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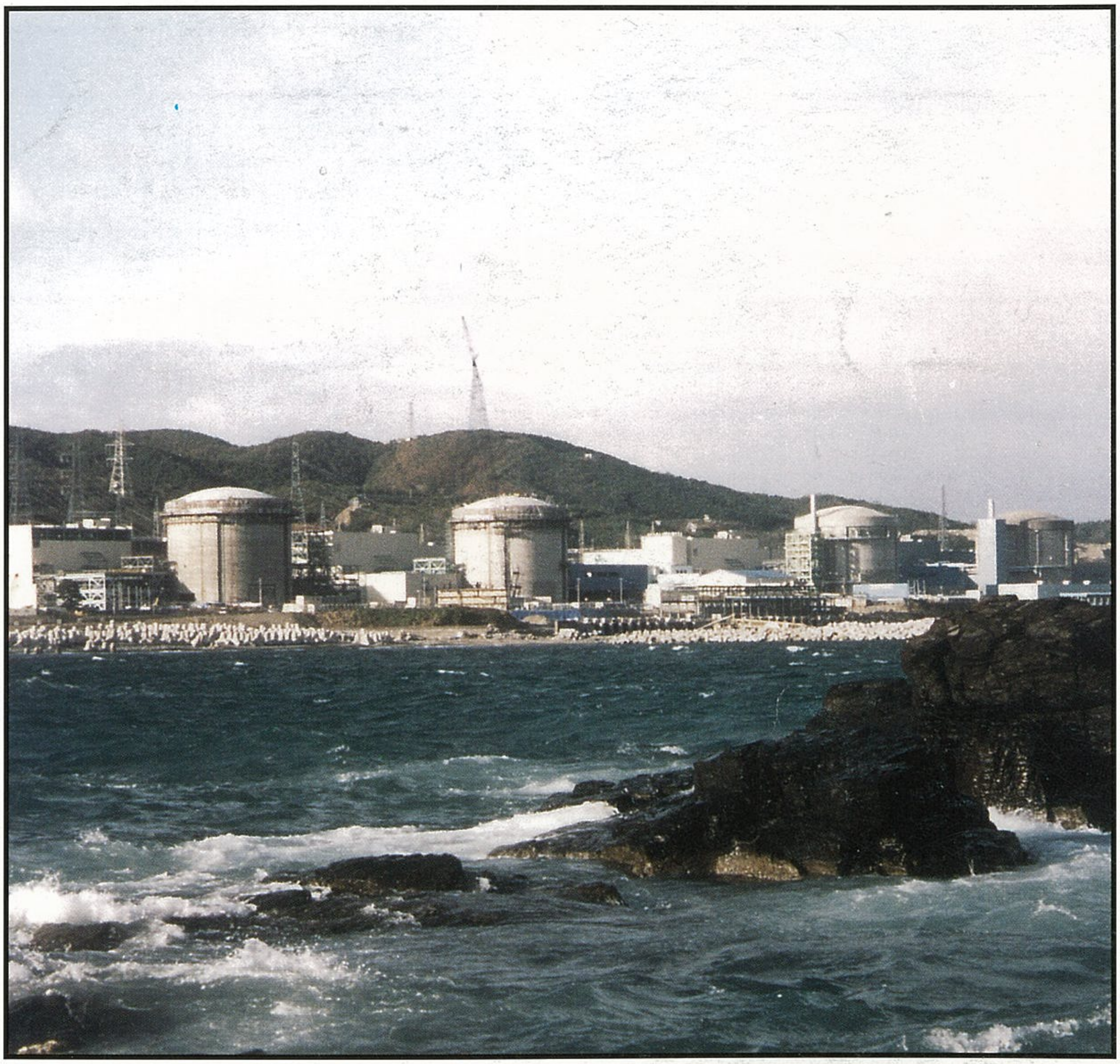

- Plutonium Destruction in CANDU
- CNS / CRPA Symposium
- Le Concept de Risque
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Cover Illustration

The photograph on the cover shows the Wolsong site in Korea with its four CANDU units - to mark the achievement of "criticality" at Wolsong 2 on January 27, 1997. Unit 1 is at the far right, unit 4 at the left.

(Photo courtesy of AECL)

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EDITORIAL

AN UNEVEN PICTURE

The past few months have been mixed ones for the Canadian nuclear community.

On the export front things have been quite positive - Wolsong 2 started up in January; the contract for the CANDU units at Qinshan, China, were finalized; negotiations are proceeding for Cernavoda 2 in Romania; and several countries are showing considerable interest in CANDU.

On the mining front, Cameco reports record earnings; the Atomic Energy Control Board has approved mining at Cogema's McClean Lake site; and an Environmental Assessment Panel has recommended approval of the McArthur River project.

But on the domestic, nuclear power, front the news has been much less positive, even depressing. The performance of CANDU type nuclear power plants in 1996 was generally miserable. According to a report in UNECAN News, based on figures from the Candu Owner's Group, only four CANDU units placed in the top 50 for capacity factor. The eight Pickering units were a major part of this poor showing, with an overall (grouped) capacity factor of only 43 per cent.

Peer review reports of Ontario Hydro's nuclear plants, which were released as a result of a court order in late February, provide some insight into the poor operation that led to the low capacity factors. The evaluations noted the negative impact of the loss of senior, experienced, operating staff resulting from Ontario Hydro's "downsizing" a few years ago. An operations organization that had, for years, achieved world record performance was eviscerated through short-sighted focus on the "bottom line". The result was predicted by many (see our editorial in Vol. 15, No. 3). Now Ontario Hydro has imported "experts" from the USA in an attempt to restore what has been thrown away.

The problems at the CANDU 6 plants are serious but are primarily technical, and history shows that our industry has been successful in overcoming technical challenges. This is essential if the export possibilities being pursued are to materialize.

A further disappointing situation is the continued reluctance of the federal and Ontario governments to support, financially, the ITER project, despite sound analyses which show that they would recover their investment, through taxes, within a couple of years. This is an area where lobbying, through letters to the Ministers concerned, might have a significant effect.

Perhaps it is unrealistic to expect everything to be positive. But it is discouraging to realize that the troubles being experienced were of our own making. If, but only if, those responsible for the major decisions recognize this, there is hope for the future.

IN THIS ISSUE

First, apologies. Due to the editor being our of the country for four weeks in the crucial period leading up to publication, this issue of the CNS Bulletin is late. There is, typically, not much time sensitive material in the Bulletin but in the case of deadlines for papers, we hope that the organizers involved will be understanding.

The lead paper this issue, **Advanced CANDU Systems for Plutonium Destruction,** by **Peter Boczar** et al, deals with the topical issue of burning military plutonium in CANDU reactors. As the authors conclude, CANDU offers immediate as well evolutionary solutions to the plutonium disposition question.

Suivant, nous avons notre premier (dans notre connaisance) papier en français, **Définition du Concept de Risque,** par **Éric Lacroix.** Le risque existe; la sécurité absolue n'existe pas. Nous espérons que beaucoup de nos lecteurs essayent le lire.

Then, there is a further essay from **Archie Robertson** on anti-nuclear arguments, entitled, **A Frequent Flyer Program for Nuclear Mythology.** If you are mystified by the title, read his paper.

There are reports on two meetings. The article **Radiological Impacts on Non-Human Species** provides a summary of the joint CNS / CRPA seminar on that contentious topic, which was held in Ottawa last December. The other was the annual **CNA / CNS Nuclear Winter Seminar** which took place in February. The latter is accompanied by the remarks from the Prime Minister, in **PM Supports Nuclear** and the opening address by **Reid Morden** on **CANDU Exports and Opportunities.** A further paper derived from that seminar is **Uranium Update** by **Robert Steane,** which gives a succinct review of the Canadian uranium mining situation.

For a change of pace there is a short bit of history in **Algonquins to Atoms Along the Ottawa** by **Jeremy Whitlock.**

There is a scattering of general news and a larger than normal section on **CNS News,** reflecting the active nature of the Society.

And, in closing, we hope you note the colour notice on the back cover inviting all readers to attend the 11th Pacific Basin Nuclear Conference which will be held in Banff in May 1998. Nuclear energy is burgeoning in the countries of the Pacific rim and they will undoubtedly be well represented, so it is advisable to book your room early.

As always, we invite your comments, suggestions, and contributions.

DEADLINE

The deadline for the next issue, which will be published about the end of May, will be **May 15, 1997**

Advanced CANDU Systems for Plutonium Destruction

Abstract

High neutron economy, on-line refuelling, and a simple fuel-bundle design result in a high degree of versatility in the use of the CANDU[1] reactor for the disposition of weapons-derived plutonium. CANDU mixed-oxide (MOX) fuel is a near-term, technically achievable, economic option. Studies led by AECL show that four Bruce A reactors could consume 50 te of plutonium in less than 12.5 years. The symmetry in the simultaneous drawdown of excess weapons-derived plutonium from both the United States and Russia in Canada was an important consideration in the recent US Record of Decision, which includes the CANDU MOX option for further evaluation.

The CANDU versatility enables advanced options for plutonium destruction. One such option is the use of an inert matrix, non-fertile material as the carrier for weapons-derived plutonium. Mixing the plutonium with inert SiC in a standard 37-element CANDU bundle would result in destruction of 93% of the fissile plutonium (^{239}Pu and ^{241}Pu). Fuel management studies were conducted, confirming that fuelling rates and maximum powers are well within limits. Because of the very high thermal conductivity of SiC, fuel temperatures would be very low, and negligible fission-gas release is expected.

The Pu-ThO_2 cycle would also achieve a very high efficiency in plutonium destruction. With ~2.6% weapons-derived plutonium in ThO_2 in a modified CANFLEX bundle (a large central graphite displacer surrounded by 35 fuel elements in the two outer fuel rings), a burnup of 30 MW•d/kg heavy element (HE) can be achieved, and >94% of the fissile plutonium destroyed. Good neutron economy is the key to high efficiency in plutonium destruction with ThO_2. Of course, ^{233}U is produced, through neutron capture in ^{232}Th and subsequent b-decay, and partially burned in situ. This material is safeguarded in the spent fuel and is not attractive for weapons because of contamination with ^{232}U. The spent fuel could be stored until an economical and proliferation-resistant means of recycling the ^{233}U is developed.

1. Introduction

1.1 CANDU FUEL CYCLE FLEXIBILITY

The CANDU reactor has unsurpassed flexibility in its ability to accommodate different fuels and fuel cycles. This flexibility is a result of the following key features of the reactor.

- High neutron economy, that is due to the use of heavy water as coolant and moderator, the use of low-neutron-absorbing structural materials, and on-power refuelling. It also permits the use of fuel with low fissile content (with the capability of exploiting unique, proliferation-resistant fuel cycles), and enables the initial fissile content to be burned down to low levels.
- On-line refuelling provides flexibility in fuel management. One can vary the number and type of bundles added to a channel, the location of the channel to be refuelled, the frequency of refuelling, and even the axial location along the channel where the new fuel bundles are inserted. Both axial and radial power distributions can thus be shaped and controlled, as can the amount of reactivity added to the reactor during refuelling.
- The simple fuel bundle design facilitates optimization of the fuel composition. Fuel type and enrichment can be varied from ring to ring to achieve design objectives, such as tailoring reactivity coefficients, or minimizing linear element ratings. The simple design and small size of the bundle make it easy and economical to fabricate, either "hands-on" or remotely, and to test advanced fuels.

1.2 CANDU PLUTONIUM-DISPOSITIONING OPTIONS

These features enable the CANDU reactor to meet a range of plutonium-dispositioning objectives, without any major changes to the reactor. This paper examines three such options.

The first option uses conventional mixed-oxide (MOX) fuel in CANDU reactors. Although not an advanced option for plutonium dispositioning, it provides a reference for the advanced options discussed and illustrates the flexibility of the reactor in accommodating a very wide variety of fuel designs and strategies. Significant work has been done on this concept since the NATO workshop on conventional MOX fuel for dispositioning excess weapons-derived plutonium in November 1994.[1] The objective of the MOX option in plutonium dispositioning is to convert the plutonium into spent fuel, while generating useful electricity. The spent MOX fuel has similar proliferation-resistant characteristics as spent UO_2 fuel, whether CANDU or PWR. The barriers to subsequent diversion include the intense radioactivity of the spent fuel; the chemical form (oxide); dilution of the plutonium, both in the fresh fuel, and even more so in the spent fuel; degradation of the plutonium isotopic vector; and the phys-

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ical form and weight of the fuel bundles (spent CANDU fuel bundles are stored in sealed assemblies). Since the MOX option converts the plutonium to a form that has no more proliferation risk than the very much larger quantity of spent fuel from civilian reactors, there is no short-term urgency to further reduce the proliferation risk of the spent MOX fuel.

The second option that will be discussed in this paper, and the first "advanced" CANDU option, is plutonium "annihilation" in an inert matrix. Here, the objective is to destroy plutonium, without at the same time creating new plutonium. Hence an inert matrix material is used as a carrier of the plutonium. The CANDU reactor can achieve a very high efficiency of plutonium destruction in a once-through cycle without reprocessing and with no significant changes to the reactor system.

The third option that will be discussed is another MOX option, where the plutonium is mixed with ThO_2, rather than with UO_2. This option, too, achieves a very high degree of plutonium destruction. It has the additional benefit of creating a reserve of ^{233}U (created through neutron capture in ^{232}Th and subsequent β-decay), which can be safeguarded in the spent fuel until such time in the future when it is economical to recover and recycle the ^{233}U, using proliferation-resistant technology. This option has a high plutonium destruction efficiency, and the highest energy yield potential of all the options considered.

The truly remarkable fuel-cycle flexibility of the CANDU design enables these diverse plutonium management options to be achieved in an existing CANDU reactor, with no significant changes to the reactor.

1.3 MEASURES OF MERIT

This paper uses several "measures of merit" to characterize these options.

1. *Net Pu-Destruction Efficiency* (%): Net *Total* Pu destroyed, as a fraction of the *Total* initial Pu in the fresh fuel

2. *Net Fissile Pu-Destruction Efficiency* (%): Net *Fissile* Pu destroyed, as a fraction of the initial *Fissile* Pu in the fresh fuel

3. *Pu-Disposition Rate* (Mg Pu/GW_e•a): the amount of Pu used or dispositioned (i.e., in the fresh fuel) to produce 1 GW_e•a of energy

$$\sim \frac{[\text{Pu-fraction in the fresh fuel}]\ (\text{te Pu / te HE}) * 365\ \text{d/a} * (1000\ \text{MW/GW})}{\text{Burnup}\ (\text{MW}\bullet d_{th}/\text{te HE}) * \eta\ (0.3)}$$

4. *Energy Produced* (GW_e•a/ Mg Pu): inverse of above.

Table 1 summarizes the three CANDU plutonium management options in terms of these measures of merit. For the MOX option, two variants are considered.

2. CANDU MOX

2.1 The 1994 CANDU MOX STUDY

The objective of the MOX strategy is not to *destroy* the plutonium, but to convert it to a form that has a high degree of diversion resistance through the characteristics of spent fuel, while producing electricity. The important considerations are the timeliness of the deployment option, the plutonium disposition rate, and the economics. Of the four parameters defined in Table 1, the Pu-disposition rate is the most relevant for this objective.

In 1994, the United States Department of Energy (USDOE) commissioned an AECL-led team to examine the use of CANDU reactors for dispositioning excess weapons-derived plutonium. The target plutonium disposition rate was 50 te Pu metal in 25 years. A detailed assessment was performed, including technical, economic, safety, licensing, safeguards, security, MOX fuel fabrication, transportation, and eventual disposal of the spent fuel. The team concluded that use of two of the four 825 MW(e) reactors at the Bruce A station near Kincardine, Ontario, could

TABLE 1. Summary of CANDU plutonium management options

	Pu/U MOX (1)	Pu/U MOX (2)	Pu-inert matrix (annihiliation)	Pu/Th
Net Pu-Destruction Efficiency (%)	34	23	82	77
Net Fissile Pu-Destruction Efficiency (%)	58	41	93	94
Pu-Disposition Rate (Mg Pu/GW_e•a)	1.56	2.22	1.66	1.04
Energy Produced (GW_e•a/Mg Pu)	0.64	0.45	0.61	0.96 (>>1 with ^{233}U recycle)

achieve this. Using all four Bruce A units, 50 te of Pu could be utilized in less than 12.5 years.

CANDU MOX fuel fabrication would take place close to the source of the weapons-derived plutonium, and only finished MOX bundles would be transported to Canada.

The reference fuel uses the standard 37-element geometry and is designed to perform within the operating and safety envelopes for natural-uranium fuel. Depleted uranium is the matrix material throughout the bundle. In the central element, and the next ring of 6 elements, 5% dysprosium (a burnable poison) is mixed with the depleted uranium. Plutonium is confined to the outer two rings of fuel: 2.0% plutonium in the third ring of 12 elements, and 1.2% plutonium in the outer ring of 18 elements. The bundle average burnup of the reference MOX fuel is 9.7 MW•d/kg HE, compared with 8.3ÊMW•d/kg HE for natural-uranium fuel in Bruce A reactors. Peak element burnup is about the same as for natural uranium (about 16 MW•d/kg HE). The fresh fuel contains 232 g plutonium per bundle, of which 94% is fissile.

An advanced MOX fuel design was also conceived. This employs the CANFLEX geometry, a 43-element bundle having 2 element sizes arranged in rings of 1, 7, 14, and 21 elements. The CANFLEX bundle has 20% lower peak element ratings than the 37-element bundle operating at the same bundle power, and improved thermalhydraulic performance (6 to 8% higher critical channel power). The lower ratings facilitate achievement of higher burnup, and the advanced MOX design has a core-average burnup of 17.1 MW•d/kg HE, which results in a peak element burnup of under 30 MW•d/kg HE. These are burnups for which there is CANDU experience. The advanced MOX bundle contains 374 g plutonium in the fresh fuel. As in the reference bundle, the plutonium is confined to the outer two rings of fuel: 3.5% plutonium in ring 3, and 2.1% in ring 4, mixed with depleted uranium. The central 8 elements contain 6% dysprosium mixed with depleted uranium. There is some minor optimization of the internal element design (pellet size and shape, and clearances).

The use of a burnable poison mixed with the depleted uranium in these designs achieves a number of objectives. The excess reactivity of the fresh fuel is suppressed, reducing the power ripple during refuelling. The Pu-disposition rate is increased, since additional plutonium is needed to achieve a given burnup. Finally, the design results in negative void reactivity, which eliminates any power pulse during a postulated loss-of-coolant-accident (LOCA), thereby simplifying the safety and licensing analysis. Mixing the burnable poison with depleted uranium in the central, low-power elements avoids the issue of fuel performance for MOX fuel containing integral burnable poisons, that must be addressed by other reactor concepts.

Each Bruce A reactor would consume about 1 t of plutonium per year (assuming an 80% capacity factor), in both the reference and advanced cases. The higher burnup CANFLEX MOX bundle would require a lower MOX fuel fabrication capacity, thus lowering the mission cost.

In both cases, the initial plutonium content is reduced by about one third in the spent fuel. Table 2 summarizes the fuel isotopic composition for the reference 37-element bundle, calculated using WIMS-AECL.[2]

Fuel management is particularly simple for both the reference and advanced MOX options: bi-directional (adjacent channels are refuelled in the opposite direction), two-bundle shift fuelling in the direction of coolant flow. The resultant axial power distribution is excellent from the perspective of both fuel performance (fuel at extended burnup does not experience a power boost) and thermalhydraulics. A full MOX core can be accommodated with no changes to the reactor system, other than the provision for safe and secure storage of new fuel. Reference 3 gives more complete technical details of the 1994 USDOE study on the CANDU MOX option for dispositioning excess weapons-derived plutonium.

TABLE 2. CANDU MOX:
Fuel composition for reference bundle
(g/bundle)

(37-element bundle, 1994 study)

Nuclide	0 MW•d/kg	9.7 MW•d/kg
239Pu	218	79
240Pu	14	58
241Pu	0.3	13
242Pu	0.05	4
Total	232	153

2.2 The 1996 CANDU MOX STUDY

The AECL-led team conducted additional studies for the USDOE in 1996, aimed at further increasing the plutonium disposition rate. A 50% increase in the plutonium disposition rate was achieved by increasing the plutonium content of the bundle. To compensate for the excess reactivity, the burnable poison content in the central elements was increased from 7% to 15%, and the purity of the coolant and moderator was downgraded from 99.75% to 97% purity.

The resultant 37-element fuel bundle has a plutonium loading of 300 g confined to the outer 2 rings (3.1% Pu in ring 3, 1.6% Pu in ring 4), 15% dysprosium in the central 7 elements, with depleted uranium as the base material throughout the bundle. The average discharge burnup is slightly greater than in the earlier study, 10 MW•d/kg HE. The plutonium disposition rate in a Bruce A reactor is 1.5 t Pu per year per reactor (assuming an 80% capacity factor). The

MOX fuel fabrication capacity requirement is 78 t per year per reactor. As with the earlier design, the reactor operates within the natural-uranium license envelope.

The modified CANFLEX advanced MOX fuel bundle has a plutonium loading of 470 g (4.6% Pu in ring 3, 2.6% Pu in ring 4), 15% dysprosium in the central 8 elements, with depleted uranium as the base material throughout the bundle. The average discharge burnup is about 17.1 MW•d/kg HE. The plutonium disposition rate in a Bruce A reactor is 1.2 t per year per reactor. The MOX fuel fabrication capacity requirement is 41 t per year per reactor.

2.3 STATUS OF CANDU MOX OPTION FOR PLUTONIUM DISPOSITIONING

One major advantage of the CANDU option is the participation of a trusted third country, Canada, that can provide security and safeguards assurances in a balanced, simultaneous drawdown of both US and Russian weapons-surplus plutonium. CANDU MOX is a low-cost, low-risk option, readily available in the near-term, which would enable a quick start to the disposition of weapons-surplus plutonium, by converting it to spent fuel. It is one of the options chosen for further evaluation by the USDOE in its recent Record of Decision.

Preparations are now in place for the first physical tests towards qualifying the use of CANDU MOX fuel, fabricated from weapons-surplus plutonium. The program consists of the fabrication of a small amount of CANDU MOX fuel in the United States and in Russia, for testing under simulated CANDU reactor conditions in AECL's NRU research reactor at the Chalk River Laboratories. Although AECL has tested MOX fuel for decades, these new tests will confirm the behaviour of fuel using weapons-grade plutonium. This type of small-scale experimental test was endorsed by the G7 leaders at the Nuclear Summit in Moscow in 1996 April.

There is real interest in Russia in the CANDU option. A joint Canada-Russia feasibility study sponsored by the Canadian government builds upon previous USDOE studies. Its aim is to establish the viability of a CANDU MOX fuel fabrication plant in Russia, addressing related safeguards and security issues. The first interim report, issued in the fall of 1996, establishes the feasibility of CANDU MOX fuel fabrication in Russia.

