for revising operating documents to reflect the design back fits;

(iv) Ensure complete and coherent set of design documents — minimize configuration management efforts; reduce OM&A;

(v) Ensure a fully detailed list of **all** environmentally qualified equipment and components — ease maintenance burden; will avoid inappropriate parts replacement; reduce OM&A;

(vi) Procurement of well proven, high quality equipment — provide high reliability and reduce OM&A;

(vii) Operator displays that really assist with plant upsets and automation of routine activities — more reliable and safe plant performance; reduce OM&A;

(viii) Comprehensive maintenance manual based on reliability centered maintenance techniques for effective and efficient maintenance — improve plant maintenance from the start; reduce OM&A;

(ix) Provide features to accommodate extensive condition based maintenance — improve maintenance effectiveness and efficiency; reduce OM&A;

(x) Provide more maintenance support facilities i.e. provision to clean boilers, service outlets where inspections are done — lower maintenance costs; reduce OM&A;

(xi) Integration of modern information technology into plant design — avoid costly additions, assist utility to improve productivity and reduce OM&A;

(xii) Enter into a service agreement with the client that is based on a win-win agreement — lowers customer's cost and improves plant performance.

Experience has shown that in the past, these above features were not always provided. After 30 years of design and operation, new plant installation should not require the extensive modification experienced by many utilities in their early years of nuclear operation.

Older plants have operated with a very high cost for ongoing safety analysis. Today the industry is highly developed and the need for expensive ongoing work should be very limited. Only where probable events have been overlooked should changes be made to plant operation or design.

Probabilistic safety analyses are being done in ever increasing detail and this all has to be financed, usually from OM & A funds. Also the current work being done around the world on the reconstitution of the design basis, brings with it the heavy cost burden for utilities. The delivered design documents must be improved for the client.

The issue of 'environmental qualified equipment' and maintaining the qualification throughout the 40 year life of the plant is a demanding job for the operations and maintenance organization. The task can be made significantly easier when all equipment and **components** are clearly identified, together with the condition for which they have been qualified.

Much work has been done in examination of the man machine interface for control room operators. This should result in a layout which simplifies routine operations, and allow operators to focus on initiating event(s) that cause plant upsets.

Include as part of the plant design, modern information and communication facilities. Finally, offer new client a viable service agreement on a win-win basis. This would be arranged to assist the client achieve maximum performance of the unit.

2.1.5. External factors influence staffing

There are three main external factors which influence the staffing: company policy — tending to reduce numbers; regulator influence — tending to increase numbers; and trends within the nuclear industry — tending to increase numbers.

Company policy

Utilities try to hold down costs. Staffing is seen as a major cost element over which there is some control. For a mature NPP there is continual pressure to limit staffing costs and minimize the OM & A costs.

When a utility enters the nuclear business, there is an expectation that further plants will follow. The strategy used by Ontario Hydro in the early days, was to have extra staff, who, while contributing to the NPP work programs, were also being trained for a future assignment at the next station. This strategy was very effective and contributed significantly to the early success in Ontario Hydro. The 'extra' 25% development staff were termed 'management development staff' (MDS) where the wages for the group was a capital expense and accrued against the next station. Point Lepreau followed this model to a lesser extent, as the future of their next station was uncertain.

The major benefit from this O.H. strategy was that the commissioning and operations group in a new station, were never short of well trained, highly skilled staff. The investment gave a very good return.

When the plants matured, the staffing level was reduced due to severe pressure to cut costs. Much of the current difficulties in O.H. and NBP are linked to the cost reduction initiatives. As mentioned previously, great care is required in optimizing staff numbers.

Regulator influences

The influence of the regulators over the years, has been very significant and pressure from the regulators have resulted in higher staff requirements. Initially this influence affected functions which were related to QA, and safety analysis, which increased support staff. Eventually the influence extended into the other areas of plant operation and maintenance. Staff numbers were adjusted to cope with additional demands of bureaucracy, reporting, record keeping, verification approvals etc.

As a result of the safety analysis work, plant modifications resulted in major work programs. This required more staff in all areas including engineering, technical support, training, administration, operation and maintenance.

The regulators introduced new requirements for new plants, which, in many cases, were backfitted placing more demands on operation and maintenance staff. More staff were hired.

Trends within the nuclear industry

The Nuclear Industry has placed high demands on itself. Several major incidents of note highlighted areas where improvements should be made. Extensive interchanges within the industry developed and various institutions were created to improve the performance record of the industry.

Major initiatives were taken in the following fields:

- Training
- Man-machine interface
- Environmental qualification
- Accident analysis — extreme events
- Improved maintenance and supervision
- Emergency preparedness
- Operating experience
- Configuration management
- Design bases reconstitution
- Conduct of operation and maintenance staff

Each of these has added to the need for staff and is essentially an ongoing program.