3. Plutonium Annihilation in CANDU

3.1 INTRODUCTION

The Pu-annihilation concept incorporates the weapons-plutonium in an inert matrix that will facilitate the burning of the plutonium without generating new plutonium — thus resulting in maximum plutonium destruction. The carrier's purpose is to dilute the plutonium for incorporation in standard CANDU fuel elements and bundles. (Without dilution, the heat generation would be so localized that it could not be removed efficiently and the plutonium would melt.) A related application is actinide burning—the destruction of actinide waste produced in normal LWR reactor operation, and concentrated by reprocessing. Long-lived, carcinogenic nuclides are the main targets for actinide burning, specifically, ^{237}Np, ^{244}Cm and ^{241}Am. This application is the main motivating force for the European interest in inert-matrix fuels.

3.2 DESIRABLE PROPERTIES OF INERT MATRIX MATERIALS

Besides neutronic considerations, the selection of suitable inert-matrix materials must consider the following materials properties:

- compatibility with coolant and clad, the latter to elevated temperatures for accident conditions;
- phase stability—changes in phase that are due to temperature changes or irradiation could degrade the fuel's performance (including possibly disintegration of the matrix material to powder);
- irradiation properties—under irradiation, the carrier material should not swell or undergo phase changes. It is known that some potential candidates, such as Al_2O_3, quickly amorphize, with associated swelling, when exposed to fission-fragment damage;
- compatibility of the fission products with the matrix carrier;
- melting temperature—a high melting temperature provides insurance during off-normal and accident scenarios;
- thermal conductivity—a high thermal conductivity, leading to lower operating temperatures, is not a prerequisite, but is a strong advantage for safety considerations. Such an advantage over UO_2 provides a strong additional motivation to compensate for the costs of moving to inert-matrix fuels, and would allow operation at higher bundle powers;
- Pu-microstructure—the formation of a solid solution or fine dispersion of the Pu-containing phase is a prerequisite.
- heat capacity—high heat capacity ensures that after-heat generation during a LOCA will not heat the fuel excessively. However, at the same time, it means that there is more stored heat for dissipation in a loss-of-coolant flow (or regulation) incident. Generally, high values of heat capacity are preferred to limit fuel temperature increases.

3.3 CANDIDATE MATRIX MATERIALS

Many candidates are being considered by various countries. The Japanese are focusing on rock-like candidates, which should be especially stable for underground disposal after irradiation. A partial list of candidates under consideration in Europe, the United States and Canada includes SiC, $MgAl_2O_4$ (spinel), $ZrSiO_4$ (zircon), ZrO_2, CeO_2, $CePO_4$ and BeO. Advantages and disadvantages of some of these materials are discussed below:

- SiC has a very high thermal conductivity and melting point, and, as a good industrial material for many applications, is being widely studied. It is generally very stable chemically and has high resistance to oxidation.
- $MgAl_2O_4$ (spinel) has a cubic microstructure, which, theoretically, suggests good irradiation properties. However, accelerator simulation tests, described below, do not confirm this expectation.
- $ZrSiO_4$ (zircon) is a naturally existing mineral, which suggests that it is stable and would form a stable waste form.
- ZrO_2 is known to have good irradiation properties (no swelling) but has poor thermal conductivity. Stabilized zirconia with burnable poisons is the main candidate of the Los Alamos National Laboratories (LANL).
- CeO_2 has a cubic microstructure, identical to that of UO_2, suggesting good irradiation properties. Again, this has not been confirmed by our accelerator simulation tests.
- BeO has very high thermal conductivity and is stable; however, it is toxic and therefore has not yet been seriously considered.

Table 3 shows thermal properties of these candidates.

TABLE 3. Thermal properties of candidate inert-matrix materials

Material	Melting Temp. (°C)	Thermal 100°C	Conductivity 1000°C	Heat Capacity (J/cm^3•K)
ZrO_2	2715	1.9	2.3	2.6
BeO	2530	220	20	3.1
$MgAl_2O_4$	2135	10.7		
CeO_2	2600	10.9		2.6
SiC[a]	2700	61.6	27	2.2
SiC[b]	2700	77.5	50	2.2
Si	1410	108		1.7
UO_2	2878	8.8	3.2	2.6

[a] Sintered α-phase

[b] Sintered β-phase

3.4 ACCELERATOR SIMULATION TESTS

Because of the large number of candidates and the expense of fabricating fuel and performing irradiation tests, AECL has used the Chalk River Laboratories Tandem Accelerator to simulate irradiation damage, thus providing an initial screening of the candidates. The damage caused by fission fragments moving through the inert matrix with kinetic energy of about 70 MeV is severe (compared with neutron or γ-ray damage). Therefore, the specimens were bombarded with a beam of iodine at 70 MeV, a typical fission fragment and energy. Bombardment dose and sample temperature were varied, the former between 10^{18} ions/m^2 and 10^{20} ions/m^2, the latter between room temperature and 1200°C. Expected results were obtained for benchmark tests on Al_2O_3 and UO_2; Al_2O_3 is known to rapidly amorphize and swell from fission-fragment damage, whereas UO_2 does not amorphize or swell. The samples of $ZrSiO_4$ and $CePO_4$ showed swelling; the samples of SiC and ZrO_2 (including additives) did not show any swelling.

3.5 OTHER SIC TESTS

Sintered samples of SiC containing Al_2O_3 (a sintering aid) and CeO_2 or CeC (Ce is a non-radioactive surrogate for plutonium) were prepared with various amounts of Ce up to 30 wt %. Various sintering aids, in addition to Al_2O_3, were also tested to reduce the normally high temperatures required for sintering SiC. With these additives, sintering densities of 96% theoretical density (TD) were achieved at 1860°C and 90 to 94% TD at 1780°C. This work is on-going.

Compatibility tests of SiC with alkaline water (pH of 10.7) at 300°C were performed with good results. Similarly, compatibility tests with Zircaloy-4 were performed up to 1700°C. No interaction was seen at 1000°C; some diffusion of Si into Zircaloy was seen at 1500°C; and at 1700°C a layer of ZrC formed at the SiC/Zircaloy interface, and the remainder of the Zircaloy formed a molten Zr-Si alloy phase.

On the basis of these assessments, AECL is focusing its efforts on SiC as the most promising candidate for inert-matrix applications. Its very high thermal conductivity will result in very low temperatures, both in normal operation and in postulated accidents, with the expected benefit of low fission-gas release. Its high melting temperature is also a benefit. There do not appear to be any long-lived activation products resulting from its irradiation, and it would appear to be a stable waste form. Simulated irradiation performance, and other tests, are positive to date. Needless to say, much further work must be done to assess SiC, and other candidates. If other materials are shown to be superior, they too can be used for actinide burning or plutonium annihilation in CANDU reactors.

3.6 REACTOR PHYSICS ASSESSMENTS FOR ACTINIDE BURNING

AECL has performed reactor physics assessments of actinide burning in CANDU systems under contract to a commercial client. Although the analysis has not been as detailed as the work previously described on CANDU MOX fuel for plutonium dispositioning, these studies have nonetheless shown actinide burning in CANDU reactors to be technically feasible from the reactor physics aspect. The results are reported here because they are directly applicable to plutonium annihilation. These assessments were conducted using the WIMS-AECL[2] lattice code with the ENDF/B-V data library, and the RFSP[4] fuel management code, and are more detailed than earlier studies.[5]

For actinide burning in CANDU systems, SiC was chosen as the inert-matrix carrier, with a standard 37-element bundle. The actinide-mix consists of the ^{237}Np, ^{241}Am, ^{243}Am, and plutonium from spent PWR fuel. The actinides were mixed with SiC uniformly throughout the bundle. Because the fission energy derives almost totally from plutonium, and because there is no fertile material (either ^{238}U or ^{232}Th) present to produce additional fissile material

TABLE 4. Fuel composition:
Actinide-burning in an inert matrix
(g/bundle)

Nuclide	0 MW•d/kg	582 MW•d/kg
^{239}Pu	205	5.7
^{240}Pu	96	57
^{241}Pu	31	15
^{242}Pu	19	42
Total Pu	351	125
^{237}Np	20	10
^{241}Am	20	2
^{243}Am	3.5	8.7

Total of 400 g actinide mix per bundle

to compensate for the loss of plutonium, the reactivity and bundle power decrease rapidly during irradiation. To compensate for what would otherwise be a very high refuelling ripple (increase in reactivity, and local power during refuelling), a burnable poison was added to the bundle. For this application, gadolinium was chosen (having a higher depletion rate than the dysprosium used for CANDU MOX fuel). The fast burnout rate of gadolinium reduces the burnup penalty.

Three actinide inventories were considered: 400, 200 and 100 g per bundle in the high-, medium-, and low-inventory cases, with total plutonium contents of 351 g, 175 g, and 89 g per bundle, respectively, and fissile plutonium loadings of 236 g, 118 g, and 59 g per bundle, respectively. The bundles had gadolinium contents of 60, 20 and 10 g per bundle, respectively. Gadolinium was confined to the innermost 7 fuel elements; in the high-inventory case, for example, the central element had 20 g gadolinium, and the remaining 40 g gadolinium was distributed uniformly over the six elements in the next ring.

Coolant void reactivity in all cases is negative, as is the power coefficient. Hence there would be no power pulse in a postulated LOCA, and the safety and licensing analyses would be greatly simplified. The fuel temperature coefficient is very slightly positive; however, this is irrelevant in the safety analysis since any increase in heat in the fuel would immediately be transferred to the coolant because of the high thermal conductivity of the SiC, thus reducing the coolant density and producing a negative reactivity feedback because of the negative void reactivity coefficient.

Table 4 gives the actinide composition for the fresh and spent fuel, for the high-inventory case: 63% of the total original actinide inventory is destroyed, as is 91% of the initial fissile plutonium inventory. The high-inventory case results in the destruction of 0.68 Mg of actinides in a CANDU 6 reactor per year (assuming an 80% capacity factor).

Detailed, realistic fuel management simulations were performed using RFSP for a standard CANDU 6 reactor. On-line refuelling enables a full core of Pu-SiC to be used in CANDU. Acceptable bundle and channel powers were obtained for all cases. A bi-directional, 2-bundle shift refuelling scheme was used in the high- and medium-inventory cases, and a 4-bundle shift refuelling scheme was used in the low-inventory case. Refuelling rates in bundles per full-power-day were 9.2, 20.4 and 52.3 for the high-, medium- and low-inventory cases, respectively. The current fuel handling system can easily meet the requirements of the high- and medium-inventory cases; modifications would be required to meet the demands of the low-inventory case.

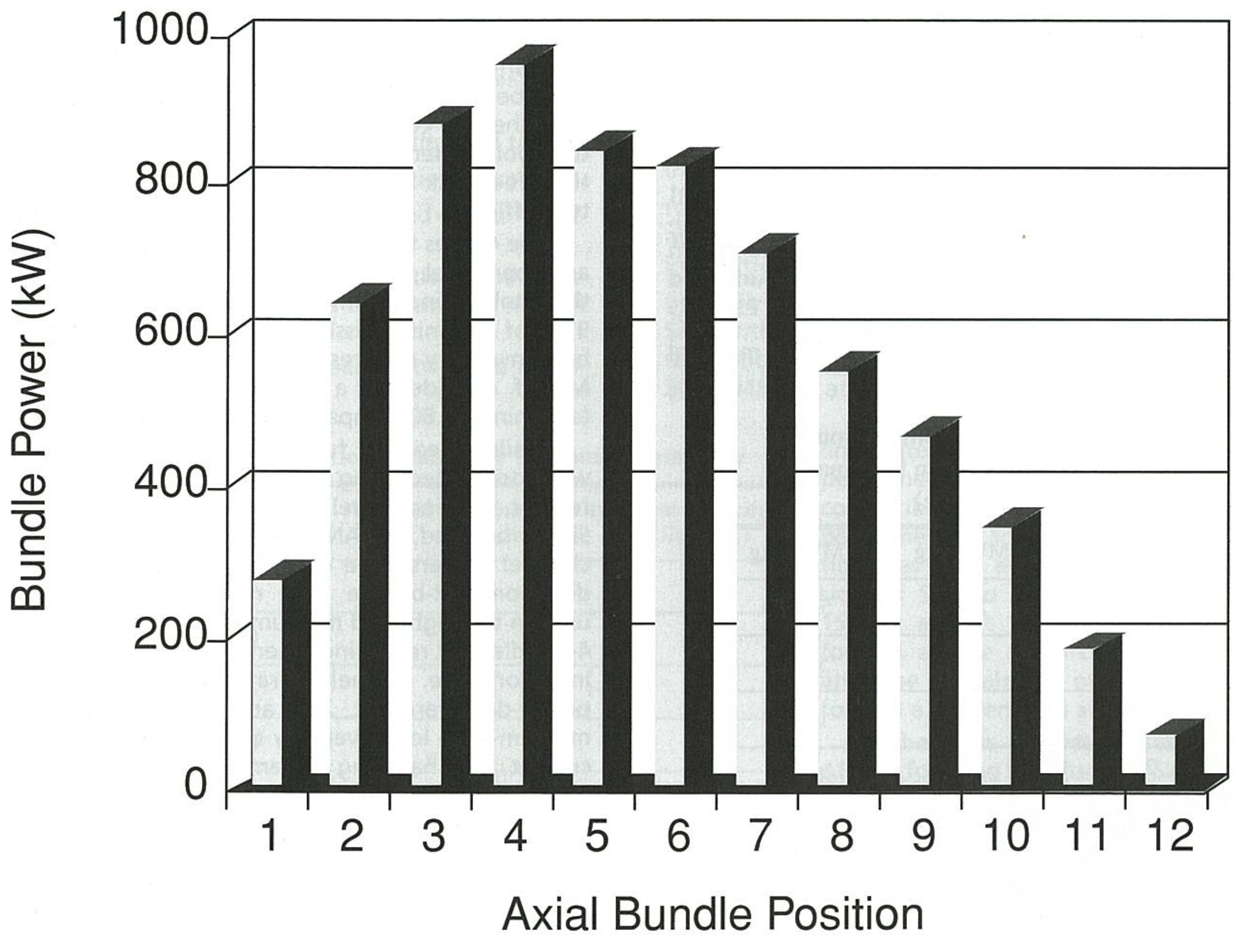
In all cases, maximum time-average channel powers were less than 6320 kW, and maximum time-average bundle powers were less than 960 kW. Again, these are within current limits. With the high thermal conductivity of the SiC matrix, corresponding fuel temperatures would be very low, and fission-gas release is expected to be negligible. (For a fuel centreline temperature of 2000°C in UO_2, the SiC fuel temperature would be about 500°C.)

Figure 1 shows the axial bundle power profile for the highest power channel (a central channel, N-10, near adjuster rods), in the high-inventory case. The axial power distribution corresponds to an instantaneous "snapshot" at one moment in time. The axial power distribution is typical of that with enrichment in CANDU, and in fact is similar to that with MOX fuel: it peaks towards the inlet end of the channel (axial bundle position 4), thereafter decreasing towards the outlet end. Only relatively fresh fuel would experience power boosting during refuelling (in shifting from axial bundle position 1 to 3, and from position 2 to 4), and the critical channel power (the channel power at which the fuel first experiences dryout) will be higher than for a cosine-shaped axial power distribution; thus thermal margins are better.

3.7 REACTOR PHYSICS ASSESSMENTS FOR PLUTONIUM ANNIHILATION

The above results for actinide burning are directly applicable to the case of burning weapons-derived plutonium. Table 5 shows the composition of the fresh and spent fuel for the high-inventory case above, with 250 g weapons-derived plutonium in the fresh fuel (no other actinides), calculated using WIMS-AECL with the ENDF/B-V data library. Void reactivity and power coefficient are both negative. Refuelling rate, and power distributions will be very similar to the high-inventory actinide-mix case above (RFSP was not re-run).

Looking at the "measures of merit" in Table 1, plutonium annihilation in an inert matrix has high net-plutonium and fissile-plutonium destruction efficiencies. The Pu-disposition rate is comparable with the CANDU MOX options, at 1.66 Mg Pu/GW(e) a. The fission energy derived from the plutonium is also good.



Refuelling direction: →
Maximum Channel Power, 6858 kW, channel N-10

FIGURE 1: Typical axial bundle power profile, Channel N-10, actinide mix

TABLE 5. Fuel composition:
Pu-annihilation in an inert matrix (g/bundle)

Nuclide	0 MW•d/kg	733 MW•d/kg
239Pu	235	7
240Pu	14	23
241Pu	0.9	10
242Pu	0.07	10
Total Pu	250	46

4. CANDU Pu-Thorium

The final CANDU plutonium-annihilation option to be considered in this paper employs the use of ThO_2 as a carrier for the plutonium. This is a responsible, forward-looking strategy that uses plutonium to convert ^{232}Th to ^{233}U, to be used as a future energy resource. The ^{233}U would be safeguarded in the spent fuel, with all the proliferation-resistant features of spent UO_2 or MOX fuel. Moreover, the radiation fields caused by the presence of ^{232}U (which emits copious a-particles) and its daughter products (particularly ^{208}Tl, which emits a 2.6 MeV γ-ray), provide a high degree of self-protection and render ^{233}U unattractive as a weapons material. The ^{233}U could be recovered in the future using a proliferation-resistant technology, when the price of uranium is high enough to warrant its recovery. Uranium-233 is the best fissile material in a thermal reactor, having the highest h-value (fission neutrons produced per neutron absorbed). In CANDU reactors, the production of 233U also maintains the option of the "self-sufficient-equilibrium thorium cycle", a long-term fuel cycle option which, in equilibrium, results in as much 233U in the spent fuel as is needed in the fresh fuel. This CANDU "near-breeder" fuel cycle provides long-term assurance of fissile fuel supplies.

The assessment of Pu-ThO_2 for plutonium management in this paper was limited to reactor physics lattice calculations, using the multigroup lattice code WIMS-AECL. Actinide inventories were calculated using a fully-coupled multiregion WIMS-AECL / ORIGEN-S code package.[6,7] Reactor calculations and fuel management simulations were not performed. However, given the CANDU flexibility in fuel management, no technical feasibility issues are anticipated.

A somewhat different approach was taken in designing the Pu-ThO_2 fuel bundle for this application. To maximize the destruction of the plutonium, good neutron economy was desired. A reduction in void reactivity was also sought, to compensate for the faster dynamic behaviour of the fuel (shorter neutron lifetime, and smaller delayed-neutron fraction). To achieve these two objectives, the central elements in a CANFLEX bundle were replaced with a large central graphite displacer. Plutonium at 2.6% (354 g per bundle) was mixed with thorium in the remaining 35 elements in the outer two fuel rings of the CANFLEX bundle. Computer analyses confirmed that enrichment grading in the outer two fuel rings would result in peak element ratings that are comparable to those in a 37-element bundle with natural-uranium fuel. The resultant burnup was 30 MW•d/kg HE, a burnup for which there is CANDU experience with Pu-ThO_2 fuel. Void reactivity was 8.6 mk, which is judged to be acceptable with the current shutdown system. Computer simulations also showed that using SiC instead of graphite in the central displacer reduces the magnitude of the void reactivity somewhat.

Addition of a small amount of burnable poison to the central displacer would further reduce void reactivity, increase the plutonium loading per bundle as well as the absolute amount of plutonium destroyed, but would decrease the plutonium destruction efficiency. (The plutonium destruction efficiency would be reduced from about 77% to 71%, by poison addition that reduces void reactivity from about 8.6 mk to zero.)

Table 6 shows the composition of the fresh and spent fuel: 77% of the total plutonium is destroyed, and 94% of the fissile plutonium, a destruction efficiency which is similar to that for plutonium annihilation in an inert matrix. Fissile ^{233}U (including its parent ^{233}Pa) is produced to the extent of 168 g, which can be recovered and recycled in a proliferation-resistant fashion. (For example, the ^{233}U, remaining plutonium, and ^{232}Th could be co-extracted, without separating the ^{233}U, and fresh weapons-derived plutonium added to maintain burnup, and further

TABLE 6. Fuel composition – Pu/ThO_2 (g/bundle)

Isotope	0 MW•d/kg	30 MW•d/kg
Pu-238	0.2	0.3
Pu-239	331.3	5.3
Pu-240	21.2	45.2
Pu-241	1.4	14.5
Total Pu	354.3	81.2
U-233 + Pa-233	0	167.7
Np-237	0	0.004
Am-241	0	0.59
Am-243		2.21
Cm-242		0.26
Cm-244		0.42

destroy plutonium stockpiles). Looking at the "measures of merit" in Table 1, this option achieves high plutonium destruction efficiency and has the highest energy yield, even without recycling the ^{233}U. Recycling the ^{233}U would increase the energy yield many fold.

5. Summary

The CANDU system provides unsurpassed flexibility for plutonium management through high neutron economy, on-line refuelling, and a simple, economical fuel-bundle design.

CANDU MOX offers a timely, technically achievable, cost-effective option for dispositioning weapons-derived plutonium. The use of the Bruce A reactors in Canada for the simultaneous drawdown of plutonium from both the United States and Russia offers an attractive symmetry and is actively being considered.

If the objective in plutonium management is annihilation, then CANDU can achieve this using an inert-matrix fuel. On-line refuelling enables reactivity to be added incrementally to compensate for the rapid depletion of the plutonium, allowing a full core of inert-matrix—plutonium fuel. High neutron economy enables a large fraction of the plutonium to be destroyed. A detailed reactor assessment including realistic fuel management simulations indicates that this is achievable in existing CANDU reactors. More than 93% of the fissile plutonium can be destroyed in a single pass.

The Pu-ThO_2 cycle offers a high plutonium destruction efficiency, while creating a stockpile of ^{233}U that is safeguarded in the spent fuel for future recovery using proliferation-resistant technology. It is a forward-looking option that maximizes the energy potential from the plutonium.

Hence CANDU offers immediate, plus evolutionary approaches to plutonium management.

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Définition du Concept de Risque

par Éric Lacroix[1]
[1]

1.0 Introduction

Définir précisément le concept de risque est une tâche difficile étant donné le grand nombre d'acceptations différentes de ce concept (aussi bien dans le langage courant que dans le langage technique) et de la confusion souvent faite avec le concept de probabilité. Il existe plusieurs propositions de définitions pour ce concept qui visent toujours à associer deux aspects d'un même événement soit: sa probabilité d'occurrence et ses effets ou conséquences.

Ce document a pour objet de présenter le concept de risque par la présentation de résumés ou d'extraits de lectures. En premier lieu, la définition ainsi que les expressions mathématiques du risque décrites par Nieuwhof(1) sont exposées. Cette définition tout en étant générale (champ d'application large) utilise une terminologie précise éliminant les incompréhensions. Par la suite, ce document introduit les aspects de la perception et du niveau d'acceptabilité du risque tels que présentés dans le livre de Villemeur(2). Ils sont suivis par la méthodologie d'évaluation du risque ainsi que sa critique comme présentées par Tanguy et Guyonnet(3). La notion de bénéfice attendu qui est utilisée pour les comparaisons économiques impliquant des risques(4) est aussi présenté et, finalement, une transposition du concept de risque aux centrales nucléaires de type CANDU a été effectuée.

2.0 Définition du risque

Le risque peut-être défini comme suit :

"La perte ou le dommage envisagé et considéré qui est associé à l'occurrence d'un événement indésirable possible."

Certains termes de cette définition demandent quelques explications supplémentaires:

1. « **événement indésirable** »

Ce terme inclus :

l'occurrence de conditions indésirables ;

un accident (ex.: une défaillance, une destruction, une désintégration, etc.) ;

une action défavorable particulière (dangereuse ou coûteuse).

2. « **la perte ou le dommage envisagé**»

Ce terme sera traité avec une attente mathématique

Si *p* est la probabilité qu'une personne perdra une somme d'argent *S* durant une action particulière de jeu d'argent (gambling), alors l'attente mathématique de la perte d'argent est défini comme le produit de *p* et *S*, c'est-à- dire

Nous pouvons présenté cette situation de la manière suivante:

La perte attendue par une personne qui parie une somme d'argent S dans un jeu particulier est :

Prob.{perdre la somme *S*} x [la somme d'argent *S*]

Dans cet exemple l'événement indésirable est l'ac-

Tableau 1 Directives de la CCEA pour des conditions accidentelles(7)

Situation	Fréquence maximale	Environment	Dose-limite individuelle	Dose-limite de la population
Exploitation normale		Pondéré selon l'effet (fréquence multipliée par la dose pour obtenir le dégagement unitaire)	0,5 rems/an (corps entier) 3 rems/an (thyroïde)	10^4 hommes-rems/an (corps entier) 10^4 rems/an (thyroïde)
Défaillance simple	1/3 ans	La pire température prévalant au plus 10% du temps ou la condition F de Pasquill si les données locales sont incomplètent	0,5 rems (corps entier) 3 rems (thyroïde)	10^4 hommes-rems (corps entier) 10^4 rems (thyroïde)
Défaillance double	1/3000 ans	La pire température prévalant au plus 10% du temps ou la condition F de Pasquill si les données locales sont incomplètent	25 rems (corps entier) 250 rems (thyroïde)	10^6 hommes-rems (corps entier) 10^6 rems (thyroïde)

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tion défavorable de parié la somme d'argent S.

3. « **considéré** »

Si nous évaluons le risque associé à un type particulier de perte causé par un événement indésirable particulier, alors nous ne devons pas inclure les pertes causées par d'autres événements. Le concept de risque, comme défini ci-dessus, est pratique seulement si l'événement et les pertes sont définis précisément.

À partir de la définition du risque et de sa discussion et avant que le risque d'une perte particulière associé avec l'occurrence d'un événement particulier puisse être établi, il est clair qu'un modèle probabiliste valide doit être confirmer. De la théorie de base des probabilités, il est reconnu qu'un modèle probabiliste demande :

"Une expérience bien définie, laquelle détermine tous les résultats possibles et permet de différencier un résultat qualifié de "succès" ou "d'échec"."

Par « une expérience bien définie » nous entendons une description précise du système, son opération ou action, et les conditions sous lesquelles il est supposé fonctionner. Le terme « système » est utilisé dans un sens très général. Il inclus les systèmes techniques, biologiques, organiques, etc. En association avec le risque il est évident qu'un "échec" est la perte ou le dommage causé, si l'événement indésirable possible se produit.

3.0 Les expressions mathématiques du risque

L'expression mathématique la plus générale du risque est :

Risque = [Prob.{événement se produise}] x [le coût probable si l'événement se produit]

ou

Risque = [Prob.{événement}] x [Estimé{coût par événement}]

Avec ceci en tête, trois types de modèle de risque peuvent être distingués.

I. Risque associé avec :

l'incertitude de l'occurrence d'un événement indésirable et ses conséquences fixes ou déterministes.

Risque I = [Prob.{événement}] x [Estimé{coût / événement} = *C*]

Risque I = [Prob.{événement}] x *C*

II. Risque associé avec :

l'incertitude de l'importance des conséquences d'un événement indésirable d'occurrence fixe ou déterministe.

Risque II = [Prob.{événement}=1] x [Estimé{coût/événement}]

Risque II = Estimé{coût/événement}

III. Risque associé avec :

l'incertitude de l'occurrence de l'événement indésirable et l'incertitude de l'importance de ses conséquences.

Risque III = [Prob.{événement}] x [Estimé{coût/événement}]

4.0 Exemples

Il est très important de bien comprendre, premièrement, la distinction entre le concept de risque et celui de probabilité et, deuxièmement de définir de façon très précise l'événement indésirable et ses conséquences. Voici quelques exemples que l'on peut entendre dans la vie courante et qui peuvent présenter certaines difficultés.

1. Le risque de se briser la jambe pour un skieur inexpérimenté est plus élevé que celui d'un skieur expérimenté.

Dans ce cas, la conséquence est fixe et c'est la probabilité d'occurrence qui varie. On considère que le skieur inexpérimenté tombera plus souvent et conséquemment il est plus probable qu'il se blesse. Ici l'événement indésirable est une chute en ski et non se briser une jambe. Le fait de se briser une jambe est la conséquence de la chute.

2. Le risque de mort ou de blessure est plus élevé pour ceux conduisant une automobile sans ceinture de sécurité que pour ceux la portant.

Ici, la probabilité d'accident est théoriquement la même pour les deux types de conducteur. Cependant, les conséquences ne sont pas les mêmes. L'événement indésirable est un accident et ses conséquences sont la mort ou des blessures.

3. Le risque de blessure à la tête et/ou au visage des joueurs de hockey professionnels est plus faible aujourd'hui qu'auparavant.

Dans cet exemple l'événement est de jouer au hockey et ses conséquences sont d'être blessé à la tête et/ou au visage. La probabilité d'occurrence a augmenté (les joueurs jouent plus de parties qu'avant) mais les conséquences ont diminué (le port du casque avec visière).

Comme on peut le constater, l'augmentation du risque n'est pas nécessairement associé avec une augmentation de la probabilité d'occurrence d'un événement. Il ne faut donc pas mélangé le concept de risque et celui de probabilité. La description de l'événement et de ses conséquences doit être la plus précise possible pour éviter les erreurs. L'exemple numéro 1 n'a de sens que lors d'une descente en ski car dans la vie quotidienne le fait d'être un skieur expérimenté ne nous protège point des accidents.

5.0 Acceptation du risque

L'acceptation du risque par les individus et par la société est influencée par de nombreux facteurs. Le plus important d'entre eux est lié au caractère volontaire ou involontaire du risque couru ; on accepte ainsi de courir des risques plus importants lorsqu'ils sont volontairement pris. Citons d'autre facteurs : les effets immédiats ou retardés du danger, la présence ou l'absence d'alternatives, la connaissance précise ou imprécise du risque, le danger commun ou particulier à certaines personnes, la réversibilité ou l'irréversibilité des conséquences.

Les activités volontaires et involontaires se définissent de la manière suivante :

- Activité volontaire : l'individu décide librement d'exercer cette activité en fonction de son expérience, de ses goûts, etc. (exemples : alpinisme, tabagisme).
- Activité involontaire : l'individu est soumis à ce risque dont généralement le choix, le contrôle ou la maîtrise lui échappe.

Dans les pays occidentaux industrialisés, le risque de décès provenant de maladie est d'environ 10-2/an. C'est une référence pour les plus hauts niveaux de risque involontairement acceptés. Le plus bas niveau de risque involontairement accepté est celui qui résulte d'événements naturels tels que la foudre, les inondations, les piqûre d'insectes, etc. Il est d'environ 10-6/an. Entre ces deux extrêmes, le public semble accepter des risques involontairement courus en fonction des bénéfices escomptés. L'enquête menée par Otway et Erdmann(5) aboutit schématiquement aux conclusions suivantes sur les niveaux annuels de risque individuel de décès :

-10^{-3}/an: Ce niveau de risque est inacceptable ; dès qu'un risque approche ce niveau, des mesures immédiates sont prises pour le réduire.

-10^{-4}/an: Le public réclame des dépenses publiques pour contrôler et réduire ce risque (ex. : trafic automobile, incendies, etc.).

-10^{-5}/an: Les risques de ce niveau sont identifiés par le public (ex. : noyade, arme à feu, etc.). Des conseils sont donnés pour les réduire (ex. : ne jamais nager seul en mer).

-10^{-6}/an: Les risques de ce niveau n'inquiètent pas l'individu moyen ; l'individu est au courant de ces accidents mais pense que ça arrive uniquement aux autres ; il se montre résigné face à de tels risques.

Les auteurs de cette enquête en concluaient que le risque individuel de décès de 10-7/an est une limite supérieure acceptable pour le risque issu d'accidents de centrales nucléaires.

6.0 Perception du risque

De très nombreux facteurs affectent la perception des risques par les individus. Une intéressante enquête aux Etats-Unis[6] a montré la relation entre le risque perçu par le public et le risque réel. Il apparaît ainsi que :

- Les causes de décès du type « maladie » et « accident de la route » sont considérées comme équivalente alors que les premières sont dix fois plus nombreuses.
- Les risques qui contribuent de manière importante au nombre de morts sont sous-estimés.
- Les risques qui contribuent peu au nombre de morts sont surestimés ; ainsi les événements de caractère exceptionnel (inondations, tornades) sont considérés comme beaucoup plus meurtriers qu'ils ne le sont en réalité.

Cette enquête semble confirmer le fait que le public juge « moins dangereux » une activité qui fait 1 mort tous les jours que 300 morts une fois par an. La perception des risques dépend de nombreux facteurs moraux et psychosociologiques qui apparaissent difficilement quantifiables ou même explicables.

7.0 Prévision du risque

Pour les événements indésirables se produisant avec des fréquences relativement élevées, il est possible de partir des observations du passé pour fonder une évaluation prévisionnelle qui prenne en compte l'évolution du niveau d'activité et des techniques employées. Par contre, pour ceux dont la probabilité d'occurrence est faible, il faut adopter une approche entièrement différente.

7.1 Méthode d'évaluation du risque

1. Rechercher les événements initiateurs d'accidents

Établir la liste de toutes les défaillances envisageables, sur les composants et sur les organes de liaison, susceptibles de faire sortir le système de son fonctionnement normal et de créer un accident.

2. Étudier les scénarios d'accidents

À partir des événements initiateurs, on doit ensuite établir l'ensemble des séquences accidentelles qui peuvent en découler. On est donc amener à tracer ce qu'on appelle un "arbre ou séquence d'événements". Dans certains cas, on peut partir d'événements indésirables rencontrés et remonter aux différentes causes initiales qui peuvent en être l'origine, ce qui correspond à la méthode de "l'arbre de défaillances".

3. Évaluation de la probabilité d'accident

Le scénario d'accident ayant été établi, il est possible de calculer la probabilité de voir arriver l'événement indésirable à partir de la probabilité des événements initiateurs et des probabilités respectives des événements successifs. Généralement, on s'appuie sur les statistiques disponibles sur les types d'événements considérés pour évaluer leur probabilité.

4. Exposition de l'environnement

Pour évaluer les conséquences du scénario, il est nécessaire de connaître l'état de l'environnement du système au moment où se produit l'événement indésirable.

5. Calcul des conséquences

Pour chaque type d'environnement, l'événement indésirable conduira à des dommages résultant de l'événement considéré et de l'environnement dans lequel il se produit. Pour chaque événement on dispose donc d'un spectre de conséquences dont chaque élément sera affecté du temps d'exposition dans l'environnement considéré.

6. Évaluation du risque

La quantification du danger est généralement représenté par une grandeur à plusieurs dimensions (nombre de victimes, dommages financiers, etc.) fonction du couple défaillances - environnement retenu. Cette grandeur sera toujours bornée supérieurement, le danger potentiel maximal correspondant à la défaillance totale du système survenant dans l'environnement le plus critique.

Remarque: Il faut signaler qu'il peut y avoir une corrélation entre le scénario d'accident et l'environnement et qu'il faut porter une attention particulière aux causes communes de défaillances.

7.2 Critique de la méthode

1. Le manque d'exhaustivité des événements initiateurs

On ne sera jamais parfaitement sûr d'avoir pensé à tous les scénarios possibles pouvant engendrer l'événement indésirable considéré.

2. L'insuffisance des connaissances sur certains phénomènes

Le calcul des probabilités des événements s'appuient toujours sur une bonne connaissance des systèmes en question et une compréhension bien formulée des phénomènes qui s'y passent. C'est loin d'être toujours le cas, pour le physicien s'efforçant de comprendre les phénomènes et pour l'ingénieur s'efforçant de les manoeuvrer.

3. La difficulté d'appréhender les probabilités cherchées

- La rigueur des méthodes de calcul n'est pas toujours acquise. Il faut interpréter avec prudence les valeurs de probabilités obtenues.
- Les données de base nécessaires au calcul de la probabilité de l'événement indésirable en fonction des probabilités de ses causes ne sont pas toujours accessibles quand elles existent, parce que les rapports d'exploitation n'ont pas été conçus en vue de la gestion des risques. Le plus souvent ces données n'existent pas.
- Le facteur humain qui est essentiel dans tous les scénarios est difficilement quantifiable.

4. La difficulté d'évaluation des conséquences possibles

L'extension spatiale sur des centaines de kilomètres, la multiplicité des formes prises par les dommages, l'influence différée sur des années, le mode pernicieux de l'agression (invisibilité des radiations), le comportement irrationnel des humains en groupes importants (panique), tous ces facteurs rendent une évaluation exacte des conséquences très difficile, voire impossible sans une marge d'erreur d'un facteur 2, 4, 10 ou plus?

8.0 Le bénéfice attendu

Le bénéfice attendu est la mesure standard utilisée pour les comparaisons économiques impliquant des risques. Il prend en considération les effets des risques sur les résultats potentiels grâce à une moyenne pondérée. Les résultats sont pondérés en fonction de leur probabilité d'occurrence et la somme des produits de chaque résultats multipliés par sa probabilité respective est le bénéfice attendu.

Prenons comme exemple le jeu suivant: On doit payer 1$ pour avoir la chance de lancer deux pièces de monnaie. Si l'on obtient deux "face" on reçoit 2$, pour deux " pile" ont reçoit 1$ et rien pour les autres résultats. Le calcul du bénéfice attendu est le suivant:

$$BA = P(F,F)*(2\$-1\$) + P(P,P)*(1\$-1\$) + P(P,F)*(-1\$) + P(F,P)*(-1\$)$$

$$= 0{,}25*1\$ + 0{,}25*0\$ + 0{,}25*-1\$ + 0{,}25*-1\$ = -0{,}25\$$$

Ce calcul démontre que ce jeu n'est pas payant car la perte moyenne par partie est de 0,25$. Cependant pour chaque partie que l'on jouera, le risque de perdre la somme misée sera de :

$$\text{Risque} = P\text{ (perdre 1\$)} * 1\$ = 0{,}5 *1\$ = 0{,}50\$$$

Si pour deux "face" l'on obtiendrait 10$ au lieu de 2$, le bénéfice attendu deviendrait 1,75$ mais le risque de perdre la somme misée demeure le même.

Le bénéfice attendu est une notion liée au risque. Il peut altérer la perception que l'on a d'un risque et servir de critère d'acceptabilité. Dans l'exemple cidessus, le risque est le même mais cependant un joueur avisé choisira le 2e jeu.

9.0 Évaluation du risque des centrales nucléaires de type CANDU

Toute activité implique un certain degré de risque et la plupart des activités industrielles comportent certains danger publics. Certains de ces risques sont chroniques, comme le dégagement continu de produit chimiques toxiques provenant des camions, fonderies et centrales au charbon ainsi que l'échappement continu de petite quantités de matières radioactives provenant des centrales nucléaires. Certains de ces risques sont aigus (accidents) comme par exemple, les explosions, les ruptures de barrages et l'écroulement de bâtiments. Pour une centrale nucléaire les accidents pouvant entraîner la libération de grandes quantités de matières radioactives présentent un danger pour la santé publique.

Dans le cas de la sûreté nucléaire, la probabilité d'occurrence de l'événement est d'habitude la fréquence annuelle c'est-à-dire "le nombre de fois par an" et la mesure de conséquence est généralement "la dose d'irradiation reçue par le public".

Au canada, la Commission de Contrôle de l'Énergie Atomique (CCEA) établit les directives sous une forme numérique pour la fréquence et les conséquences des accidents (Tableau 1).

10.0 CONCLUSION

Peu importe ce que nous faisons, il existe toujours un risque, il est irréductible à zéro quoi que l'on fasse. La sécurité absolue n'existe pas. Cependant, on peut s'efforcer de fixer des critères d'acceptabilité pour chaque catégorie de risque par référence aux risques admis dans des activités existantes et en fonction des bénéfices attendus, individuels ou collectifs. Ces critères ne peuvent pas avoir de valeur objective absolue et la fixation des niveaux de risques acceptables restera toujours en définitive du ressort du pouvoir politique.

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Call for Abstracts

20th CNS Nuclear Simulation Symposium

Niagara-on-the-Lake, Ontario
September 7 - 9, 1997

The scope of the Symposium covers all aspects of nuclear modeling and simualtion. The main objective is to provide a forum for discussion and exchange of views among scientists and engineers in the nuclear industry

Papers are invited in all subjects relating to simualtion of applications of nuclear technology. Papers on advances in the state of the art, on future developments and on novel approaches are envouraged, in particular on the folowing topics:

- reactor physics, including fuel management and advanced fuel cycles
- system and sub-channel thermalhydraulics
- safety analysis methods including code uncertainty
- copmuter code validation

Deadline: The deadline for abstracts is April 18, 1997. Abstracts should be approximately 300 words in length. Authors will be informed of paper acceptance by June 27, 1997. Camera ready full papers are due August 1, 1997.
Each abstract must present facts that are new and siginificant or repesent a state-of-the art review.

Abstracts should be submitted to:

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FAX 905-823-0416
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A Frequent Flyer Program for Nuclear Mythology

by J.A.L. Robertson

Abstract

The anti-nuclear literature contains many erroneous and misleading allegations, collectively constituting a mythology. These are repeatedendlessly, however often they are refuted, and are quoted uncritically by the media. Many are collected here, together with my rebuttals. For an explanation of the use here of the term "frequent flyers", read on ....

Introduction

In experimental sciences individual results that appear anomalous compared with most others are termed "flyers". Occasionally, further investigation leads to dramatic new insights: more often, the cause is careless research, so that the flyer has to be rejected as unreliable. It is in that sense that many of the myths perpetuated in the anti-nuclear literature are assembled in this collection of flyers. They are "frequent flyers" in that they are frequently quoted despite the many times they have been exposed as erroneous or misleading.Since 1990, a federal environmental assessment panel has been reviewing an Environmental Impact Statement (EIS) on the disposal of nuclear fuel wastes, submitted by Atomic Energy of Canada Limited (AECL). I have participated in the work of the Panel, both through my own submissions and through comments on about four hundred other submissions. I found the same misunderstandings, errors and unjustified allegations repeated time after time. Lewis Carroll knew of this phenomenon when he had the Bellman in The Hunting of the Snark say: "What I tell you three times is true." Here I have assembled some of these frequent flyers, with my responses.

Wrong from A to Z

A is for Alfven, Hannes Alfven, Nobel Laureate in Physics, who wrote about nuclear energy in 1972: "No Acts of God may be permitted". This became a favourite catch-phrase of nuclear critics. The same myth was worded differently by Carl Hocevar:"Nuclear power is an unforgiving technology. It allows no room for error. Perfection must be achieved if accidents that affect the general public are to be prevented."

Uncritical repetition of these myths has resulted in a widespread perception in the anti-nuclear literature that any departure from absolute perfection will lead to a catastrophe. Those designing, operating and regulating nuclear reactors know full well that equipment fails, that humans make errors and that Acts of God occur, and they act accordingly. One means they use is defence-in-depth, whereby they assume that failures will occur and so they provide backups, and often backups for the backups. When this is combined with the feedback of operating experience to correct faults when they occur safety is continuously improved and serious accidents can be prevented.The success of this approach is demonstrated by the fact that each year Canadian nuclear utilities submit to the Atomic Energy Control Board (AECB) some hundreds of "Significant Event Reports (SERs)" documenting equipment and human failings, yet there has never been a nuclear reactor incident in Canada in which a member of the public has received a radiation exposure exceeding the regulatory limit. Critics appear unaware of their inconsistency in attacking the industry for what they regard as the large number of SERs while claiming that perfection must be achieved if accidents that affect the general public are to be prevented.

Some examples of the belief in "an unforgiving technology" found in submissions to the Panel are : "if there were a (traffic) accident, thousands of innocent people would ... die a horrible death", "changes in climate (etc. could result) in an accident of catastrophic proportions", "could spell disaster for the human race", "render this planet uninhabitable", and "when (water is contaminated) you are killing the entire world". Given these beliefs, it is not surprising that guarantees of perfection are demanded, e.g.: "flawlessly", "one hundred percent guarantee", and "no element of doubt".

Another aspect of the Alfven effect is the demand for examination of worst case scenarios. The fallacy here is that there is no such thing as a worst case. Whatever the proponent may propose as a worst case a critic can always postulate, without any justification, that something fails to operate, resulting in a worse case. There is no end to this game. Z is for zero risk and zero emissions, frequent demands by those opposing nuclear energy. This is another expression of the demand for perfection. There is no such thing as zero risk for any human activity. The home is at least as dangerous as the workplace. Even staying in bed is not absolutely safe: for instance, a natural-gas explosion may occur in the house next door to where people are asleep. The emission of individual chemicals can be reduced to very low levels, but the limits of chemical analysis prevent us from ever knowing whether zero has been reached. For radiation, we know that zero cannot be reached since mankind has been immersed in naturally occurring radiation since the beginning of time. The real questions therefore become the magnitude of any risk at issue, and how this compares with the risk from other options yielding the same result.

Mr. Justice Wright, in his Reasons for Judgment in dismissing claims by Energy Probe and others concerning the Nuclear Liability Act, expressed it thus:

"The level of adequate protection need not, and almost certainly will not, be the level of 'zero risk'. ... [S]afe is not the equivalent of risk-free .... [An activity] can hardly be considered 'unsafe' unless it threatens ... a significant risk of harm.

Even those critics who do not expect zero risk usually demand, without any examination of the consequences, that the risk from radiation should be minimized. They often support this position by citing the ALARA principle (As Low As Reasonably Achievable) developed by the International Commission on Radiological Protection (ICRP) and endorsed by most national nuclear regulators, including Canada's AECB. What they ignore is the proviso in the full enunciation of the principle: "economic and social factors being taken into account". Thus the principle, that everyone says they support, is that the risk should be optimized, not minimized.

The true ALARA principle requires that safety, freedom from risk, must be compromised with economic and social factors. Nuclear critics seem unaware that, in arguing for public opinion to be a factor in decision-making, they are requiring safety to be compromised. There is a very good, fundamental reason why the risk from nuclear energy should not be minimized uncritically. Devoting society's limited resources to reducing unduly the risk in any particular sector would result in them being unavailable to reduce greater risks elsewhere. The consequence would be exposure of society to a greater than necessary overall risk.

No Safe Level

One of the most frequently quoted myths, one that underlies many of the public's fears of radiation, and hence nuclear energy, is: "Experts admit that there is no safe level of radiation: even the smallest amount can cause cancer and genetic damage." The basis for this is the Linear Non-Threshold Hypothesis (LNTH) for estimating the effects of radiation on humans. This hypothesis is indeed recommended by health-science experts on the ICRP and other expert committees, and endorsed by many national nuclear regulators, including the Canadian AECB, as a prudent assumption for regulating exposures to radiation.