After four decades the situation should stabilize and long term staff requirements should be easier to determine.

2.1.6. Lessons learned

The major lessons learned from the nuclear power program in Canada regarding staffing requirements are as follows:

(i) The total magnitude of the job should not be under estimated.

(ii) Recognize the main areas requiring staff and staff each from the beginning with the appropriate numbers.

(iii) Avoid the tendency of staffing to satisfy the demands regulator, at the expense of the operating and maintenance staff. Ensure there is always a balance.

(iv) Do not economize at the expense of training. Training is an investment to provide a well operated and maintained plant. Have sufficient staff to allow a consistent portion to be on a training program.

(v) Develop staff to be able to cope with the majority of plant work. Set up service agreements to deal promptly with non routine problems and work.

(vi) Develop good managers and supervisors, trust in their contribution when evaluating the optimum staff required.

(vii) Constantly assess the staff's capability against the work load demands and control backlogs.

(viii) Ensure adequate staff are dedicated to the long term work requirements, relating both to the physical plant conditions and the integrity of the supporting documentation.

(ix) For station staff, be conservative and err on the high side of 'optimum' (Fig 1).

(x) Have a small dedicated group of staff to examine critically what is **not** being done that **should** be done.

(xi) Recognize the efforts and responsibilities for operating a nuclear power plant goes well beyond the task of producing electricity.

2.2. Expectation of staffing requirements for future SMR designs

2.2.1 Overview of current status of new SMP division

The following reflects the experience related specifically to the CANDU 6 Reactor (700 mw) designed by Atomic Energy of Canada.

The reactors have been selected by several utilities for their initial nuclear power program.

Projects	In Service	Utility	Location
*Pickering A	1971 -	Ontario Hydro	Canada *Early CANDU
Gentilly II	1983 -	Quebec Hydro	Canada
Point Lepreau	1983 -	New Brunswick	Canada
Embalse	1984 -	C.N.E.A.	Argentina
Wolsong I	1983 -	K.E.P.O.	Korea
Cernavoda I	1996 -	RENEL	Romania
Wolsong 2&3	1997&1998	KEPCO	Korea
Qinshan	Planned 2003	TQNPC	Zhejiang, China
Akkuyu	Proposal	TCAXS	Turkey

The current CANDU 6 has been refined based on much feedback and experience from units currently in service. The units are designed for a forty (40) year life with the main attributes as follows:

— Licensable in any country (complies with AECB and IAEA safety guide lines).
— External events; aircraft strike, explosions, seismic, tornado.
— Advance control room.
— Extensive application of computer control.
— On power fueling.
— Minimize emissions.
— Significant defense-in-depth philosophy; prevention, protection, mitigation and accommodation.
— Low OM&A and high capacity factors.
— Engineering support for configuration management and effective maintenance program.

2.2.2. Review of design & expected operating characteristics of future SMR

The following list shows the essential characteristics of future SMR design which should lead to better use of staff:

(i) Proven product with built-in improvements from design, commission, and operational feedback.

(ii) The feedback experience should be systematically applied based on:

⇒ What did not work well and why.
⇒ What improvements have been made to resolve the problems in (i).
- What has worked well and should remain.
- What was not included and should be provided in the future.

(iii) Systems and equipment that provide ease of maintenance and operation.

(iv) Provide control room staff with a user friendly interface to the systems, providing ease of monitoring and annunciation interpretation.

(v) Provide abundant monitoring provisions for systems and equipment to maximize the application of condition based maintenance techniques. Establish a comprehensive maintenance program.

(vi) Provide the client with completely integrated design documents and electronic facilities to allow the client to maintain effective configuration management from the beginning of the operation.

(vii) Provide the maximum amount of automation, particularly for routine testing and for normal operation.

(viii) The design should be mature to the extent that little if any future analysis or modification work would be required.

(ix) Provide complete and comprehensive service facilities as a built in feature where systems and equipment will require extensive inspection and maintenance activities.

(x) Include modern information management facilities for all aspects of the operation, maintenance and administration as part of the design.

By providing an improved design, staff may focus on the production of power, and maintenance of equipment and systems.

2.2.3. Estimate of the number of staff to operate a new SMR

Before providing an estimate of staff numbers required to operate a new SMR, it is important to appreciate the staffing model used and the major assumptions. The numbers shown on Table IV reflect a single unit, built in Canada, on a coastal location, some distance from the main industrial centres. The utility strategy is to be reasonably independent and have sufficient staff to cope with the majority of normal maintenance work. Specialist services will be purchased for specific work requiring specialized skills.