It is true that according to the hypothesis the probability of incurring these adverse health effects is linearly proportional to the exposure and that there is no threshold for exposures below which the probability is zero. There is general agreement that the hypothesis represents well observations at relatively high exposures, e.g., for Japanese bomb survivors. What is obscured by the simplification, however, is the controversy at low exposures, around the values to which we are all exposed daily from natural sources. Some well qualified bodies, e.g.,the French Academy of Sciences and the U.S. Health Physics Society, have challenged the assumption of the LNTH at low exposures, suggesting that the available evidence can best be interpreted as showing a threshold somewhere near the natural background level. There are even some suggestions that small increases in exposures may be beneficial, not harmful.

There are some reasons why all this need not be surprising. While it is known that radiation damages DNA, the genetic template in all our cells, and that the amount of damage is proportional to the exposure, it is also known that there is a natural process for repairing the damage. Thus, as long as the damage does not occur fast enough to swamp the repair process, it is not obvious that any residual damage will remain to result in cancers or genetic effects. Furthermore, there are examples where exposure of a body to small levels of a stress, other than radiation, stimulate natural defences against subsequent exposures to the same stress and so are beneficial, in a manner analogous to vaccination. In another area, large amounts of some chemical elements are harmful but small amounts are essential dietary elements, i.e., more than beneficial. Even if there is no threshold, the scares raised by "there is no safe level" can be seen to be exaggerated by quantifying the risk. The maximum annual exposure for any member of the public from nuclear activities, such as a nuclear power station, by AECB regulations, is 1 millisievert (mSv); and actual exposures are normally less than one percent of this, even for those most exposed. For comparison, the average Canadian is exposed to 2 mSv per year from other sources and some are exposed to several mSv, depending on location and life-style. From this perspective the academic debate over the validity of the LNTH is the modern equivalent of the mediaeval one over the number of angels that can dance on the head of a pin.

Chernobyl

The 1986 reactor accident at Chernobyl in the then U.S.S.R. was the worst in the history of nuclear energy; and too many people have died and been injured as a result. The myth is that the deaths have run into the tens of thousands: even as high as 125,000 has been quoted. In 1991 the Canadian Broadcasting Corporation was quoting 10,000 to 15,000 immediate deaths, without qualification. The facts are that 31 people died as an immediate result of the accident (28 from radiation injuries, two from non-radiation blast injuries and one due to a coronary thrombosis), and 134 were diagnosed with acute radiation syndrome. Of the latter, 14 people have since died, but their deaths were not necessarily attributable to radiation exposure. In addition, about 800 cases of thyroid cancers have been reported in children, of whom three have died. The total of 48 deaths, tragic as it is, has to be compared with the hundreds that die in other natural and man-caused disasters.

Much of the scare-mongering about Chernobyl concerns allegations of widespread occurrences of cancer in the surrounding population due to the radiation, already observed or predicted. It is true that the incidence of cancer there had been rising in the 1980s, but it continued to rise at the same rate after the accident. Specifically, there has been no significant increase in the incidence of leukemia, the radiation-induced cancer that shows up soonest. In considering the thyroid cancers among children, it should be recognized that these are treatable and not usually fatal. Also, they have occurred in a region of Belarus where iodine deficiencies in thyroid glands are already endemic, rendering the population abnormally susceptible to absorption of any radioactive iodine.

We have to face up to the fact that further deaths attributable to the accident are to be expected in the future. However, of the 116,000 people that were evacuated, fewer than ten per cent received doses of more than 50 mSv, a dose that can be incurred in a few years of living in regions of high natural radiation, without any observations of an anomalous incidence of cancer. Depending on whether or not the LNTH is valid, additional deaths worldwide over the next 70 years can be predicted, somewhere in the range from a high of 24,000 down to a possible zero. This value has to be compared with the 350 deaths that would have been expected to have occurred in the former U.S.S.R. each year, if it had foregone nuclear energy in favour of coal-fired electricity.

The basis for my claims of what are facts is an international conference that was held in Vienna in April of 1996. It was organized by the World Health Organization, the IAEA (both agencies of the United Nations) and the European Community, in cooperation with three other UN agencies and the Organization for European Cooperation and Development: it was attended by 845 scientists from 71 countries and 20 organizations. Can anyone seriously suggest a world-wide conspiracy among all these people to conceal the truth?

Also attending the conference were 280 journalists but the media are still talking of thousands already dead from Chernobyl. In some instances the source of the myth can be identified. For instance, the figure of 125,000 said to be those already dead from Chernobyl was in fact the number of deaths during the period 1988-94 from all causes in the area affected by the accident. A figure of 10,000 deaths in the 600,000 people who helped in the clean-up represents the normal death rate over five years in any comparable population. The most likely explanation of the media's irresponsible propagation of mythology is laziness, simple repetition from other media, combined with a relish for disasters and conspiracy theories that sell "news". Thanks to the media,and according to Mark Twain:

> *"It's not that people know too little. It's that they know too many things that just ain't so."*

It is not just differences in reactor design that have prevented accidents such as those at Three Mile Island in Pennsylvania and at Chernobyl occurring in Canadian CANDU reactors. The importance of a sound safety culture in the operating organization is well recognized and our utilities participate in peer reviews by other utilities and through the IAEA. Good regulation is another important contribution to safety.

Wastes

The debate over the disposal of nuclear wastes has provided a wealth of the nuclear mythology of "an unforgiving technology" and Alfven's demand for perfection. A claim that there is sufficient radioactive material in storage to threaten the continuation of life represents scare-mongering. I challenge those making such claims to present any plausible scenario whereby radioactive material in storage could eliminate life from the earth. Demands for disposal in fracture-free rock ignore the fact that the proposed concept assumes fractures and faults in the rock representative of those observed in practice through the large amount of experience of the Canadian Shield, and estimates the performance on this basis.

The wastes would not "remain toxic and life threatening over tens of thousands of years." any more than natural ore deposits. The claim that these wastes are "the most toxic substances ever created, some with a half-life longer than all recorded history hitherto" is misleading in failing to mention that this applies to only a small fraction of the wastes; that the plutonium, to which this presumably refers, has a toxicity comparable to that of radium, created by nature and present in all soil, water, etc.; and that the external radiation hazard from plutonium is negligible. The wastes will remain "highly toxic" for millions of years only if the same description applies to countless ore bodies of uranium, arsenic, mercury, and others.

There is a widespread, but false, belief that those responsible for commercializing nuclear energy went ahead without considering how to dispose of the wastes. In fact, early AECL researchers developed a process for immobilizing separated wastes in the early 1950s and had initiated a demonstration burial below the water table in a monitored site at Chalk River by the end of the decade. The results of this program were reported at international conferences and in the open literature. AECL's proposal for the immobilization and geological disposal of the wastes, essentially the same concept as in the current EIS, was reviewed and endorsed by an independent panel in 1977. The panel's report was tabled in the House of Commons that year and was the subject of public hearings of a standing committee the following year.

This brief history contradicts one of the most frequent flyers: "There is no solution to the nuclear waste problem". I could agree with a more carefully worded claim: "There is no demonstrated solution to the nuclear waste problem acceptable to everyone". However, there is a catch-22 involved here in that this claim is used by nuclear critics to prevent any demonstration: it is like the situation of young people who cannot get a job because they have no experience. Also, there will never be a proposal acceptable to everyone.

The AECB's Regulatory Policy Statement for the disposal of radioactive wastes (R-104) requires that predictions of releases from the wastes cover a timescale of 10,000 years. This limit can be defended as being the longest for which we can have any reasonable confidence in our predictions concerning human behaviour; and is comparable to the periods between ice ages. However, it has been criticized for ignoring the risks to generations beyond 10,000 years. In fact, R-104 includes the proviso:

> *"Where predicted risks do not peak before 10,000 years, there must be reasoned arguments that beyond 10,000 years the rate of radionuclide release to the environment will not suddenly and dramatically increase, and acute radiological risks will not be encountered by individuals."*

The AECB's R-104 has been misinterpreted in another respect, in claiming that it prohibits retrieval. In fact, it states:

> *"For the long-term management of radioactive wastes, the preferred approach is disposal, a permanent method of management in which there is no intention of retrieval ...."*

I.e., retrieval is not intended, but it is not prohibited.

A common theme among those opposing the geological disposal of nuclear wastes is a combination of pessimism that current technology is inadequate to ensure safety and optimism that future technology will solve the problem. Many propose, even now, that the wastes should be disposed of in space, ice-caps, etc., or by transmutation, ignoring the reasons against these "solutions" that have already been given. The geological concept has been criticized for doing nothing to make radioactive waste less dangerous, but this ignores the fact that the danger consists of two factors, the material's inherent hazard and its accessibility. By isolating the waste its accessibility is greatly reduced, and thus the danger it presents is also greatly reduced.

Another frequent flyer concerning wastes is that the proposed facilities would be so expensive that they would harm the economy and be a heavy burden on taxpayers. The estimated cost of the facility is very large, but so too is the value of the electricity generated from the used fuel to go into it. As a result, the estimated cost of waste disposal is only a few per cent of the cost of the electricity. The necessary funds are already being collected from electricity customers, according to the user-pays principle, and would not be paid by taxpayers.

Non-Proliferation

Many flyers relate to the alleged connection between civilian nuclear energy and nuclear weapons. Some of the technologies are shared but there are many significant differences. Medicine and biological weapons share technologies, but nobody suggests that we give up the benefits of medical science to prevent the use of these weapons. Used fuel contains fissile material capable in principle of being recovered and fabricated into the explosive of a nuclear weapon. This scenario would require not only a large plant to separate the fissile material from the highly radioactive waste products and another plant to fabricate the material into components, but also the technologies for a nuclear detonator and sophisticated electronics and conventional explosives to achieve a nuclear explosion. In judging the likelihood of this scenario, one has to consider the alternatives open to any country or group seeking weapons. I provided reasons for believing that neither countries nor terrorist groups would seek to divert material from nuclear-electricity production in "Preventing Nuclear Weapons Proliferation: A Positive Factor for Peace" in The Energy Newsletter in 1982.

Cui Bono? (Who Benefits?)

There is a widespread but false belief that only those in Southern Ontario who use nuclear electricity benefit from the Canadian nuclear industry. About sixty per cent of Ontario's electricity is nuclear so that almost all Ontario, connected to the grid, would be crippled by any shortage. Even aboriginal communities in Northern Ontario would be affected: a submission to the Panel by the Nishnawbe-Aski Nation shows that nearly half its communities are connected. Also, about one third of New Brunswick's electricity is nuclear, and Quebec too has some. Saskatchewan's mining industry benefits from its uranium sales.As well as electricity the Canadian nuclear industry produces radioisotopes for medical, industrial and research applications. About one in every three diagnostic procedures in Canadian hospitals involve radioisotopes. An estimated half-million people in seventy countries are treated for cancer annually with over 1,300 Canadian therapy machines using radioactive cobalt irradiated in Canadian reactors. The Canadian nuclear industry contributes about $3.5 billion per year to the economy, and direct employment of about 30,000 jobs. It is one of only two high-technology industries making a positive contribution, of about one-quarter of a billion dollars per year, to our trade balance. Turning to the environment, each year Canada's use of nuclear energy, rather than coal, is avoiding the release of more than a million tonnes of acid gases, and nearly a hundred-million tonnes of carbon dioxide (largely responsible for global warming).

From this brief summary nobody can doubt that all Canadians benefit in one way or another from nuclear energy. Those calling for its abandonment show no evidence of having examined the consequences.

Another flyer concerning benefits is the assumption that only this generation benefits from the nuclear energy being produced now, so that future generations should be protected from all consequent risk. While the present generation should take responsible measures for the disposal of its own wastes, as proposed in AECL's EIS, the risk assessment for future generations should take into account the benefits that they will inherit. The most obvious is a developed technology that can, if they wish, provide them with energy for centuries through the recycling of used fuel. Even when the uranium - and thorium - is burned, they will benefit from the fossil fuels that were not burned, and that could be used as chemical feedstock. Less direct, economic benefits to any generation continue to benefit succeeding generations. To understand this we only have to look back at the Industrial Revolution: despite all the social and environmental harm from its "dark satanic mills" our lot today as a result of it is greatly improved over that of those living in "the good old days". Constant criticism of Ontario Hydro's "debt" is misleading, since it no more than the equivalent of a house mortgage, which is not normally regarded as a "debt".

Major cost overruns on Ontario Hydro's construction of its Darlington station are advanced as evidence that the cost estimates for waste disposal are underestimated. While Ontario Hydro was unquestionably responsible for some of the overruns through poor estimating and delays in construction, inflation and political decisions made major contributions. The real answer, however, is that the bulk of the capital costs for a geological repository would be expended on hard-rock mining for which Canada has extensive experience. Even the remote handling aspect, which differs from conventional mining, is an area of Canadian expertise. The allegation that transportation of the wastes is a high-risk undertaking that has never been done before in Canada is another frequent flyer. Canadian experience in all aspects of the proposed concept should contribute to confidence in the cost estimates.

Too Cheap to Meter

Nuclear critics frequently claim that nuclear energy has failed to deliver on its early promise of "electricity too cheap to meter". The only source of this quotation is a talk in New York on September 16th, 1954, to the National Association of Science Writers by Admiral Lewis L. Strauss, then Chairman of the US Atomic Energy Commission, when he said: "It is not too much to expect that our children will enjoy electrical energy in their homes too cheap to meter." What the critics do not tell is that Strauss was talking about nuclear fusion energy, not fission that is today's nuclear energy. Nevertheless, it was a stupid remark. Anyone can understand that any means of generating and distributing large amounts of electricity, renewable or non-renewable, requires large and hence expensive engineering structures. Thus even if the fuel were free capital charges would still have to be paid by somebody.

The Canadian situation was never confused by this myth. Here, nuclear energy was introduced in the 1950s as a result of Ontario Hydro running out of readily accessible hydroelectric sites to exploit. It was importing coal from the U.S. for its fossil-fired stations. AECL made its proposal for what later became CANDU reactors only when it could demonstrate that these offered the prospect of being competitive with coal-fired stations, both economically and for safety. There is no evidence that the Canadian nuclear industry promised "electricity too cheap to meter".

"Soft" Energy

Basic to the opposition to nuclear energy is the myth that "soft" energy sources (most derived from solar energy) render it unnecessary. National and international inquiries have repeatedly warned that these sources cannot satisfy the foreseen demand. (See, for instance, my 1993 report AECL-10768 reviewing the composition and findings of more than thirty inquiries). It is not a matter of renewable versus non-renewable energy or conservation versus supply: all those that are acceptably safe and economic will be needed if we are not to harm our economy and our environment. Discussion of this usually fails to point out why renewable energy sources, except hydro-electricity, are always going to be expensive, however much R&D is done — they are diffuse and intermittent, requiring large engineered structures for collection, back-up and storage.To claim that renewable energy sources are non-polluting, is simplistic when the collection, storage and transmission systems are included. (For a numerical comparison see IAEA Bulletin, 37/4 revised in 38/1 and 38/2.) Hydrogen is not an energy source but has to be produced from an energy source: if nuclear energy were phased out, more coal would be used in electricity generation, resulting in "hydrogen-generated power" being highly polluting.

Secrecy

Another frequent flyer concerns the accusation of "the secretive nuclear industry". This was valid half a century ago, before the existence of the present nuclear industry, i.e., one directed towards civilian nuclear energy; and is still partly true for countries with nuclear weapons programs, especially the U.S. where much of this mythology originates. However, in Canada nuclear energy has been virtually free from secrecy, apart from commercially valuable know-how, for decades.

Around 1980 the Chairman of Ontario's Royal Commission on Electric Power Planning (RCEPP) contradicted an accusation of the industry's secrecy by nuclear critics. The AECB is similarly free from secrecy. It encourages public participation at its regular Board meetings, but few members of the public attend: it has had an open Office of Public Information and reading room in downtown Ottawa for years, but again public participation is negligible. Anyone propagating the myth of secrecy should be obliged to state what information has been refused, and the reason given for any refusal.

The secrecy myth is closely related to the military-industrial-complex myth. These may be applicable in the U.S., from where both are imported, but are irrelevant to the Canadian nuclear industry. Anyone claiming that a "security state" exists in Canada should be invited to visit one of the Visitor Information Centres at nuclear generating stations and laboratories.

Ethics

Perhaps the frequent flyer most offensive to those of us in the nuclear industry is that it is unethical and that we are mercenaries. I have argued in another article (The Geometry of Nuclear Energy; Getting the Right Angle on the Ethics, Canadian Nuclear Society Bulletin, 13, 3) that for many applications nuclear energy is the energy source of ethical choice, rebutting opinions to the contrary. Even more, it would be unethical to deny to present and future generations an energy source that saves lives and protects the environment when compared with available alternatives.

Err-Miles for Nucle-err Frequent Flyers

To alleviate frustrations when exposed to anti-nuclear literature, readers could award "err-miles" to each frequent flyer detected. The Canadian Nuclear Society could then present a certificate to the individual or organization with the most err-miles each year at its Annual Meeting.

Radiological Impacts on Non-Human Species

A report on a joint CNS/CRPA Symposium

Ed Note: *Much of the following is thanks to Ray Lambert who prepared a report for the Bulletin of the Canadian Radiation Protection Association.*

A symposium on **The Radiological Impacts on Non-human Species from Nuclear Facilities** was held in Ottawa on December 2, 1996.

Organized jointly by the Canadian Nuclear Society (CNS) and the Canadian Radiation Protection Association (CRPA), the Symposium had two purposes;

- to inform stakeholders about Environment Canada's legislated ecological risk assessment of radionuclide releases, and,
- to facilitate discussions on a proposed approach to environmental protection, being considered by the regulators.

The approach proposed by the Atomic Energy Control Board (AECB) would require licensees to estimate, directly, effects of radionuclide releases on non-human biota. The Environment Canada's mandate is already in progress; its outcome will influence the direction the AECB proposed regulations will take.

The chairperson and key organizer of the symposium was **Judy Tamm** (AECL, Whiteshell Laboratories), Deputy Chair of the CNS Waste Management and Environmental Affairs Division. Support for the symposium is provided from the Atomic Energy Control Board, Atomic Energy of Canada Limited, Cameco Corporation, CANDU Owners Group, Environment Canada, Ontario Hydro and The Montreal Foundation for Radiation Protection.

Radionuclide releases from nuclear facilities, has been placed on Environment Canada's second Priority Substances List (PSL-2), which requires an assessment to determine toxicity according to the Canadian Environmental Protection Act (CEPA).

Conducting such ecological risk assessments is a major task, and the results could have a significant impact on future environmental protection programs of Canadian nuclear facilities. Components of the ecological risk assessment process are likely to become a required part of environmental management systems. The Atomic Energy Control Board and Environment Canada are cooperating in this assessment effort and have indicated that they welcome industry input and consultation.

This Symposium provided an overview of the new federal environmental initiatives. The speakers addressed the state of the art in methodology, type and quality of available data, and identified issues or areas which require further development or investigation. The Symposium closed with a panel discussion, open for questions from all participants.

Rob Maloney, from the AECB, was the first speaker, with a presentation entitled "A Proposed Approach to Environmental Protection". Mr. Maloney defined environmental protection as "a goal to maintain a viable environment for continued human development". On several occasions he defended this work with the claim that the current approach of the ICRP (that if man is protected then so is the environment) is not socially acceptable, based on feedback from public forums. When asked to define "socially acceptable", Mr. Maloney replied that this will be determined through a public consultative process. The AECB wish to develop an internal policy by 1997 March and then start the consultation process. The policy will define an environmental management system and establish monitoring criteria. As they will wait for the results of the PSL-2 assessment, they expect the process to take about 5 years.

Patsy Thompson, also from the AECB, gave a presentation on the assessment of radionuclides under CEPA's PSL-2 Assessment. She is currently assigned to Environment Canada to undertake this project. A PSL-2 Assessment determines if a substance is toxic as defined in CEPA. Such a judgment requires that the substance be toxic and be actually present in the environment at sufficiently high levels for its toxicity to have an effect on the environment.

During the questioning Dr. Thompson noted that a substance that is found "CEPA-toxic" will be placed in one of two possible tracks. Track 1 is virtual elimination (i.e. zero release) for substances with long environmental half-lives. Substances normally found in the environment (that is, which are not primarily anthropogenic) cannot be Track 1 because it is not possible or practical to eliminate the substance from the enviornment. Track 2 substances are subject to full life cycle management; releases to be controlled and reduced to a level which depends on the value to society of the activity causing their release. When asked if there is a comparison between relative risk, for example that associated with the releases from burning coal vs nuclear power, Dr. Thompson noted that the objective of the assessment is not to compare relative risks but to look at absolute risks.

David Myers (a consultant, formerly with AECL) gave a presentation from the Joint Working Group (Health Canada and the AECB's three advisory committees ACRP(1), ACNS(2) and GMA(3)) on "Assessment and Management of Cancer risks from Radiological and Chemical Hazards". He supported the current thinking of the International Commission on Radiological Protection (ICRP) (ICRP 1991 and 1977) that, the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imablance between species. Dr. Myers also noted that information on each of the tens of thousands of non-human species will never be as complete as that for humans.

Gordon Blaylock (SENES Oak Ridge, Inc., Tennessee) discussed Environmental Pathways and Radiological Dosimetry for Biota. His message was similar to that of Dr. Myers. Dr. Blaylock cited the BEIR Report 1972, ICRP 1991, NCRP 109 (1991) and IAEA 332 (1992) in support of the statement that if man is protected then the environment is protected. He noted that for non-human species we are concerened with the effect on populations rather than the individual. The question was later raised, "what do we define as a population"? For example, the ground preparation for a nuclear reactor may destroy several local populations of worms, ants and other non-human species that have lifetime movement of less than the area of a football field.

The presentation by **Florence Harrison** (LLNL, Washington) was on "Radiobiological Endpoints Relevant to Ecological Risk Assessment". Based on her research she concluded that the critical factor in risk assessment is reproduction (vs mortality) and fertility should be used as the indicator.

Larry Barnthouse (McLaren-Hart Environmental Engineering, Tennessee) discussed the extrapolation of risks from individuals to populations to ecosystems. He compared environmental protection for chemicals to that for radiation and concluded they are not as different as they appear. Both are consistent with risk assessment/management principles. He recommended that if we are truly interested in sustainable development then we need to go beyond the current approach used with chemical and radiation risk assessments and look at them in a combined manner.

D. Wismer, R. Zach and **J. Takala** (AECL Whiteshell) reviewed some Canadian case studies of assessments of radiation effects on non-human biota. They presented the different methodologies used and their findings. The conclusions from each study were much the same: the effect of radionuclides released on biota was usually insignificant as compared to the non-radiological stressors. They also concluded that further work is required to improve the methodology, acquire more data on the enviornmental impact of radionuclides released and communicate the findings with the public.

Dennis Woodhead (Dept. of Fisheries Research, UK), gave an overview of the recently released UNSCEAR report on "Effects of Radiation on the Environment". He discussed a few questions raised by the report. For example, how are small doses to small organisms to be interpreted considering RBE, the probability associated with radioactive decay (for example the few Pu atoms in contaminated fish eggs may not decay or in some they may all decay). Also what is the equivalent to a sievert (Sv) for non-human species. The Sv includes radiation and tissue weighting factors. His overall conclusion is that there is little likelihood of damage in populations if the incremental dose rates from low LET radiation to the most highly exposed members of the populations are less than 40 Gy/h for land animals and 400 Gy/h for plants and aquatic organisms. A comparable conclusion cannot be made for alpha emitters, yet, because the effect of LET is unknown. Dr. Woodhead indicated strongly that these were values of dose rate below which further environmental studying is not warranted.