The major assumptions used to establish the staff numbers for a new CANDU 6 are:

— Staff will be hired and trained to develop independence.
— Contract agreements with labour unions will include multi-skilled staff and composite trades for flexibility of assignments.
— The design features listed in 2.2.2 above are provided.

— Limited regulatory pressure/influence because of high confidence in the design and operating organization.
— Effective material management systems for supply of spare parts.
— Extensive application of lessons learned from other utilities.
— Utilize best practices, work management and outage planning techniques.
— Implementation of modern information management facilities.
— Highly rated training program.

Based on the above, the staff shown on Table VI are expected to be fully trained and competent in all aspects of each job. It is reasonable to expect that this would be achieved in the first 5 years of full power operation. During that period additional staff of 10%–25% would be required. The staff shown are the total staff for all station operation maintenance and administration.

The basic qualifications for the staff would be as shown previously in Section 2.1.1.

All staff would require specific training within the utility for common subjects covering science fundamentals, radiation protection, worker safety, nuclear system & processes, basic and advance nuclear physics. Specialized training is also provided for the various work groups of operation, mechanical, electrical, instrument and control, services, chemistry, technical support etc.

It is also assumed that the single unit has a simulator and training centre, (staff number included in Table VI).

2.2.4. *Joint studies between design and operator staff*

AECL and utility operators have carried out a number of joint studies; the main topics addressed have been:

- Operating, maintenance and administration cost reduction (OM & A).
- Capacity factor improvement.
- Plant life management.
- Maintenance program based on RCM principles.
- Application of 3-D CADDS to reduce OM&A costs.
- Commissioning program schedule reduction.
- Main control center development program.

Each of these studies has had active participation by CANDU 6 utilities. The result of these efforts is an improved CANDU 6 product, which will minimize OM&A cost, maximize capacity factor, provide effective maintenance programs and have an advanced control room providing safer and more effective operation.

2.2.5. *Recommendation on qualification & training requirements*

Future nuclear utilities should avoid using the staffing model for conventional power plants to staff a nuclear power plant. Due to the increased diversity and regulatory demands, it is recommended to adopt a staffing model that has worked well for other nuclear utilities.

The IAEA has extensive publications on the topic of training and staff development. The first recommendation for a potential new client is to have an association with the IAEA and or INPO etc., and select from their benchmarking material.

The various job families in the organization must be clearly identified and a dedicated training and development program put in place for each job family. When entering a nuclear

TABLE VI. UPDATED OM&A STAFFING FOR A NEW CANDU 6 STATION

Staff Designation	Pt. Lepreau 1-Unit (1997)	CANDU 6 1st Unit	CANDU 6 2nd Unit	CANDU 6 2-Units
Management (head office)	6	6	1	7
Station manager	1	1	0	1
Planning	6	6	3	9
Stores	18	16	6	22
Production manager	1	1	0	1
Operations	79	81	75	152
Maintenance	141	141	109	250
Maintenance support	0	7	4	11
Fuelling	21	21	19	40
Chemistry	16	16	10	26
Technical manager	1	1	0	1
Technical EC&I	23	21	16	37
Technical mechanical	25	22	18	40
Technical specialists — safety systems	12	12	9	21
Technical engineering services	3	3	2	5
Nuclear safety manager	1	1	0	1
Nuclear safety analysis	11	4	0	15
Nuclear safety licensing	3	2	0	4
Nuclear safety reliability	4	3	1	6
Administration manager	1	1	0	1
Public affairs	1	1	0	1
Budget and cost control	1	1	0	1
Security	21	21	0	21
Administrative support (clerical)	34	32	11	43
Training	18	18	9	27
Quality assurance	8	8	2	10
Health physics	19	17	10	27
Health physics laboratory	3	3	1	4
TOTAL	478	467	306	773

power program, partnering with another utility has proven to be successful. With this partnership, key staff assignments can be made with the utility for on-the-job training. Entering into a contract for a new nuclear plant, the client should specify that the SMR supplier provide a training program to develop the utility staff to a level of competence to safely run the plant at full power. This is one of the most cost effective ways of gaining competence. CANDU 6 projects have been done this way, in each case it has been very effective. There may be a tendency for the client to minimize staff committed to training programs in an off-shore assignment. This should be given careful consideration as training is an investment and it is one of the costs of doing business. It takes a significant amount of time and effort to hire and fully develop staff; good training is indispensable.

Senior management and supervisory staff training should be an integral part of all training programs. Good managers and supervisors are the key to well run plants.