The symposium concluded with a panel and question period chaired by **Dr. John Heddle,** York Univesity. It was noted that there is no evidence to contradict the ICRP position that, if man is protected other species will be. Rob Maloney replied that they were not concerned about contradiction but that the current position was socially unacceptable. Considerable discussion ensued on the question of where did the environment (of a particular facility) begin and end, with no clear consensus emerging. A participant commented that the costs of doing the analyses could run into millions of dollars which he considered intolerable. Rob Maloney replied that any new Regulations would have to be reviewed under the government's cost effectiveness policy.

At the end, when asked, do we really have a problem? Rob Maloney replied, "We don't know, but the present situation is unacceptable."

Based upon very positive feedback from the participants, this first joint CNS/CRPA Symposium was a success. Both organizations have agreed to explore further collaboration.

(1) Advisory Committee on Radiological Protection
(2) Advisory Committee on Nuclear Safety
(3) Group of Medical Advisors

CNA / CNS Winter Seminar

In what has now become an annual winter ritual, over 100 senior representatives of the Canadian nuclear community gathered in Ottawa on the evening of February 11 and all day February 12 for a review and status report on the industry.

The first evening was devoted to a "Meet the MPs" reception and dinner at which about two dozen parliamentarians joined with the seminar delegates for an enjoyable meal interspersed with some quiet lobbying. In place of Prime Minister Jean Chretien, who was unable to attend, his Parliamentary Secretary, Dr. Ray Pagtakhan, presented the PM's talk (which is reprinted elsewhere in this issue). The key message sent by the Prime Minister was that, "you can be assured that the Government of Canada supports the nuclear option...". Following the talk, Hong Huynh, president of the Canadian Nuclear society presented a plaque for the Prime Minister which reads:

The CNS President's Award to The Right Honourable Jean Chretien, Prime Minister of Canada, for leadership in supporting the global success of Canadian nuclear technology.

In making the presentation, CNS President Huynh commented that the award was being presented, "in recognition of the Prime Minister's continuous support for Canadian nuclear technology since he became Minister of Energy, Mines and Resources in 1982 through to his recent active support for the sale of two CANDU units to China".

The following day Reid Morden, president of Atomic Energy of Canada Limited, was the lead-off speaker, after introductory remarks by CNA chairman Ernie Card and CNS president Hong Huynh. (Morden's talk is also reprinted in this issue.)

Then, John McManus, former secretary of the Atomic Energy Control Board gave a status report on Bill C-23, the proposed new Nuclear Safety and Control Act. (As he prophesied, that Bill received third reading and was passed by the House of Commons a little more than a week later.) The Act must now be approved by the Senate before it can be proclaimed. However, McManus said the new Act will not be put into effect until the accompanying Regulations are ready and, he promised the participants, there would be full public consultation on these Regulations. McManus said that the new Act is "powerful and flexible" and that nuclear regulators in other countries had praised it a "masterpiece". It enshrines, he said,"principles of: openness, concentration, accessibility, independence"

The rest of the day was filled with concise updates on several key areas of the nuclear program. Frank King, of Ontario Hydro, reviewed the history of the nuclear fuel waste disposal program from the Canada / Ontario agreement of 1978 up to the Environmental Assessment hearings on the Deep Geological Disposal Concept concluding this month. He noted that Ontario Hydro was now funding and directing the disposal program but AECL continues, under contract, as the proponent at the hearings.. He stated that $40 million had been budgeted for continuing research and development over the next three years.

This was followed by presentations on public affairs (communication) by Rhea Cohen, of AECL and Murray Stewart, president of the CNA. Stewart referred to NucNet, a Geneva based Web site which draws information from over 300 sources in over 40 countries. This is a fee based system and the CNA is the Canadian distributor.

After lunch, Ron Oberth, of Ontario Hydro reviewed his utility's role in weapons plutonium disposition. He noted the recent decision in the USA to follow a dual track of immobilization and disposal, and burning using MOX (mixed oxide) fuel in reactors, including CANDU. Russia, he commented, considers the plutonium as a "national treasure" and prefers the MOX route. There is considerable experience in using MOX, he noted,. France, for example, has 16 reactors now operating with MOX fuel. The Canadian proposal to burn MOX fuel in the Bruce reactors complements the USA and Russian programs, he said. A major problem is public acceptance.

David Shier, of the Canadian Nuclear Workers Council, first clarified that his organization was NOT a union but a group representing unions working to ensure union support for the Canadian nuclear program. They are now associated with the international World Council of Nuclear Workers.

Robert Steane, vice-president of Cameco Corporation, provided an excellent review of uranium mining in Canada, with emphasis on the "Canadian advantage" of the very high quality deposits in Saskatchewan. (A separate article based on his talk is included in this issue of the CNS Bulletin.)

An update on efforts to have the next large thermonuclear fusion machine (ITER) located in Canada was provided by Don Dautovich, vice-president of Ontario Hydro Research, representing the ITER Siting Board. They are still seeking federal / provincial funding of about $300 million each which would be offset by predicted ANNUAL tax revenues of $550 million. They are also looking at private financing. The schedule calls for a draft cooperation agreement by January 1998 and a decision on siting by January 1999.

The day closed with a "workshop" on government relations presented by David Miller, of the firm Hill and Knowlton.

Most delegates appeared satisfied that the event had been successful and worthwhile, and it will, undoubtedly, be repeated again next February.

PM Supports Nuclear

***Ed. Note:** Following are the words of greeting from the Prime Minister brought to the CNA/CNS Winter Seminar in Ottawa, February 10, by **Dr. Rey D. Pagtakhan,** MP, and Parliamentary Secretary to the Prime Minister. Dr. Pagtakhan has a further connection with the nuclear industry as being a former medical associate of Dr. Agnes Bishop, president of the Atomic Energy Control Board.*

Good evening.

I am honoured to bring you greetings on behalf of the Prime Minister, the Right Honourable Jean Chretien, who asked me to send his best wishes to your Association and Society. As he could not join us this evening, he asked me to send his regrets. My medical practice may be on hold, but I believe I am making the correct diagnosis when I say 'you wished the Prime Minister could have joined you tonight in person'.To ease your disappointment, I assure you that my speaking notes bear the Prime Ministerial seal of approval - - they came straight from his heart. The Prime Minister would like me to bring to your attention:

- the highlights of 1996 for your industry in partnership with the government,
- the challenges 1997 and onwards bring to this partnership, and
- the government's commitments and initiatives in the policy front, particularly in legislation and regulation.

I hope I do justice to the task in front of me - to convey to you the Prime Minister's message, which I share.

I. Highlights

Let me outline the highlights of a significant year for your industry by beginning with a look at the success of CANDU in Asia and Eastern Europe.

China

In China, the highlight of the year was the signing of a $4 billion contract between Atomic Energy of Canada Limited (AECL) and the China National Nuclear Corporation for two CANDU 6 reactors to be built at Qinshan, near Shanghai.

The Prime Minister is particularly pleased that this contract signing was a direct consequence of the 1994 Team Canada Initiative.

Mr. Chretien was also delighted to have participated in the signing ceremony last November.

This is a major development for the Canadian nuclear industry, because the construction of the two reactors at Qinshan signals the start of a major CANDU program in China.

While we hope that this recent contract with China is a sign of even better things to come, Canada's biggest success in the Asian market has been the sale and construction of reactor units in Wolsong, South Korea.

Wolsong, South Korea

Wolsong is a huge project that has delivered significant benefits to Canada in terms of jobs, growth and other spin-off business opportunities.

The federal government has actively supported your marketing efforts in Korea, and is keen to hear the results of the Korean decision on CANDU 9.

East Block Nations

In Europe last year, we demonstrated that Canada has a valuable role to play in helping former East-Bloc nations meet the challenge of developing the infrastructure they need to participate in the free market.

Cernavoda, Romania

Let us now go to one of these nations.

On April 17, 1996, the Prime Minister formally inaugurated the Cernavoda 1 CANDU reactor in Romania.

The plant is now fully operational, providing much needed electricity to Romania.

Cernavoda is a success story which is largely due to the dedication and commitment of your industry.

I understand that discussions are now in progress on the completion of Unit 2. I hope that a satisfactory arrangement can be developed.

Let me move to the industry sector that provides the raw material for our nuclear activities.

Uranium Mine Development

Canada's uranium mining industry continues to prosper, hosting three of the world's top ten uranium-producing companies.

In 1996, it is estimated that primary uranium production exceeded 11,600 metric tons (tU), or almost one-third of total world output.

Also last year, increased spot market prices spurred the confidence of companies that are guiding the development of several significant new uranium development projects, such as the new McClean Lake project in northern Saskatchewan. Later this year, McClean Lake will become Canada's first new uranium-producing operation since the Key Lake mine began production in 1982.

Public environmental reviews are moving forward on several other proposals in Saskatchewan.

Following approval, the Cigar Lake and Midwest projects will ship ore to the McClean Lake mill, where combined annual uranium production could exceed 9,000 metric tons.

The Joint Federal-Provincial Panel on Environmental Assessment is expected to release its report on the McArthur River project in the near future. McArthur River is the world's richest uranium deposit, and has the potential to become a major production centre.

Here in Canada, 1996 was a year of substantial change that provided many challenges for your industry.

II Challenges

AECL Review

One of the major challenges was the federal Program Review at Atomic Energy Canada Limited.

The results of this review confirmed full government support for AECL's mission to focus on the CANDU business. We share the industry's commitment to the CANDU product as a leading example of successful Canadian high technology development.

While activity accelerates in the area of uranium mine development and the sale of CANDU technology, we also saw significant progress on some challenging policy fronts last year.

New Nuclear Legislation

Bill C-23, which proposes to establish the Nuclear Safety and Control Act, is now awaiting Third Reading in the House of Commons. By replacing the 1946 Atomic Energy Control Act, this new legislation will establish a modern regulatory regime for Canada's nuclear industry as we head into the twenty-first century.

Radioactive Waste

Last July, on behalf of the Government of Canada, Anne McLellan, the Minister of Natural Resources, announced the approval of a Policy Framework for Radioactive Waste. The Framework lays out the ground rules and sets the stage for the development of institutional and financial arrangements for waste disposal in a safe, environmentally-sound, comprehensive, cost-effective and integrated manner.

The federal government has the responsibility to develop policy, to regulate, and to oversee radioactive waste producers and owners in order that they meet their operational and funding responsibilities in accordance with approved waste disposal plans.

With regard to the disposal of nuclear fuel waste, let me emphasize a couple of key points.

No decision will be taken on next steps for long-term management until the Canadian Environmental Assessment Panel has completed the important and extensive public review of the disposal concept for nuclear fuel waste and provided its recommendations to the federal government. Be assured that the federal government will give careful and thorough consideration of the panel recommendations before providing a response on this important and challenging issue.

Conclusion

Ladies and Gentlemen, as I conclude, I hasten to say that the Prime Minister had also asked me to tell you that you deserve to look back at 1996 as a significant year of change and triumph.

Indeed, the significant achievements of 1996 reflected, I believe, the strong partnership between government and your industry. In particular, the successful sale of CANDU reactor technology to China demonstrates the effectiveness of the Prime Minister's Team Canada initiatives.

And the Government of Canada recognizes the many challenges you face.

Your challenge is to stay the course, and focus on the future in order to remain a competitive force in the global marketplace.

You can be assured that the Government of Canada supports the nuclear option as a source of energy, thanks to innovative CANDU technology, and the dedicated designers, engineers and operators who ensure every day that CANDU is one of the safest nuclear generating reactors in the world today.

Your activities will continue to create high technology jobs and stimulate economic growth for Canada.

In Asia and eastern Europe, you are demonstrating that Canadian ideas and technology are providing a competitive means to harness nuclear power for peaceful purposes.

You have earned a solid reputation in the international nuclear field. Your industry is a world leader in the areas of nuclear technology, nuclear product development and uranium production and sales.

I encourage you to keep up the good work; future generations are counting on it.

CANDU Exports and Opportunities

by Reid Morden

***Ed. Note:** The following is the prepared text for the address by Reid Morden, President of Atomic Energy of Canada Limited, to the CNA/CNS Winter Seminar in Ottawa, 11February 1997. Before beginning his official paper, Mr. Morden congratulated the Canadian Nuclear Society for its growth and active programs.*

The key to our industry's survival rests with our ability to succeed in the export market. Therefore I am going to talk for a few minutes this morning about our international efforts. Taking China on a departure point.

China

Last year we set a target for ourselves of selling ten CANDU reactors in the next ten years. Ambitious but, in my view, achievable. We have made a good start by successfully concluding a contract with the Chinese for two of our ten CANDU reactors.In 1989.

China had an installed capacity roughly equal to Canada's with a population 40 times the size. Since 1989, the capacity has grown to 230,000 Mwe and is growing at a current rate of roughly 15,000 Mwe per year. While this growth rate is phenomenal, there is no end in sight. It is estimated that there are still close to 100 million people without electricity. By the year 2020, China aims to have a total installed capacity of 800,000 Mwe of which 40,000 Mwe will be nuclear. While the competition will be tough as other vendors pursue the enormous opportunities, market share of at least 25% should not be beyond our reach.

What will we need to achieve this?

1. We must do a first class job of completing the Qinshan project, including meeting or beating the schedule. There is no doubt the Chinese are watching carefully how we perform.
2. We must secure adequate amounts of financing for a very ambitious program in China. We must also continue our quest for more innovative financing including the possibility of some type of modified BOOT.

   We must pursue localization as the Chinese government will be heavily influenced by our willingness to do so.
3. We must increase and broaden our marketing efforts. Korea is the other market contributing to our "Ten in Ten" objective. We have been working diligently to have two CANDU 9 units included in Korea's basic construction plan which was due out before the end of 1996. It was however delayed and we have been responding to requests from the Koreans for more information and elaboration related to the feasibility study which has been done on the CANDU 9 reactor. In this case, we are not competing with another foreign supplier but with the indigenous Korean standard plant. Clearly, this is a vitally important decision as it will signal whether Korea will continue with its two reactor policy and it would provide us with the first opportunity to build a CANDU 9 reactor abroad. A decision is expected soon. Beyond these two vitally important markets, we are pursuing a number of other opportunities.

Turkey

The most imminent is Turkey where, at long last, an invitation to bid was issued on December 17. We are busy now on bid preparation as the closing date is June 30. This will be the first time in living memory that we have been in a true, competitive, international competition. Clearly, price will be a critical element. We will be bidding two CANDU 6 units against competition from NPI (Convoy model), Westinghouse/Mitsubishi (OHI model) and, perhaps, Ansaldo with some unidentified partners. We have a strong consortium and expect to have a competitive bid. As always, financing will be a major challenge and we are working hard to maximize the amount we obtain in Canada.

Romania

Cernavoda unit one has been performing very well at a time when Romania has desperately needed the power and this has enhanced and, we hope, advanced our chances of a contract for the second unit. As you know, the second unit, including the equipment, is mostly complete and the new Government seems keen to complete Unit 2 on the same basis as the first unit. We are working with our Italian partner, Ansaldo to put a proposal to the Romanians within the next month. In fact our chairman, Bob Nixon and I will be going to Romania at the beginning of March to meet with or customer Renel and make the acquaintance of members of Romania's new government.

South East Asia

Less immediate but very important opportunities exist is South East Asia. In particular Indonesia, Thailand and the Philippines are all considering seriously nuclear power, aiming to have it in place around the year 2008. That being the case, decision time is not too far away and we are very active in all three markets. In the case of Indonesia, they continue to insist that they must have a BOO model or, at least, a modified version thereof and we continue to give thought to how this might be done. To date, no nuclear power project has been done on this basis. Vietnam too appears seriously interested but that opportunity is probably a little further off again because of the difficulty in financing a project of this magnitude in Vietnam.

Hungary

Finally, an opportunity appears to exist in Hungary. The Hungarians have requested and paid for a feasibility study for a CANDU 6 reactor in Hungary. The study will be completed in May, so we may have a new and somewhat unexpected opportunity.

Let me conclude by repeating that, at least to the medium term our future lies outside Canada in markets that, in most cases have ready access to fossil fuels and investors willing to invest in IPPs. To succeed, we must compete with these other sources of power. All of us in this room must devote our efforts to improving our competitiveness, whether it be through cost reduction or enhanced performance.

That said - in my view nuclear power - far from fading away as some would have it - is poised for significant expansion - propelled by its competitiveness and its environmental friendliness . To be part of the expansion - we must take the internal markers. I've just mentioned - cost reduction and enhanced performance and join them to:

- Judicious strategic alliances abroad
- Innovative financing tapping new sources of funds
- Strong efforts at localization
- Solutions for stable fuel supply and to the disposal of spent fuel.

I think we and the Canadian industry are equal the there tasks. This country and its industrial base are founded on finding solutions to big problem. Together we can do it in the nuclear.

Uranium Update

by Robert Steane

Editor's Note: *The following is drawn from the talk by Robert Steane, recently appointed vice-president, mining, at Cameco, Canada's largest uranium company, at the CNA/CNS Winter Seminar in Ottawa, February 11, 1997.*

This talk is about the current uranium mining situation, especially that in Saskatchewan.

Canada has a unique advantage with the Saskatchewan uranium deposits. Making the most of this opportunity is important to Canada. I will review:

- project development and the time and capital it takes to bring a new project into production;
- the supply and demand situation to show where the future production fits into the world market;
- our foreign competition and how we have to be careful not to loose our opportunity.

Saskatchewan Update

With the closure of the Stanley mine in Ontario, all of Canada's uranium is produced in Saskatchewan.

There are three operating mines: Cluff Lake on the west, Key Lake, and Rabbit Lake on the east side of the Athabasca Basin. McClean Lake is under construction and plans to start production in July this year. McArthur River and Cigar Lake are currently in the late stages of the Environmental Review process.

The Saskatchewan Advantage

Million lbs U_3O_8

	Reserves	Grade % U_3O_8
McArthur River	416	15.0%
Cigar Lake	353	14.0%
Key Lake	52	1.5%
Rabbit Lake	81	1.4%
World Average		0.15%

The mining of the Deilmann pit at Key Lake continued through 1996 but the end is coming into sight. The last ore will be mined in two or three months from now. Once mining is finished there will be sufficient ore on the stockpile to sustain mill production at fourteen million pounds per year until mid 1999.

Mining at Rabbit Lake continued from the Eagle Point mine with development underway to sustain mining at about 300,000 tonnes per year for the next three years. The construction and mining activity associated with the mining of the A and D zone deposit that has been ongoing for the past couple of years is drawing to a close. D zone was completed in the first half of last year and mining of A zone should be finished in about 3 months. These two deposits add about 20 million pounds of U_3O_8 to our ore stockpile.

The Rabbit Lake mill achieved a significant milestone by producing 10.3 million pounds last year. This is highest production in its 27 year history and is even the more remarkable because it achieved this record with operation only every second week.

Cluff Lake continued operation with production of about 5 million pounds of U_3O_8.

Reserves

A comparison of the major uranium producers in the world with the Saskatchewan operations shows the significant advantage in quality which has lead to the high production, low cost operations. There are large deposits elsewhere, but with lower grades and generally smaller production capacities than those in Saskatchewan.

Key Lake, Rabbit Lake and Cluff Lake have made Saskatchewan the world leader in the uranium industry. But their reserves are coming to an end; particularly Key Lake and Rabbit Lake.

So what is going to replace them?

Cigar Lake and McArthur River are the future of uranium mining in Saskatchewan. These two deposits eclipse any other deposits in the world.

McArthur River has total geological reserves containing 416 million pounds at an average grade of

Reserves/Grades & Production Capacity

Million lbs U_3O_8	Reserves	Grade % U3O8	Annual Capacity
Kay Lake	52	1.50%	14
Rabbit Lake	81	1.40%	12
Cluff Lake	43	0.94%	5
Ranger (Australia)	57	0.27%	0
Olympic Dam (Australia)	700	0.06%	9
Rossing (Namibia)	260	0.4%	5
Akouta Arlit (Niger)	200	0.46%	7
Krasnokomonsk (Russia)	200	0.15%	5
Highland (US)	20	0.15%	1

Mineral Value Comparison	
$US	Value/Tonne
McArthur River	$5,000
Cigar Lake	$4,500
Jabiluka (Australia)	$150
Gold at 2 oz/ton	$700
Voisey's Bay	$190
Key Lake	$775

10% U_3O_8. Detailed drilling has defined 189 million pounds of mineable reserves at 19% U_3O_8. This was when we stopped the exploration because there was no point in spending more money delineating any addition reserves at this time. A tonne of McArthur River ore has a mineral value of $5,000 (US).

Cigar Lake has 385 million pounds of U_3O_8 with 353 million pounds mineable reserves defined.

Clearly these deposits are in a class by themselves. The previous deposits at Key Lake and Rabbit Lake were exceptional in their time; these deposits are 10 times higher quality than those and about 100 times the world average grade.

These deposits provide the opportunity for Canada to maintain its world leadership role.

To further highlight the quality of these deposits if one compares them on a value per tonne with other ores the comparisons are quite amazing.

No other mineral deposit in the world compares. A tonne of ore at Australia's Jabiluka deposit has a contained value of $150 while an extremely rich gold deposit of 2 oz/tonne only has a value of $700 per tonne.

As valuable as the Key Lake ore was it pales compared to the McArthur and Cigar material. I have not seen this comparison done elsewhere but it is very effective at highlighting the significance of these two Saskatchewan deposits.

In a global context Saskatchewan deposits have dominated the industry. Lower costs and higher volumes have enabled Saskatchewan producers to remain competitive during the long, significant decline in uranium price seen through the past. Saskatchewan can continue in this dominant role because of the quality of these new resources.

Development Time

The development of a uranium project is a long process. Looking at today's mines and those projects under review you can see that it can take from 7 to 25 years from discovery to production. What is important is the relatively long time to start a new project.

If the exploration leading to discovery is added this can extend the time span to several decades.

It is true that some of these developments may have been paced by market or other circumstances but if a deposit were discovered today it is unlikely you could see any production within the next decade. This is easily illustrated by looking specifically at the McArthur River project.

The McArthur River project has been moved along as fast as it could since initial discovery. It was discovered in 1988. Surface exploration continued through 1991 and in mid 1992 the decision was made to carry out underground exploration.

This exploration phase was necessary to obtain sufficient detailed information to allow preparation of an Environmental Impact Statement and start a detailed feasibility study. Even this phase of the project was subject to the public hearing process prior to being allowed to proceed. This was the first time a project was subject to public hearings for exploration. The total exploration phase took until mid 1995 to complete.

The next phase, which we are still in now, was to file an EIS, complete the feasibility and start the mine and mill design.

The next phase was to go through public hearings leading to government approval (or perhaps not).

Then we have to do the detailed engineering, obtain licences and approvals to construct the facilities.

Lastly we have to construct the facilities which will take about 2 years.

Finally we get to commissioning in mid to late 1999 at the earliest. This on a project that has been advanced as fast as it could at every stage since discovery.

Demand

Fortunately the demand for uranium doesn't change quickly or dramatically so we can project future requirements with some comfort.

We know how much uranium the world's 437 operating reactors consume. Also with the long lead times required for construction of the 30 new reactors now being built the resulting consumption is fairly predictable.