2.2.6. Features in new design

To improve the design of the CANDU 6 product, AECL has worked closely with various CANDU 6 utilities. AECL has also participated in several international committees and conferences. The Product Development Program provides the following features:

	Improvements	Benefits
1.	Improve material selection for feeders	Lower maintenance
2.	Improve design of pressure tube	Longer life, less maintenance
3.	Improve chemistry control features	Less plant degradation
4.	Improve ventilation systems	Minimize D_20 loss and emissions
5.	Improve boiler design	Increase plant performance and maintenance
6.	Improve control room layout & plant display systems	Improve plant performance
7.	Increase automation features for operation testing & annunciation integration	Lower OM&A costs
8.	Provide extensive plant monitoring features to maximize condition based maintenance features	Lower OM&A costs.
9.	Provide integrated electronic design documentation for ease of configuration management	Lower OM&A costs.
10.	Provide full 3-D CADDS facilities for viewing all drawings	Lower OM&A costs.
11.	Improve computerize material management system	Lower OM&A costs.
12.	Provide comprehensive electronic databases for design details on plant equipment	Lower OM&A costs
13.	Provide comprehensive maintenance program focused on CBM and RCM	Lower OM&A costs.

Each of these features result from feedback from various clients. Many other smaller improvements have been made also. The objective is to provide the client with a competitively priced NPP with reasonably low OM&A costs.

2.2.7. Comparison of staff requirements between currently operating and new designs

Recent studies carried out by AECL have been done to establish recommended staffing levels for new plant design. The model used is that described in Section 2.2.3 above. The staff distribution proposed makes the assumption that the previous decades of concern and effort will be integrated into the new design as part of the design improvements and be a one time expense on the initial capital costs.

Recent experience at Point Lepreau is given as an example for comparing staff requirements. A backlog of maintenance and configuration management issues among other things resulted in a reduction of plant performance. To overcome these difficulties, the staff at the station was increased from 478 in 1996 to about 600 in 1998. The current AECL estimate for a new CANDU 6 based on the Point Lepreau model (as outlined above) with all the design improvements is 467 fully trained and experienced_staff (see Table VI). No adjustments have been made for the influences of a foreign location.

It is understood that a new client would have to operate for several years with an additional staff of 10%–25% while adopting the best practices identified as benchmarks by the various nuclear institutions. It also assumes that the NPP organization has composite trades and embraces the modern facilities of information technology to support the running of their business.

2.2.8. *External factors which influence staffing regulators*

For future stations, there is an expectation that the regulators should not cause the staffing numbers to increase. The design, analysis, construction and commission will assure a proven product. The area of focus will now shift to the performance of management, supervisors, operators and maintainers who are responsible to safeguard the workers and public. Providing the utility applies the lesson of the past, little escalating pressure should result from the regulator.

However, if the regulator shifts the focus from design to operations staff performance, and levels the same influence as in the past with relation to the design issues, then there will be significant pressure and that will likely result in staff increases.

Despite 40 years of operation, nuclear power is still not widely accepted by society. In an effort to satisfy the public, some very conservative practices have been adopted by the nuclear industry. Continuing this trend may continue to increase staff levels. Additional pressure to increase staff levels will result from: continued social pressure to make plants safer; environmentalists gaining support that nuclear power is a threat; and bureaucrats insisting on more checks and balances. A point of interest in Canada is that while the designers work out ways to automate the plants and reduce the numbers of shift workers, the utilities adopt practices for emergency preparedness that tends to increase the number of shift workers.

Vendor support

Support from the vendors offer a real opportunity to enter into a win-win service agreement, where with careful selection of services, staffing numbers could be reduced. This area has not been explored to the full extent.

Company policy

The final note relates to company policy, which is the key to staffing. The Nuclear Industry is such that mistakes made by one utility that result in a nuclear incident, reflects poorly on the whole industry.

An enlightened company policy will recognize the fact that, as shown on Fig. 1, OM & A costs that are too low for too long result ultimately in very high total costs. There is a need for a balanced approach on the disbursement of OM & A funds to secure the optimum nuclear defense in depth from the three major elements: (1) highly reliable special safety systems; (2) high quality components and process systems; (3) well trained and equipped staff.

In the past, limited OM & A funds were directed to safety analysis at the expense of maintenance and training. Future plants with built-in safety features should not experience this problem. Managers will be able to focus on improving plant maintenance and staff training. These improvements will result in a safer nuclear power plant.

Conclusion

Future plants that are well designed and improved through user feedback will provide a good return when the focus of the utility is to have an excellent maintenance program, supervised and executed by adequate numbers of fully trained staff. Management and supervisors, following the desired code of conduct, will result in a well run economical NPP. This should be the aim for the future.