The total world demand is expected to increase to 185 million pounds by 2006, from the 167 million today.

Similarly the western world demand is projected to rise from 146 million pounds to 160 million.

The largest supply source to meet this demand will be from western production.

Production

Between 1988 and 1994 the severely depressed prices resulted in annual western world production falling by almost 40 million pounds. The downward trend stopped in 1995 with rising prices bringing unused capacity back into use and new capacity being started. Although the figures are not available yet this increasing trend is expected to have continued through 1996.

Price

This increase resulted from the largest year-to-year price increase in nearly two decades. In 1996 the price maintained its strength closing the year at $14.73.

With this sustained price increase some more operations are increasing production and more new projects are being readied to bring into production.

Supply / Demand

Looking at the supply/demand balance is quite interesting. Over the next decade the production from the existing mines in the western world will drop below 40 million pounds per year.

Almost 30 million pounds will be lost in Saskatchewan with the depletion of Key Lake, Rabbit Lake and Cluff Lake.

The draw down of the excess western inventories will continue over the next few years but this source should seen be exhausted.

It is expected that Europe and Japan will fill some of their needs through the reprocessing of spent fuel – beginning with about 2 million pounds this year and growing to about 6 million pounds a year by 2004.

Supplies from the CIS and China are expected to remain at about 20 million pounds per year as they continue to sell their inventory.

The most uncertain source of supply is the highly enriched uranium (HEU) from the dismantling of weapons in Russia and the United States.

The signing of a 20 year agreement between the US and Russia will result in the equivalent of 400 million pounds of uranium from nuclear weapons being turned into fuel. This is equivalent to another McArthur River.

It is expected (hoped) that this material will be phased in, but we still see it rising to about 24 million pounds per year by 2005.

There is still a shortfall between production and demand that can be satisfied by new production. Timing of this new production to secure the market will be very important.

The new Saskatchewan projects have a head start by being in the advanced stages of development or review. But, there remains the long time to bring a project into production.

McClean Lake is expected to start production in July this year and should produce 6 million pounds per year. This will be followed by the Midwest project coming to the McClean Lake mill in about 2003.

McArthur River and Cigar Lake could each be producing as much as 18 million pounds annually by the beginning of the next decade. This nearly satisfies the demand but I have not talked about other possible mines.

Australia

With last year's change in government in Australia their restrictive 3 mine policy was scrapped. This has allowed a number of dormant projects to be reactivated. These could contribute up to an additional 18 million pounds per year if all brought into production. We are ahead of them in the process but not by much.

USA

In the United States new mines could supply as much as 10 million pounds per year by 2005. This means there is the potential for an additional 20 to 30 million pounds per year from both Australia and the US.

MCA / CIG

This brings us back to our two major projects in Saskatchewan. We need to get these projects on line ahead of the competition to ensure we maintain our position in the market. Subject to the approval process we hope to start construction at McArthur River this summer and at Cigar Lake either late this year or early next year. Over the next few years the owners will invest an additional three quarters of a billion dollars to bring these on line. Adding the cost of exploration and development spent to date, will bring the total investment to $1 billion – this is a lot of money to get started. Then the technical challenges must be overcome.

Challenges

To successfully mine these ore bodies, three challenges must be dealt with: water ..., poor ground conditions ..., and high radiation levels.

These challenges will be met with the innovative mining techniques being developed for these sites.

The main method used at McArthur River will be raise boring.

Tunnels will be developed above and below the ore zone. A pilot hole is drilled through the ore from the upper level through to the lower level. A reaming head is attached to the drill steel in the lower level and pulled back up, boring a 2 - 3 metre diameter hole as it goes.

At Cigar Lake a jet boring technique will be used to cut the ore with high pressure water jets. A pilot hole is drilled up into the ore then the jet boring tool is introduced to excavate a cavity in the ore.

At both Cigar Lake and McArthur River, freezing will be used to control the water and improve the ground stability.

In both projects the ore will be crushed and ground underground and pumped to the surface as a thick ore slurry. The ore is contained from mining through grinding and pumping to the surface to reduce and control radiation exposures.

The ore from McArthur River will be transported to Key Lake for milling. Likewise the ore from Cigar Lake will be transported to McClean Lake for milling.

Public Hearings

Both of these projects were subject to public hearings last fall. The review of McArthur River was completed and we anxiously await the panel's report. The latest information we have is that the report has been finalized and is now in the translation and printing process. We expect to receive this report towards the end of the month.

Once this is received there will be a few months review by both federal and provincial governments to formulate their response to the panel's recommendations. Once ministerial approval is given, assuming that it is given, there still remains the lengthy process of obtaining construction and operating licenses from the AECB and SERM (the Saskatchewan Environment and Resource Management Department). We hope to be in a position to start some construction work this summer.

The hearings on the Cigar Lake project were not completed last year. The panel requested additional information regarding the proposed tailing deposition in the JEB pit at the McClean Lake site. This information is being prepared now and is expected to be given to the panel in two to three months. Once they receive it additional public hearings will be scheduled. These will most likely be a couple of days in LaRonge or some other Northern Saskatchewan locality. We are hopeful that the panel will deliver their report by the fall and that an approval to proceed will be made this year.

Road to Production

From this brief overview it can be seen that the road to production is long and requires considerable patience and commitment, not to mention money. Although Canada has an advantage over the rest of the world in terms of resource, quality and quantity, there is a disadvantage in the length of time it takes to move these projects along.

There is an opportunity for Saskatchewan to retain and even increase its leadership in the supply of the world's uranium. The timing of getting these new projects on stream to have the product available is everything. With the price increases over the past two years, a number of other projects are coming onstream and although we have a slight time advantage it would not take much more delay of our projects for them to catch up and capture a portion of the market that we otherwise would have.

It is important that we maintain our advantage. Not just to Cameco, Cogema and Uranerz, the main owners in these projects, but also to Saskatchewan and Canada.

Algonquins to Atoms Along the Ottawa

Jeremy Whitlock

Ed. Note: *This essay is somewhat of a change from the usual article in the CNS Bulletin, but given the beginnings of the Canadian nuclear program at Chalk River on the banks of the Ottawa River we enjoyed, and hope our readers will enjoy, this bit of history from Jeremy Whitlock, a very active CNS member.*

For over two centuries it was the gateway to a whole continent, one of history's important rivers. Today, the river and its history are little known to Canadians, beyond the fact that the nation's capital was built along its lower shores. Such is the irony that colours the story of the Ottawa River. Another example can be found in the upper reaches of the mighty river, where rugged country, isolation, and poor soil have restricted settlement to the same sparse pattern that existed a hundred years ago. Yet here, within the infinite pine forest, along the billion-year-old granitic shoreline, sits Chalk River Laboratories - a world-renown, high-tech institution, the birthplace of the CANDU reactor.

At first sight one is struck by the apparent paradox. In fact, the presence of the country's flagship nuclear laboratory is oddly consistent with the river's legacy. For four hundred years the Ottawa River has been linked to one vital Canadian industry or another, from the fur trade, through the logging and lumber era, to the widespread development of hydro-electricity, and finally, the pioneering of nuclear power. The story of the Ottawa is a major part of this country's cultural and industrial heritage.

Aboriginal Cultures

But the story begins earlier than this. Well before the arrival of the first Europeans, the Ottawa was an important highway for commerce, cultural exchange, and transportation. Archeological sites on Morrison Island near Pembroke reveal a 5000-year-old culture that manufactured copper tools and weapons. Copper ore was extracted north of Lake Superior and distributed via the Ottawa throughout the forbidding Canadian Shield country, down to today's northern New York state. At this time the prehistoric river still drained much of the Great Lakes basin, a legacy of the recent Ice Age (today the Lake Erie route is the sole outlet for the basin).

Two thousand years ago the river and its tributaries looked much like they do today, draining over 140,000 square kilometers of mostly Precambrian rock. Local pottery artifacts from this period show widespread similarities that indicate the continuing use of the river for cultural exchange throughout the Shield and beyond. Some centuries later the Algonquin tribe moved in and inhabited the islands and shores along the Ottawa, and by the 1600's the first Europeans found them well-established as a hunter-gatherer society in control of the river. The Algonquins called the river the "Kichesippi". The French colonials called it "La Grande Rivière des Algoumequins", and quickly recognized its strategic potential as an entry point to the nether regions of the New World.

The Fur Trade

Over a thousand kilometers long, the Ottawa starts out in the flat highland due north of today's city of Ottawa, travels west to the Ontario/Quebec border, finally switching eastward and following an ancient fault line (carved out by glacial meltwater) down to the St. Lawrence at the Island of Montreal. It was here at this confluence of the two mighty rivers that Samuel de Champlain, founder of Quebec in 1608, set up the first "trading place" and thus initiated the great fur trade. The pelts of beaver and other wildlife were brought down the Ottawa in massive flotillas of birchbark canoes each Spring. Although only the Algonquins inhabited the river, many other tribes used it as a highway, most significantly the Huron tribe of the lower Georgian Bay area.

For half a century the Hurons dominated the French colonial fur trade, travelling up Georgian Bay from their homeland around present-day Midland, Ontario, ascending the French River to Lake Nippissing, crossing the height of land at present-day North Bay, and finally descending the Mattawa River to the Ottawa. This was the same waterway Champlain travelled in 1615 to winter with the Hurons, and indeed for the next 250 years it was the favoured access route to the Great Lakes, and thence the inner continent. Alternately, one could access northern Canada by climbing the Ottawa further north past Lake Temiskaming, and portaging another height of land to the Hudson's Bay watershed. In the early 17th century, however, except for a handful of Europeans, including Jesuit and Récollet missionaries, the Ottawa was the privy world of the North American native.

The Algonquins along the Ottawa showed entrepreneurial spirit. On Morrison Island, location of the 5000-year-old copper artifacts, the Kichesippirini band levied a toll on canoe flotillas descending the river. However, in the mid-17th century the thousand-year Algonquin civilization along the Ottawa came to an abrupt end. The lucrative fur trade had fanned the flames of inter-tribal aggression, and finally the Iroquois League from south of the St. Lawrence, armed by their Dutch allies, attacked in force and decimated the tribe. It is another irony in the story of the Ottawa, that its very name (and consequently, the name of Canada's capital) comes from a tribe that never lived anywhere near the river. The Ottawas, from north of Lake Huron, were merely among the tribes who brought furs down the river in the late 1600's.

The fur trade, of course, continued and prospered. Although the great Huron canoe flotillas were no more (also victims of the Iroquois), furs continued to be brought down the river in increasing numbers. Adventurous young Frenchmen, decades later called the "coureurs de bois", were starting to penetrate the Ottawa watershed, wintering and trading with the native bands, with or without the sanction of the colonial government. Two well-known such fellows, Radisson and Groseilliers, made a famous trip down the Iroquois-held Ottawa in 1660 with a load of furs, against prevailing wisdom. It was also against the French government's blessing, and the resulting falling-out lead to the establishment of the Company of Adventurers of England Trading into Hudson's Bay (the Hudson's Bay Company) in 1670. The French sent a flotilla of soldiers under Chevalier de Troyes up the Ottawa in 1686 to capture some of the Company's forts; Troyes' record of this trip is one of the earliest comprehensive studies of the river.

The 18th century saw a growing number of organized trading ventures, based in Montreal or Quebec. The Indian trapper was still the key to this industry, but increasingly the furs were being transported down the Ottawa by French "voyageurs" - hardy rivermen who paddled monster canoes (thirty-six to forty feet in length) and portaged five times their body weight in furs and supplies past each dangerous rapid.

By the end of the century the various trading efforts using the Ottawa had amalgamated in the Northwest Company, with transport lines stretching well beyond the western shore of Lake Superior. Following the transfer of the New World to England in 1763, a large influx of English and Scottish traders caused rapid escalation in the industry, and finally in 1821 the Northwest Company merged with the Hudson's Bay Company. The combined company was to operate trading posts all along the Ottawa Valley.

Logging and Lumbering

As fur-trade canoe traffic on the Ottawa was reaching its peak at the turn of the 19th century, another major Canadian industry was gearing up, inspired by two global military events. America's victory of independence in 1783 meant the end of New England timber for the English navy. Then, when Napoleon closed the Baltic supply route in 1806, England desperately turned to its newly acquired colony for square timber. Coincidentally, in that same year a former New Englander named Philemon Wright brought the first squared-timber raft down the Ottawa, ushering in an industry that today is still Canada's largest exporter and employer.

The Ottawa was fertile territory for the logging industry: seemingly infinite supplies of timber, most notably the revered Canadian white pine, along a massive river with seemingly infinite capacity to transport and (later) process the logs into lumber. The watershed of the Ottawa is extensive, with deeply penetrating tributaries like the Madawaska, the Bonnechere, the Petawawa, and the Mattawa on the south (Ontario) side, plus the Dumoine, the Coulonge, and the Gatineau on the north (Quebec) side. Men would spend long winters in log-shanty work camps up these tributaries, cutting, squaring, and piling the timber in preparation for the spring river-run. Before the last ice was off the river the "sticks" (a euphemism for the 60-foot-long, two-foot-square timbers) were assembled into mind-boggling rafts up to seven acres in size, and thus the product was floated down to Montreal or Quebec.

At first the rafts were broken down and sent piecemeal through the many rapids; by the 1830's the first timber slides were appearing, the first one at Chaudiere Falls, just below Parliament Hill. At the same time the first sawmills were being built, also starting at Ottawa (then called Bytown), as the appetite for sawn lumber developed. Then, with increasing settlement came the growth of steamboating, mostly along the many lakes that characterized much of the Ottawa between violent rapids. The squared-timber industry peaked in mid-century; the sawn-lumber traffic peaked at the dawn of 20th century. Clearly, this was the golden era of the Ottawa.

Hydroelectricity

Eventually, the Europeans lost their taste for furs, and a railway pushed its way deep into the Canadian Shield along the Ottawa route. The river began to be used less for industrial transportation, and more for the recreational boating that is its exclusive use today. (Although, as late as the 1980's it was still possible to see large booms of logs being towed downstream to pulp mills along the lower Ottawa.) In the year 1902, as a sign of things to come, the first hydroelectric dam was built above Parliament Hill at the site of the first timber slide, around the same time that the last of the great squared-timber rafts was sent down the Ottawa.

Over the next six decades hydro dams were built at most of the river's cataracts, and the face of the Ottawa was forever changed. The river had always taken the form of a series of elongated reservoirs separated by sudden drops in elevation, but now the massive, concrete dams flooded and silenced the rapids at these narrow junctions. There are some exceptions; in particular the whitewater near Pembroke, Ontario has endured, today supporting a thriving tourist industry. By the 1970's over 2000 MW of electricity were being pulled from the main river, and another 1300 MW from its tributaries.

The Nuclear Age

As World War II neared its finale, a far more potent source of energy was sought along the banks of the upper Ottawa. A remarkable 24-mile straight stretch of river, known to the voyageurs as "la riviere creuse" (deep river), was selected by scientists for a bold new experiment: the nuclear age had begun. Within sight of 300-foot granite cliffs that once echoed with the song of the voyageur, on land where prehistoric Indians once camped, a new type of nuclear reactor was being constructed.

The key siting requirements were isolation (for security and safety concerns), and a plentiful supply of reactor cooling water. Here again, the Ottawa was ideal: "la riviere creuse" is roughly a mile wide and over 200 feet deep, passing between two well-isolated, largely-uninhabited shorelines (but close enough to the major military base at Petawawa for disguise during the war-time construction phase), and by this period railway access was available at the village of Chalk River.

To operate the expansive supporting laboratory, hundreds of families were housed nearby in a secretive townsite, later named Deep River in honour of its historic location. In time a handful of other research reactors were built, and in 1962 the world's first CANDU power reactor went into operation near Rolphton at the head of "la riviere creuse". The frigid depths of the Ottawa were essential to this enterprise: by the 1970's the combined water usage of the power and research reactors exceeded that of the entire city of Ottawa, and constituted one quarter of the river's total usage.

And so the CANDU reactor, born among the ghosts of ancient and historic Indian civilizations, the European explorers, the voyageurs, the loggers and lumbermen, went on to world admiration and leadership. The story of the Ottawa is not a linear tale. Today, when a nuclear scientist paddles a canoe across a lake above a hydro dam, dodging half-submerged logs decades old, visiting billion-year old rock cliffs where voyageurs "baptized" their rookies, time stands still and history collapses into one inspirational point.

Selected Reading

Peter Hessel, The Algonkin Tribe, Kichesippi Books, Waba, 1987.

Clyde C. Kennedy, The Upper Ottawa Valley, Renfrew County Council, Pembroke, 1970.

Robert Legget, Ottawa Waterway: Gateway to a Continent, University of Toronto Press, Toronto, 1975.

Charlotte Whitton, A Hundred Years A-Fellin', Gillies Brothers Ltd., Braeside, 1943.

GENERAL news

ACEB invites nominations for advisory committees

The Atomic Energy Control Board is accepting nominations for possible appointment to its Advisory Committee on Radiological Protection (ACRP) and the Advisory on Nuclear Safety (ACNS) as openings occur.

Advisory Committee on Radiological Protection

The ACRP was established by the Board in 1979 to give independent advice on health aspects of exposure to ionizing radiation related to activities regulated by the Board, including:

- interpretation and application of internationally agreed recommendations related to radiation protection standards;
- review of the basis for, and the adequacy of, proposed and existing regulatory documents related to radiological protection;
- review and interpretation of new and existing information on biological effects of ionizing radiation that could have a bearing on radiological health protection;
- research and development related to radiological health protection;
- broad radiation protection issues associated with the regulatory activities of the Board.

Advisory Committee on Nuclear Safety

The ACNS was established by the Board in 1980 to give independent advice on any general or generic safety matter associated with nuclear facilities and with other nuclear activities coming under the purview of the Board, including:

- recommendations on proposed and existing regulations, licensing policies, standards, and guides;
- interpretation of new and existing information related to nuclear safety and advice on its relevance to the Board's regulatory function;
- recommendations on nuclear safety-related research and development;
- recommendations on "appropriate" or "acceptable" levels of safety for the various activities regulated by the Board and on means of demonstrating compliance;
- advice on safety issues arising from the regulatory process.

Members are chosen on the basis of their independence and perceived independence, as well as their experience and competence (as acknowledged by their peers) in the variety of engineering, scientific, and legal disciplines needed to address the above activities. It is important that they be able to apply their skills to problems outside their own specific area of expertise. As far as possible, they should reflect the nature and geographical distribution of activities regulated by the Board.

For candidates who are actively involved in regulated aspects of the Board's activities, the extent of their involvement will have to be considered.

Nominating procedures

The nomination should include a resume describing the educational and professional background of the nominee, including any special accomplishments, and include a brief statement of the nominee's particular interest in serving on one of the advisory committees. Nominations should be sent to the Advisory Committee Secretariat, Atomic Energy Control Board, P.O. Box 1046, Station B, Ottawa, Canada, K1P 5S9.

Nominations Sought for CNA Awards

The Canadian Nuclear Association has three awards which it offers annually.

The W.B.Lewis Medal was established in 1973 in honour of Dr. W. B. Lewis, with the purpose, to recognize a Canadian scientist or engineer who has demonstrated a level of technical competence and accomplishment in the field of nuclear science and engineering as exemplified by Dr. W. B. Lewis during his involvement in the Canadian nuclear energy programme, 1946 to 1973.

The Ian McRae Award was established in 1976 in honour of Ian F. McRae, the first president of the CNA and chairman of the Board of Directors of Canadian General Electric Company Ltd. Its purpose is: to honour an individual for outstanding contribution, other than scientific, to nuclear energy in Canada.

The Outstanding Contribution Award was established in 1987: to recognize Canadian-based individuals, organizations or parts of organizations that have made significant contributions in the field of nuclear, either technical or non-technical.

There are two categories; one for individuals and one for organizations or parts of organizations.

Nominations for the 1997 awards will be accepted until April 15, 1997.

For information contact Colin Hunt at the CNA, tel. 416-977-6152 ext 24.

Obituary

We note the passing, on December 28, 1996 of another early member of Canada's nuclear program. **W. R. (Roy) Thomas** gained a PhD on 1953 and joined the metallurgy group at Chalk River in 1955 after spending two years at BISRA in England. Much of his work at CRNL was on zirconium metallurgy. He became head of the Metallury Branch in the early 1960s and subsequently head of the Fuel Engineering Branch. In 1972 he joined AECL's International group and in 1980 began a four year assignment as AECL representative in Japan. He retired to Ottawa in 1984.

One of Canada's nuclear pioneers, **Dr. Henry George (Harry) Thode,** former president of McMaster University, died March 22, 1997, in his 87th year.

Dr. Thode was associated with the Montreal Laboratory during World War II and continued to conduct research related to separation of isotopes, mass spectrometry and nuclear chemistry the rest of his life.

Born in Saskatchewan in 1910, he obtained his B.Sc. and M.Sc. at the University of Saskatchewan (the home of many of Canada's early nuclear scientists and engineers) and a Ph.D. from the University of Chicago. He joined McMaster University, then a college, in 1939 as an assistant professor and remained at the university his entire career, becoming President and Vice-Chancellor from 1961 to 1972. After retiring, he remained active as professor emeritus until his death..

While head of the chemistry department and then vice-president, in the 1950s, he led the movement that resulted in the construction of the McMaster Research Reactor, the only large research reactor outside of the laboratories of Atomic Energy of Canada Limited.

Among his many other roles, he was a member of both the Defence Research Board and of the National Research Council from 1955 to 1961. His association with AECL began with the creation of the company in 1952, as a research consultant, and continued as a member of the Board of Directors from 1966 to 1981. He was awarded several honourary doctorates and was the winner of many awards over his long career.

Dr. Thode was an early member of the Canadian Nuclear Society and continued a member until his passing. He attended most of the annual conferences.

Not only was Harry Thode a recognized scientist, he was a very warm and human individual who led by inspiration. His passing closes one more fragile connection with our past.

Ed. Note: *Jeremy Whitlock, now at AECL Chalk River, gained his Ph.D. at McMaster and was co-chairman of the CNS Golden Horseshoe Branch. He sent these additional thoughts about Dr. H. G. (Harry) Thode.*

I had the pleasure to talk at length with Dr. Thode, a few years back, on the occasion of McMaster Reactor's

35th anniversary (in his office, believe it or not; at 83 years of age he was still coming in to Mac with his briefcase). I was struck then, and still am today, by how little is known about this nuclear pioneer in his own country.

Dr. Thode was part of the famed Montreal Laboratory that interacted with the Manhattan Project and spawned the Canadian nuclear industry. He was the only member of the Montreal Laboratory allowed to actually work from

his own lab away from Montreal. He and his coworkers operated a mass-spectrometer in what is now Hamilton Hall at McMaster University (Hamilton, Ontario), helping to characterize the fission products (mass, abundance, etc.) that were being produced in the early irradiated test fuels. Many of the points on the well-known double-humped fission-product curve were filled in by Harry Thode and his team.

Dr. Thode was a strong proponent of radiation diagnosis and therapy research at McMaster, leading to the establishment of one of Canada's first (if not *the* first) university-based medical physics laboratories, and later the Faculty of Health Sciences, including one of Canada's foremost nuclear medicine departments. In addition, he was largely responsible for the McMaster Nuclear Reactor, the first university reactor (and today still the largest) in the Commonwealth

He was a gentle man who could do wonders with the back of an envelope right up to his last days.

New AECB Board Member

Dr. Kelvin Kenneth Oglivie, president and vice-chancellor of Acadia University, has been appointed as a member of the five-member Atomic energy control Board, effective January 1, 1997.

He replaces William Walker, former vice-president, engineering of B.C. Hydro and Power Authority, who had been a member since 1988.

Dr. Oglivie is a native of Nova Scotia and received two B.Sc. degrees from Acadia before going to Northwestern University in the USA for his PhD. He was in the chemistry department of the University of Manitoba from 1868 to 1974 when he moved to McGill Univeristy. In 1987 he was named as vice-president and professor of chemistry at Acadia University and appointed to his present position in 1993.

Dr. Ogilvie is considered one of Canada's leading experts on biotechnology. He was awarded the E.W.R. Steacie memorail Fellowship in 1982, was named to the Order of Canada in 1991, and received the Manning Prinicpal Award in 1992.

His appointment to the AEC Board is for two years but may be renewed.

The Nuclear Safety and Control Act

Bill C-23, the Nuclear Safety and Control Act, passed its third reading in the House of Commons on February 18th, 1997. This Act will replace that part of the old Atomic Energy Control Act that dealt with the regulation of nuclear energy, and the Atomic Energy Control Board.

The Act is to pass through the Senate, and to be given Royal Assent, which is expected this spring. It is proposed that the Act then be held until the accompanying detailed Regulations are ready.

The Nuclear Safety and Control Act provides for more explicit regulation of nuclear activities, and transforms the Atomic Energy Control Board into the Canadian Nuclear Safety Commission. A full text copy of the Act is available on the Internet at website http://www.parl.ge.ca/bills/government/C-23.

The proposed Regulations will be published in the Canada Gazette for consultation and comment by the industry and the general public. After a set period of time, probably six months, the Regulations will be reviewed in the light of comments received. The Nuclear Safety and Control Act will then be implemented once the Regulations are finalized. It is currently estimated that the NCSA will come into force in mid 1998.

Among the changes associated with the new Act are:

- the powers of inspectors are enshrined in law, and include the ability to order a licensee to take any measure that the inspector considers necessary to protect health, safety, the environment or national security.
- maximum penalties for infractions are increased from $10,000 to $1,000,000 per day, and imprisonment from 2 years to 5 years.
- financial guarantees may be sought from licensees to cover decommissioning costs of nuclear facilities.
- regulations may incorporate, by reference, provincial laws and regulations, and administration and enforcement may be delegated to provincial regulators.
- in hazardous situations, remedial actions can be ordered, with the responsible parties bearing the costs of such actions.

The effect of these changes will become clearer once the new Regulations are published. These new Regulations will replace the following existing Regulations:

- Atomic Energy Control Regulations,
- Uranium and Thorium Mining Regulations,
- Physical Security Regulations,
- Transport Packaging of Radioactive Materials Regulations
- Cost Recovery Regulations

Morgan Brown, chair of the CNS Manitoba Branch presents a cheque for $300 to Dr. Roger Dutton of AECL Whiteshell Laboratories, who is also Director of the Whiteshell Campus of the Deep River Science Academy, summer 1996

CANDU Origins and Evolution Working Party

For the past year or so, a team of AECL Sheridan Park retirees has been engaged, on a volunteer basis, in the production of a series of monographs aimed at recording the "reasons why" the basic features of today's CANDU reactors were adopted in the first place. It is hoped that this documentation of the "reasons why" will provide useful background to the current designers of CANDU reactors who joined the CANDU team after many of the key early design decisions had been taken. The prime source of this information lies in the memory banks of the participating retirees since in earlier times the "reasons why" were, in general, not well recorded. Participants are also provided with access to document files to aid their memory banks plus computer and typing support as needed. Monthly coordination meetings are held at Sheridan Park to keep participants in touch with each other.

About 10 retirees are currently actively involved in the preparation of monographs in their areas of expertise. Fortunately, these areas represent a fairly broad cross-section of CANDU technology. Topics currently include such areas as reactor design, fuel design, fuel handling systems, shielding, chemistry, quality assurance, control & instrumentation, building layout, and safety systems but further input from others who have first-hand knowledge in these or other areas would be greatly welcomed. In particular, the team would welcome input from persons who were involved in the early days of the CANDU program as members of the utility, manufacturing and consulting industries. A number of these companies have already agreed to support such input from their past or current employees.

If you are interested in possibly participating, please call Gord Brooks or Stan Porter at AECL Sheridan Park (905) 822-8252 for further information.

News Briefs

- A crack in a feeder tube at Point Lepreau NGS led to a two month shutdown, extensive technical investigations to determine the cause, and considerable public controversy and political fall-out.

- The Tandem Accelerator Superconducting Cyclotron (TASCC) at Chalk river laboratories will be closed down as of March 31 despite world-wide support. Director John Hardy was unceremoniously escorted from his office, apparently because of his open lobbying to maintain the world-recognized facility.

- At the end of February, la central nucleaire Gentilly 2 was shut down for an extensive SLAR operation (spacer relocation). There is suspected contact of at least one pressure tube with a calandria tube bringing concerns of possible hydriding, which was the cause of the Pickering pressure tube failures of some years ago.

- Cameco Corporation, Canada's largest uranium mining company, reported record profits for 1995 and the Environmental Assessment Panel reviewing the proposed mine for the rich McArthur River deposit recommended approval of the project.

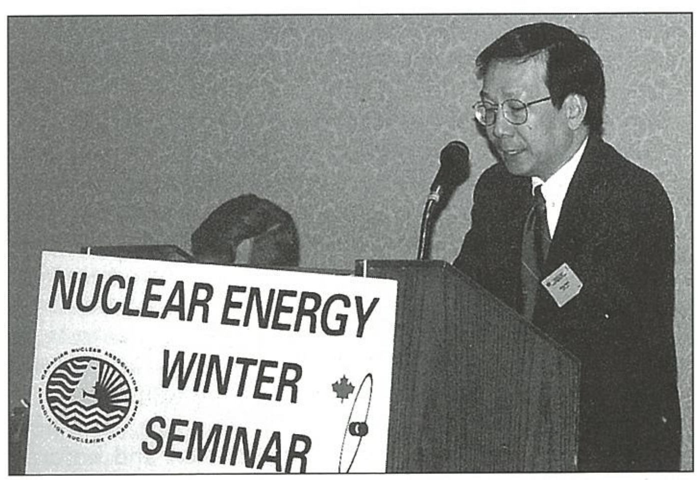
- Wolsong 2 nuclear power plant in Korea achieved criticality on January 27 and completed "Phase B" commissioning by mid February.

- After a two-year review, the Atomic Energy Control Board has issued a statement that "there is no fundamental barrier to CANDU 9 licensability in Canada". Atomic Energy of Canada Limited had contracted AECB to conduct the review to meet requests from potential offshore purchasers that the offered plant be "licensable in the country of origin".

- Cernavoda Unit 1 plant in Romania has operated at near 100 % power since being declared "in service" in early December 1996.

- AECL finalized its contract with the China National Nuclear Corporation for the two CANDU units at Qinshan, effective February 12, 1997.

- The AECB has conducted a "screening" environmental assessment of the proposed two MAPLE reactors to be built at Chalk River by Nordion International for radioisotope production. It concluded that the project would not result in any significant adverse effect on the environment.



CNS President Hong Huynh addresses the CNA / CNS Winter Seminar, February 11, 1997.

CNS news

CNS President Reviews 1996

Ed Note: Following is the text of CNS President Hong Huynh's remarks at the beginning of the CNA/CNS Winter Seminar, 11 February 1997.

Bienvenue au Séminaire de l'Hiver 97

L'année 1996 fut une bonne année pour l'industrie nucléaire au CANADA. La célébration du 25e Anniversaire de la Centrale Nucléaire de Pickering témoigne des progrès extraordinaires de la technologie nucléaire canadienne. Le Canada et l'Ontario on bénéficié du succès commercial de Pickering (tranche 1) pendant ces 25 années. Pickering a fourni de l'électricité à bas coût, des emplois hautement techniques et la prospérité économique associée. Depuis l'entrée en service de la première tranche de Pickering, le 29 juillet 1971, la technologie CANDU s'est étendue au Québec, au Nouveau Brunswick ainsi qu'à d'autres pays. L'année 1996 fut surtout marquée par la vente de 2 réacteurs CANDU 6 à la "China National Nuclear Corporation". Finalement, Nordion International Inc., EACL et notre Gouvernement national ont signé l'accord pour la construction de 2 réacteurs "Maple" pour la production de radioisotopes.

How about the Canadian Nuclear Society?

Membership

Our membership has grown again. as indicated in Figure 1, CNS membership has grown steadily from 528 members in 1990 to over 1,000 members today.

Divisions

As you may know, CNS is organized into 5 divisions and 12 branches. Our 5 technical divisions are established for specific technical areas of interest. These divisions organize conferences, courses and seminars, and arrange for Canadian participation in nuclear related technical meetings and conferences throughout the world.

Table 1 provides the list of major Conferences or Courses organized by CNS in 1996.

The Design and Materials Division organized the 1st International Conference on CANDU Fuel Handling in Toronto, May 96. This Conference was so successful that CNS had a request from the International Atomic Energy Agency (IAEA) to use the material from the conference proceedings as an appendix to the IAEA report (TECDOC) entitled "Advances in Heavy Water Reactors" which will be published in 1997.

The Nuclear Science & Engineering Division organized the 5th International Conference on Simulation Methods in Nuclear Engineering, in Montreal, September 96. More than 25% of the papers were international. From the feedback, conference participants were quite happy with its success, especially since they had the oppoirtunity to hear from Dr. Don Miller, President of the American Nuclear Society. Dr. Miller addressed the ANS vision of Nuclear Science and Technology for the next 50 years and its importance to humankind worldwide.

This Division also organized a CANDU Safety Course, in Mississauga, November 96. The number of attendees, 90, surprised the organizers who had planned for about 40 participants. Despite the large number of attendees, there was a waiting list of 21 persons. Given the response, CNS intends to offer this course again in May 1997.

The Waste Management & Environmental Affairs Division organized with great success the Conference on Deep Geological Disposal of Radioactive Waste, in Winnipeg, September 16-18. There were 130 technical papers and over 270 participants. For the first time, Canadians were a minority among the participants in a CNS Conference.

This Division also organized the Symposium on Biological Impacts of Radiation from Nuclear Facilities on non-human Species, in Ottawa, December 2nd.

The Nuclear Operations Division and the Fuel Technologies Division have been very busy preparing their major Conferences for 1997.

CNS also co-sponsored major Conferences with CNA. In this category, CNS organized with CNA the 1996 annual Conference in Fredericton, June 1996.

CNS also co-sponsored the Student Conference in Ottawa, in March 1996.

Branches

Branches are established on a geographical basis and hold local meetings on issues of interest. Our twelve branches have been quite active. As illustrated in Table 2, about 60 events have been organized in 1996 by these branches.

What about CNS Submissions?

In 1996, three submissions were prepared by CNS.

The first one was in October. CNS submitted comments on the proposed Bill C-23: Nuclear Safety and Control Act and subsequently, participated in oral presentations to the Standing Committee on Natural Resources concerning this Bill.

November 18, CNS submitted comments on the Discussion Paper on Institutional and Financial Arrangements for the Disposal of Radioactive Waste in Canada.

The third one is the 2nd submission to the environmental assessment panel that is reviewing AECL's concept for the disposal of Canada's Nuclear Fuel Waste. In late November 96, CNS participated also in oral presentations on this subject.

International

In 1996, several international agreements were signed.

In March, CNS finalized the agreement with the Romanian Nuclear Energy Association.

In April, CNS finalized the Chinese version of the

Agreement with the Chinese Nuclear Society.

In April, CNS finalized the Russian version of the agreement with the Nuclear Society of Russia.

In June, CNS signed the Agreement with the Nuclear Society of Thailand.

The previous CNS agreement with Euran Nuclear Society (ENS) was obsolete. Some clauses are impractical. At The request of CNS, ENS agreed to renew the proposed agreement.

Qu'arrivera-t-il aux activités en 1997?

Les chapitres locaux continueront à organiser des réunions et des présentations qui intéresseront les membres. Plusieurs présentations ont eu lieu en janvier 97 et d'autres sont planifiées pour les 2 prochains mois.

Le tableau 3 présente les Conféreences et les réunions qui seront organisées en 1997 par nos 5 Divisions. La Conférence des étudiants aura lieu à l'université du Nouveau Brunswick le mois prochain.

La Division "Conception et Matériaux" organisera la 3e Conférence Internationale sur les Générateurs de vapeur et sur les échangeurs, à Toronto, juin 1998.

La Division Sicence et Génie nucléaires organisera le cours sur la Sûreté des Réactuers CANDU de nouveau en mai 1997. De plus, cette Division organisera également un Symposium de simulation en Septembre 97.

La Division Gestion des déchets radioactifs et affaires environnementales considérera d'autres Conférences pour 1998.

La Division de l'Exploitation nucléaire organisera la 4e Conférence sur l'entretien des centrales CANDU, à Toronto, Novembre 1997.

En Septembre 97, la Division Technologie des combusitbles organisera la 5e Conférence sur les Combustibles pour les réacteurs CANDU à Toronto.

En collaboration avec l'Association Nucléaire Canadienne, la SNC organisera la Conférence annuelle, à Toronto, juin 97.

Avec la même collaboration, les préparations sont en cours pour la 11e Conférence nucléaire du bassin pacifique, à Banff, en mai 1998.

Education

In 1997, we would like to put more focus on the Education and Communication Program, especially for students in grades 6 to 9. CNS is very pleased to have Dr. Jerry Cuttler as chair of this important Committee. In collaboration with CNA former Education Committee members, CNS will develop an Education Program for the next 3-5 years.

Thank you for your attention.

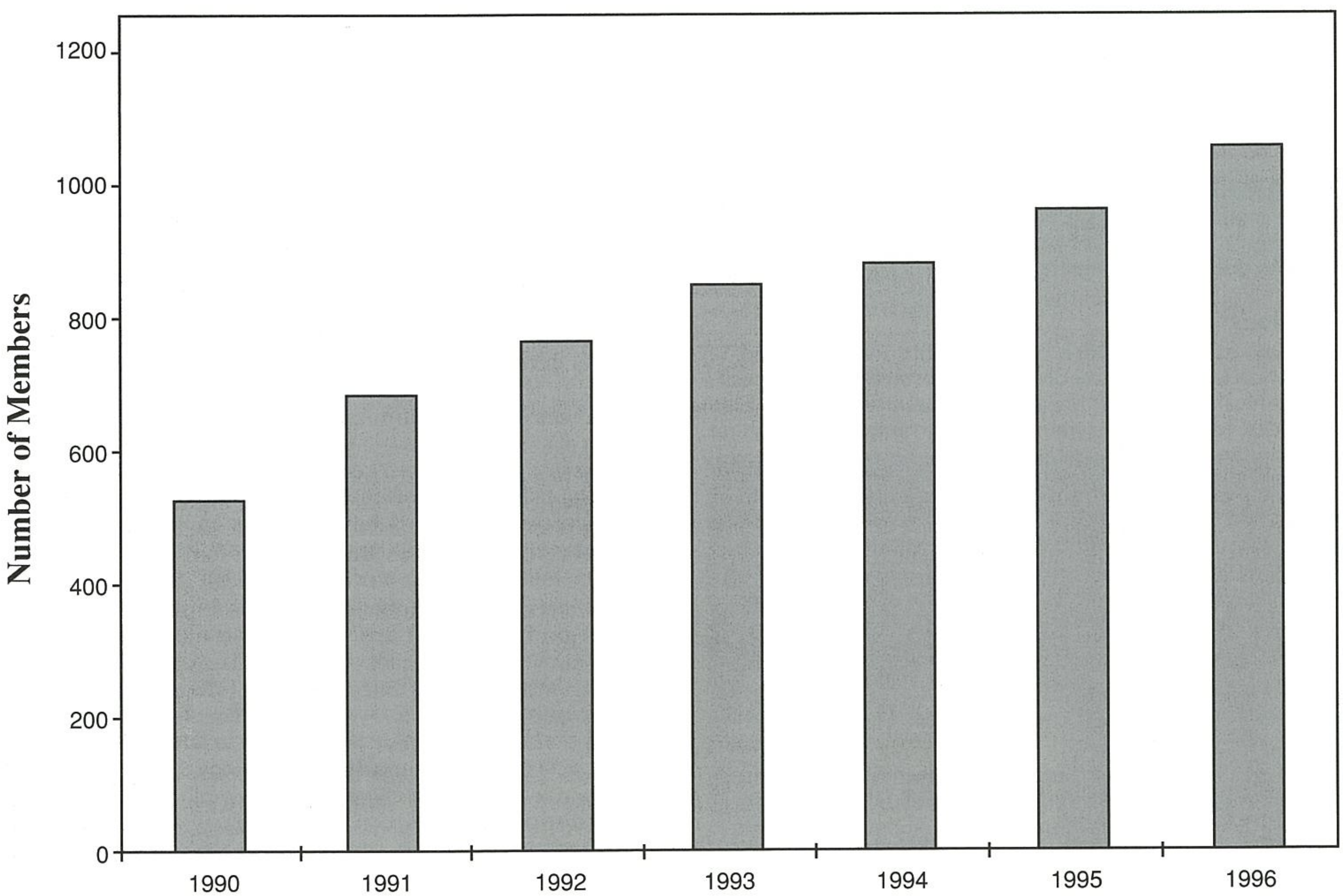


FIGURE 1: Evolution of CNS Membership

Table 1: CNS Conferences/Courses in 1996

	Title	Date	Location
Design and Materials	1st Int'l Conf. on CANDU Fuel Handling	May 13-14 1996	Toronto, Ontario
Nuclear Science & Engineering	5th Int'l Conf. on Simulation	Sept. 8-11 1996	Montréal Québec
	CANDU Safety Course	Nov. 25-27 1996	Mississauga Ontario
Waste Management & Environmental Affairs	Deep Geological Disposal of Radioactive Waste	Sept. 16-18 1996	Winnipeg Manitoba
	Biolog. Impacts of Radiat^{n} from Nucl. Facilities on non human species	December 2 1996	Ottawa Ontario
Nuclear Operations	4th CANDU Maintenance Conference	Nov. 16-18 1996	Toronto Ontario
Fuel Technologies	5th International CANDU Fuel Conference	Sept. 22-24 1996	Toronto Ontario
CNA/CNS	96 CNA/CNS Annual Conf.	June 9-12 1996	Fredericton New Brunswick
CNA/CNS	21st Annual CNA/CNS Student Conf.	March 15-16 1996	Ottawa Ontario

Table 3: CNS Conferences/Courses in 1997

	Title	Date	Location
Design and Materials	3rd Int'l Conf. Steam Generator & Heat Exchanger Conference	June 21-24 1998	Toronto Ontario
Nuclear Science & Engineering	CANDU Safety Course	May, 1997	Mississauga Ontario
	Nuclear Simulation Symposium	Sept. 7-9 1997	Niagara-on-the-Lake Ontario
Waste Management & Environmental Affairs	TBA	1998	
Nuclear Operations	4th CANDU Maintenance Conference	Nov. 16-18 1997	Toronto Ontario
Fuel Technologies	5th International CANDU Fuel Conference	Sept. 22-24 1997	Toronto Ontario
CNA/CNS	97 CNA/CNS Annual Conf.	June 8-11 1997	Toronto Ontario
	11th Pacific Basin Nuclear Conference	May 3-7 1998	Banff Alberta
CNA/CNS	22nd Annual CNA/CNS Student Conf.	March 15-16 1997	Fredericton New Brunswick

CNS Branch Activities

96/01/08	Darlington	Mr. Dan Meraw	Ontario Hydro	"OSART Assignment in Nuclear Power Plant"
96/01/09	Bruce	Mr. Ron Maruska	Ontario Hydro	"Tritium in Water – the New Perspective"
96/01/18	Québec	Dr. Daniel Rozon	École Polytechnique	"Nuclear Energy in Québec: Myths and Reality"
96/01/23	Sheridan Park	Dr. Ken Dormuth	AECL	"Status of the Review of AECL's Nuclear Fuel Waste Disposal Concept"
96/01/23	Ottawa	Mr. Tom Cousins	DRE - Ottawa	"Radiation Exposure In Space"
96/01/30	Ottawa	Mr. Peter Walker	Cdn. Ambassador to Austria	"Reception"
96/02/01	Darlington	Dr. Rick Murphy	AECL	"Tomography Inspection of Boiler Tubes"
96/02/07	Darlington			"Tour of the Ontario Hydro Clarkson Grid Control Centre"
96/02/08	Bruce	Mr. Eric Jelinski	Ontario Hydro	"Hydrogen – the Fuel Source"
96/02/12	Chalk River	Mr. Tom Cousins	DRE - Ottawa	"Radiation Exposure in Space"
96/02/20	Sheridan Park	Dr. Don Dautovich	CFFTP	"Canada as host to ITER – The Next Step in Fusion Energy Development"
96/03/05	Bruce	Mr. Juris Grava	Ontario Hydro	"ITER/MOX/Bruce Unit 2 Update"
96/03/11	Manitoba (at Winnipeg)	Dr. Paul Unrau	AECL	"Genetic Aspects of Radiation Risks"
96/03/12	Manitoba	Dr. Paul Unrau	AECL	"Genetic Aspects of Radiation Risks"

BRANCH NEWS

Ed. Note: *This report on the activities of the various CNS Branches was prepared by Ben Rouben, CNS vice-president / president elect.*

Bruce Branch

The Branch held a seminar on February 6. The guest speaker was Dr. David Whillans, of Eastern Health Physics Lab, Ontario Hydro. The title of the talk was "Health Effects of Radiation".

The Branch has scheduled the following future seminars:

- March 11, Mr. Robert James, ITER Project Manager (Business Development, Finance & Business Systems), will give an "ITER Update" (International Thermonuclear Experimental Reactor)
- April 10, Mr. Mike Haynes, Manager, Health Physics Department, Ontario Hydro, will talk about "Chernobyl - The Human Cost"
- May 6, Mr. Helmut Keil (AECL) will talk about "CANDUs For China"
- June 3, Mr. Peter Stevens-Guille, Manager Used Fuel Disposition, Ontario Hydro, will talk about "CANDU Long-Term Waste Disposition".

Chalk River Branch

On Jan. 16, the Branch presented a seminar on radioisotope production. The guest speaker was Dr. Iain Trevena, Vice-President, Isotope Products, MDS Nordion Inc.

Darlington Branch

On Jan, 16, the Branch held its first noon-hour presentation of 1997. The guest speakers were two former employees of Darlington: Mr Neville Fairclough and Mr. Dennis McQuade. Both are now working as consultants to AECL on the construction and operations aspects of the CANDU-9 reactor. The title of the seminar was "CANDU 9: The Next Generation". Branch Chair Rick Murphy sends the following summary of the talk:

> *"The overflow audience was brought up to date on the progress of CANDU-9 Marketing. All were interested in how the Darlington experiences in construction and commissioning were incorporated into CANDU 9. Neville impressed the audience with the Computer-Aided Design techniques that are planned for construction, saving considerable time over the Darlington Project. Dennis gave examples on how operations surveillance was improved in CANDU 9 based on Darlington's feedback from operations staff. Both were presented with mementoes of the Station for their time in giving us this interesting talk. It was good to see them again."*

On Feb. 6, the Branch presented a noon-time seminar by Mr. Sig Berg, Director, WANO Atlanta Center and by Mr. Rémy Carle, Chairman of WANO. Rick Murphy sends the following summary of the talk:

> *"Rémy Carle spoke first, detailing how WANO came about. Then, Sig Berg described the organizational structure of WANO and its goals. He made the talk relevant to Darlington by explaining what makes good plants good, what keeps them good, and how WANO peer reviews contribute to that process. There were more than 40 in attendance and there were many questions following the talk. We took pictures and there will be an article in our monthly paper."*

The Branch is planning its annual joint dinner evening with the Pickering Branch. The guest speaker will be Ms. Beth MacGillivray, nurse at the Ottawa General Hospital. The dinner is scheduled for Friday, April 11, at Cullen Gardens.

Manitoba Branch

The Branch has scheduled a seminar for March 20 by Dr. Gary Kugler (VP Commercial Operations, AECL). The title of the talk will be "Closing the China CANDU Deal". The Abstract for the talk reads as follows:

> *"It took two years to negotiate the commercial contracts for the sale of two CANDU 6 reactors to China. What went on during those two years? Dr. Kugler will talk about the hurdles, the issues and the final result and benefits that flow from these contracts."*

The Branch is planning for an increased role in the future in education for local school students. To that end, Branch Chair Morgan Brown has offered to continue the Branch's association with local schools in providing speakers on the topic of nuclear energy. Morgan himself gave talks (4 classes) in Beausejour on February 12, and sends the following report on this activity:

> *"Yesterday morning I visited 4 Grade-8 classes at the Ed Schreyer school in Beausejour, speaking to them about things nuclear. Always good fun, and they seemed to enjoy acting out fission! Next Thursday I go to Powerview school. Maybe I'll get them to teach me some French words for the various nuclear terms!"*

Ottawa Branch

Lindsay Patrick has left the Branch Executive. Thanks are due to Lindsay for her volunteer efforts on behalf of the CNS.

On Feb. 7 the Branch held a seminar by Peter Boczar, Director, Fuel and Fuel Cycle Division, AECL. The title of the talk was "Plutonium Fuel in CANDU: The Ultimate Swords-To-Plowshares Opportunity". The seminar Abstract read as follows:

> *"AECL is leading a team that is examining various aspects associated with the use of fuel made from weapons-derived plutonium in CANDU reactors, including technical, economic, safety, licensing, safeguards, security, fabrication, transportation, and eventual disposal of the spent fuel. Such fuel could be used in existing reactors within the current operating and safety envelopes. The fuel would be fabricated close to the source of the plutonium, whether in Russia or the US, and only ready-to-use fuel bundles would be transported to Canada.*
>
> *Canada has a long and respected history as an international peacekeeper. The use of weapons-derived plutonium as fuel in Canadian CANDU reactors would be a natural extension of this role and an outstanding application of Canadian nuclear technology in protecting the environment and contributing to global peace and disarmament."*

Branch Chair Mohamed Lamari sends the following postscriptum to this talk:

> *"The seminar by Peter Boczar was a great success. In spite of the well advertised snow storm the night of*

the event, we had a record 25 attendees, representing industry, universities and government departments. It was a most stimulating talk on the CANDU MOX-fuel initiative. This talk generated a very interesting discussion which lasted more than one hour."

An end-of-the -season dinner meeting is being planned for late April.

Pickering Branch

The Branch held a seminar on March 6. The guest speaker was Mike Haynes, Manager - Health Physics, Ontario Hydro. The title of Mr. Haynes' talk was "Impacts of Chernobyl". The abstract for the talk read as follows:

"The presentation will cover effects of the accident on those exposed at site and in the surrounding environment with particular emphasis on acute radiation syndrome for those involved in immediate actions, thyroid cancer in the public domain, stress and psychological impact on the public, environmental impact, social and economic impact and some attempt to put the consequences in perspective. It will not cover causes of the accident."

The Branch is also planning its annual joint dinner evening with the Darlington Branch. The guest speaker will be Ms. Beth MacGillivray, nurse at the Ottawa General Hospital. The dinner is scheduled for Friday, April 11, at Cullen Gardens.

Québec Branch

The Branch held a seminar on Feb. 13. The guest speaker was Mr. John McManus (AECB, retired) and the topic was Bill C-23 (the new Nuclear Safety and Control Act). Branch Chair Willem Joubert sends the following summary:

"We had the pleasure of receiving Mr. J. McManus on Feb. 13 on behalf of the AECB. Mr. McManus spoke to us about Bill C-23. His presentation was well received. Everyone appreciated his open and energetic style. The meeting took place in AECL's office and lasted more than two hours. Lots of questions were asked on issues of responsibility for utilities, for ourselves and for the regulator. Several Hydro-Québec and ENAQ staff were present."

Sheridan Park Branch

On January 16, the Branch presented a seminar entitled, "We Can Significantly Reduce Nuclear Power Plant Costs". The guest speaker was Mr. Don Shaw, previously Ontario Hydro Project Director for Construction of Darlington NPP, the largest construction project in North America at that time. Mr. Shaw has since joined a training force of the Construction Industry Institute (CII), a group of major owners and constructors with over 800 member-company personnel participating in CII task forces and sharing their experiences. The lessons learned from these experiences are offered in a series of education modules derived by the CII research to the member companies. Currently, Mr. Shaw is a Project Management Consultant with AECL. In the lecture, Mr. Shaw shared his experience in managing construction of nuclear projects, and addressed the use of innovative management and construction methods which can be applied towards achieving CANDU Nuclear Power Plant cost reductions (e.g. for CANDU 9).(See a separate report on Shaw's talk in this issue.)

On January 23, the Branch presented a seminar entitled "Turkey's Plan For Implementation of Nuclear Power" by Dr. Ala Alizadeh, AECL General Manager, Turkey. The Abstract for this talk read as follows:

"For many years, Turkey has been considering the nuclear-power option. In the last few months the activities have led to the issuing of an Invitation to Bid (ITB) for the Akkuyu site. In this CNS seminar, Dr. Alizadeh will discuss the background and present activities in Turkey."

On Feb. 13 the Branch presented a seminar by Mr. Gregory Kane, President of Eagle "I" Nuclear Assistance and Consultant to Ontario Hydro. The seminar was entitled "Regaining Excellence in Nuclear Operation". Mr. Gregory Kane has 33 years experience in nuclear power operations: 9 years in the U.S. Navy Nuclear Power Program and 23 years experience in nuclear power operations with Virginia Power. Mr. Kane was General Manager of North Anna NGS for over 6 years. Under his leadership, the station had excellent INPO ratings and completed its steam-generator-replacement outage in record time. (See a separate report on Kane's talk in this issue.)

For the coming couple of months, the Branch is planning a few more seminars. A seminar has been organized for March 18, with Mr. Ron Page (AECL, retired) as guest speaker. Mr. Page had also worked at Orenda Engines on development testing of components for the Iroquois engine being developed for the Avro Arrow supersonic fighter, and the title of his talk will be "The True Story of the Arrow & Iroquois Engine and Other Avro Aircraft". In May, the Branch will present a seminar by Messrs. P. Gulshani (AECL) and H.M. Hong (Hydro-Québec), who will speak on "Advances in Core Cooling in Absence of Forced Flow in CANDU".

On the educational front, the Branch will be participating in the Peel Region Science Fair (to be held April 5 and 6). The Branch will be donating prizes and volunteers to serve as judges. One of the prizes will be a visit/tour for 10 winners and science teachers to Pickering NGS on a Saturday. The Branch is also planning to help students do projects on nuclear science and technology.

Ted Wessman, of the SP Branch Executive, has been busy planning the Pickering tour, which is being facilitated by Jerry Cuttler and is tentatively scheduled for May 24. The tour agenda is presently as follows:

- Gathering at PNGS Main Area
- Presentation Overview (Brian Thompson)
- Videos, grab back of items, models?
- Tours (break up into 3 groups of 10?)
- Control Room
- Turbine Building
- Spent-Fuel Bay
- Grounds and Nature Preserve
- Gathering For Final Feedback Session
- Overview of Ontario Hydro's policy on communication to the public and to schools
- CNS overview of its activities in the education and communications area
- Teacher opinion/feedback on the tour, needs/wishes on nuclear issues, suggestions on ways the CNS might improve its education activities
- communication/co-operation with the school system

Time in Macedonia

(Regaining Excellence in Nuclear Operation)

by Ric Fluke

The CNS Public Presentation held at Sheridan Park on 13 February, 1997, featured Mr. Gregory Kane, President of Eagle +I+ Nuclear Assistance. He spoke about Pickering's drive to Nuclear Excellence to an attentive audience. Mr. Kane, a consultant to Ontario Hydro, is helping Pickering regain excellence in nuclear operation at Ontario's oldest nuclear power plant.

Mr. Ed Hinchley, who introduced Mr. Kane, made the provocative observation that the Koreans and Chinese are asking AECL why Ontario Hydro has brought in PWR experts to advise them on operating CANDU plants. As Mr. Kane explained, nuclear is a global issue. For example, he noted that Environmental Qualification (EQ) is an issue in the US, and if a problem related to EQ arises there, it is "posted" and all utilities world wide hear about it.

Mr. Kane describes himself as an "operations guy". The plant should be operating correctly with ample regulatory margin. His job to ensure that. He spent 20 years at Virginia Power Co., until he retired as General Manager in 1994 at which time their North Anna plant received a high INPO Peer rating.

It essential to achieve excellence in nuclear operation because competition with combined cycle gas turbines is the single most important threat to nuclear power. Flawless performance is a requirement to continue operating.

Regulatory pressures have escalated around the world, and Mr. Kane noted that the US NRC "Bad-Guy" list is growing. American utilities are paranoid about pleasing the regulator. With the US NRC emphasis on plant inspections, there have been more discoveries. Mr. Kane also noted a change in accountability at nuclear power plants; not too long ago, it was impossible for a utility boss to be fired!

Recently, Shirley Jackson (new head of the US NRC) asked utilities to provide documentation on their design basis. Many utilities could not locate it, or the plant was no longer in a "configuration" based on it. As the regulator becomes more attentive to operating problems, typical responses are:

- Early Shut-Down
- Changeout of People (utilities are good at this, he noted)
- Bring in experts (Mr. Kane admitted this he likes)
- Understand the issues
- Improve Performance

Mr. Kane is optimistic that the "Group-of-Seven" management team brought in recently by Ontario Hydro (Mr. Kane is not one of them) will provide a fresh look at the management of our nuclear operations, and will certainly shake up the status quo.

What does Mr. Kane prescribe for Pickering? His eighteen point recipe for nuclear excellence is not based on rocket science. It seems almost simplistic, a kind of common sense approach, prompting the question "why is it taking so long?"

The Eighteen Points:

1. Have a safe working environment. A cultural aspect which drives behaviour.
2. Have good chemistry. This means mutual trust and open communication.
3. Team Success. Definitely, there is no room for +silo+ mentality.
4. Effective Training.
5. Staff Development. An action plan for succession should be given high priority and there should be two or three persons qualified to perform every task.
6. Fair Discipline. Accountability and consequences must be clear and visible.
7. Accountability. Everyone must understand their role and the role of others.
8. Diagonal Communication. This means up, down and across the line.
9. High Standards. Benchmarking performance against the best.
10. Energy. Motivated people who are energetic. Often, the place of low morale is in a single plant utility that has achieved a top rating, but can be shut down and replaced by gas because it is cheaper to do so.
11. A Questioning Attitude.
12. Well Maintained Plants. Otherwise, operators are challenged and burn out.
13. Respect for Radiation. This is the key difference that sets apart nuclear.
14. Housekeeping. A sign of respect for the plant and the working environment.
15. Outside Input. As Mr. Kane put it, get out of your box and do some thinking.
16. Consistent application of the collective agreement. A polite way of saying "get along", grievances affect the trust people have for each other.
17. Planning. Outage planning should have at least a four year horizon, but there is often no department dedicated to outage planning. He observed at Pickering that resources tend to be "robbed" from an operating unit to help out with a shut down unit, a situation which needs to change.
18. Time in Macedonia

Time in Macedonia indeed! What does that mean? I saw his slide. I heard him say it. It's north of Greece. What could Macedonia have to do with nuclear excellence?Time in Macedonia means going to the source of the problem and talking to the people who know what the problem is until it is fully understood. For example, a worker has one or two hours of "wrench time" during an eight hour shift because of management barriers (procedures, signatures, work authorizations). These are the cumulative layers of control introduced as actions to correct past mistakes.Top rated plants have three hours of wrench time per eight hour shift.

Based on his presentation, there should be no doubt that the management of nuclear operations is in need of adjustment, as Mr. Kane put it, "Attitude equals Behaviour, which equals Performance".

Macedonia indeed!

CNS Supports Centre to study low doses

At its March 7, 1997 meeting the Council of the Canadian Nuclear Society decided to support a proposed Centre for Low Dose Research to be established at the University of Ottawa.

As has been recorded in the CNS Bulletin, the controversy about the effects of low doses of ionizing radiation is growing. Current dose limits, derived from on recommendations of the International Commission on Radiological Protection (ICRP), are based on the hypothesis of linearity between dose and effect, without a threshold. While there is no solid evidence of harmful effects at low dose levels, the ICRP and other international bodies have chosen to take the conservative approach of the linear, no-threshold model for radiation protection purposes. However, the hypothesis has been mis-used to make unfounded and sometimes distorted predictions of consequences, such as the claim that the low levels of radioactive contamination experienced in eastern Europe from the Chernobyl accident of 1986 could lead to hundreds of thousands of deaths. Further, the cost of protecting against very low doses is now considered by many to be unjustified.

The proposed Centre would be under the Institute for Research on Environment and Economy already established at the University of Ottawa. One reason for proposing the Centre at the bilingual U of O is the strong interest of French organizations in the proposal. Electricite de France (EdF) has already committed support and other French organizations are considering doing so.

The CNS Council voted to contribute $10,000 this year and a further $10,000 next year provided the Centre proceeds.

Any member wishing more information on this CNS initiative should contact CNS past-president Jerry Cuttler, tel. 905-823-9060 ext 2556, e-mail: cuttlerj@aecl.ca.

$13 Billion Dollar Training Program

by Ric Fluke

The former Director of Construction of Ontario Hydro's Darlington Nuclear Generating Station, Mr. Don Shaw, made a presentation at the CNS Sheridan Park Branch Lecture Series held at Sheridan Park on 16 January, 1997. His topic: "How to Significantly Reduce the Cost of a Nuclear Power Plant".

Mr. Shaw wasted no time explaining his credibility, since the Darlington construction cost over-run nearly bankrupt Ontario Hydro. So why should we listen to him? Because Ontario Hydro spent $13 billion training him!

Another project of note: the [coal generating station] Lakeview Rehabilitation Project went $60 million over budget and was not completed in time to realize the extra revenue during the winter demand peak. Other examples were cited.

Mr. Shaw's experience was one of many hard lessons that, world-wide, was becoming recognized as a problem. Although scapegoats were sought eagerly, the Construction Industry Institute was formed in the US to gather best practice information and promote good project management. Ontario Hydro joined the CII as the only non-US member in 1983, and Mr. Shaw is a member of one of its task forces on training.

According to Mr. Shaw, the strategic and operational sides of the business must be in synch. In a global market, because the world is getting "smaller" by competitive benchmarking, there is a trend to equalize performance. The winners will be the companies that recognize the role of strategic planning as well as operations, and manage their human resources well. Partnerships, strategic alliances and joint ventures are becoming the norm for major projects. In fact, Mr. Shaw gave a strong warning that Ontario Hydro and AECL stop bidding against each other for the same work.

The key message is this: Project Management must be recognized as a discipline in itself, and the project manager must be part of the management team. Best practices are available from the global body of knowledge derived through benchmarking. Many of these were described in his presentation, and are far reaching, ranging from hard issues (project execution planning, scope management, change control, standardization) to soft issues (succession plans, mentors for the young and rewards for knowledge and experience).

At present, Mr. Shaw is a project management consultant to AECL. His mandate from AECL is to help their design team reduce the life-cycle cost of the CANDU 9, including a 50% reduction in electricity cost.

CNS President Hong Huynh (R) presents a plaque for Prime Minister Jean Chretein to Dr. Rey Paqtakhan, Parliamentary Secretary to the P.M., at the CNA/CNS Winter Seminar February 10, 1997.

Call for 1997 Nominations

DEADLINE FOR ALL AWARDS: 10 APRIL 1997

Fellows of the Canadian Nuclear Society

CNS members who have been designated "Fellows of the Canadian Nuclear Society" belong to a membership category established by the Society in 1993 to denote outstanding merit. The criteria for admission to this membership category include "major and sustained contributions to the sciences and/or professions that relate to the advancement of nuclear technology in Canada." Demonstrated maturity of judgement and breadth of experience, as well as outstanding technical capability, service to the Society, and current CNS membership of at least five years standing, are also requirements for admission.

The newly admitted Fellows are presented with special membership certificates on a suitable occasion at the time of the CNS Annual General Meeting. In the tradition of honorary membership categories of learned societies, CNS Fellows are entitled to add the letters "F.C.N.S." to letters denoting degrees and professional certifications following their names. The maximum number of CNS Fellows at any one time is limited to not more than five per cent of the total membership.

All CNS branches and Technical Divisions are encouraged to forward confidential nominations statements, signed by three members, to the Chairperson of the CNS Honours and Awards Committee. Alternatively, any three CNS members, not necessarily of the same Branch or Division, may together forward a nomination. The nomination statement should include a focused rationale for the nomination, supported by information on the candidate's:

(I) formal education or equivalent,
(ii) work history, professional achievements, publications and patents,
(iii) experience, demonstrated maturity of judgement and contribution to Nuclear Science and Technology and
(iv) oast services to the CNS.

The Honours and Awards Committee will consider the above criteria with weights of 20%, 20%, 25% and 35%, respectively.

The following CNS members are Fellows of the Canadian Nuclear Society:

George R. Howey	1992
John S. Hewitt	1992
Phillip Ross-Ross	1992
John S. Foster	1993
Terrance E. Rummery	1993
Kenneth H. Talbot	1993
Alan Wyatt	1993
Fred Boyd	1994
Stan Hatcher	1994
Daniel Rozon	1994
Michel Ross	1995
Bob Jervis	1995
Dave Torgerson	1995
William I. Midvidy	1996
J. Terry Rogers	1996

CNS Innovative Achievement Award

The Innovative Achievement Award was established by the CNS in 1991. Recipients of the award are specially recognized for

"significant innovative achievement or implementation of new concepts in the nuclear field in Canada."

The award trophy, on which all recipients' names are inscribed, is in the form of an original sculpture showing three figures supporting the Society's logo. Each recipient retains a miniature replica of one figure from the sculpture, as well as a commemorative certificate presented at the Annual Conference of the CNS.

Members of the Society are strongly encouraged to nominate individuals who have made key contributions to a specific innovation. Such contributions should have been to the conceptual design, development or implementation phase of the innovation, or to a combination of these phases.

Nominations letters should be signed by three persons and accompanied by:

(I) a short biography,
(ii) a description of the particular innovative achievement for which the award would be made, and
(iii) a well focused rationale supporting the nomination.

Previous recipients of the CNS Innovative Achievement Award are:

William G. Morison	1991
Wing F. Tao	1991
Andrew J. Stirling	1992
Dé C. Groeneveld	1993
Tom Holden	1994

CNS John S. Hewitt Team Achievement Award

The John S. Hewitt Team Achievement Award was established by the CNS in 1994. This awards aims at recognizing the recipients for

"outstanding team achievements in the introduction or implementation of new concepts or the attainment of difficult goals in the nuclear field in Canada."

The award is in the form of one or more engraved plaques or certificates presented to the members of the team at the Annual Conference of the CNS.

Members of the Society are strongly encouraged to nominate teams of generally not more than five persons who have made key contributions to the introduction or the implementation of new concepts or the attainment of difficult goals in the nuclear fields in Canada. Such contributions should have been to the conceptual, design, development or implementation phase leading to the achievement, or to a combination of these phases.

Nomination letters should be signed by three persons and accompanied by:

(I) a short biography of each team member,
(ii) a description of the particular achievement for which an award would be made, and
(iii) a well focused rationale supporting the nomination.

Recipients of the John S. Hewitt Team Achievement Award are:

Don McLean, Bill Morgan and Mitch Ohta, for the development and demonstration of dry spent fuel storage 1995

Charles A. Kittmer, Roger J. Joynes and Larry W. Green, for the development and demonstration of micro-sampling of pressure tubes 1996

Staff of Point Lepreau G.S., for excellence in nuclear power plant operation and exceptional sustained plant performance 1996

Please send your nominations in confidence, before 10 April 1997, to:

The Chair
CNS Honours and Awards Committee
144 Front Street West, suite 475
Toronto, Ontario M5J 2L7

1997 / 1998 Slate of Officers Announced

The nominating committee of the Canadian Nuclear Society presents the following slate of officers for the 1997 - 1998 term of office.

Further nominations or requests for information should be sent to Dr. Jerry Cuttler, current Past-president: tel. 905-823-9060 ext 2556; FAX 905-855-9470; e-mail: cuttlerj@aecl.ca.

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Jan Popovic	AECL
Duke Segel	Independent
Harold Smith	Independent

CNS signs Agreement with Israel Nuclear Society

On February 17, 1997, Ezra Elias, president of the Israel Nuclear Society signed an "Agreement of Cooperation" between his society and the Canadian Nuclear Society.

The initiative for such an agreement began with a visit of past-president Jerry Cuttler to Israel in 1995.

Similar to other cooperation agreements the two societies agree to forward copies of publications (such as the CNS Bulletin), to provide free registration to national conferences for two official delegates of the other society, to encourage interchange between members and to inform each other of meetings, conferences and other events.

The agreement is for five years and is renewable.

The CNS now has agreements with the American Nuclear Society, the European Nuclear Society (representing all of the nuclear societies in Europe), the Russian Nuclear Society, the Korean Nuclear Society, the Nuclear Society of Thailand, the Finnish Nuclear Society, and others.

BOOK Review

Enriching Experiences

Reviewed by Fred Boyd

by Clarence Hardy
Glen Haven Publishing, Peakhurst, NSW, Australia

It is likely that few Canadians, even in the nuclear field, were aware that Australia pursued a significant progam of research and development in uranium enrichment from the mid 1960s to the mid 1980s. This slim (175 pages) paperback provides an account of that work by someone who was very much involved.

The R and D at the Australian Atomic Energy Commission focussed on two enrichment techniques - laser and centrifuge. From 1973 to 1978 there was a joint program between Australia and Japan which concluded that a centrifuge plant was feasible This was followed by The Uranium Enrichment Study Group from 1976 to 1983 which involved considered collaboration with the enrichment firm URENCO.

Following a change of government in 1983 the program was closed down, and, three years later the AAEC was dismantled.

BOOK Review

Regulations for the Safe Transport of Radioactive Materials - 1996 edition

International Atomic Energy Agency

This is the latest revision of these internationally accepted standards for transport packaging which serve as the basis for national regulations such as the AECB's Transport Packaging of Radioactive materials Regulations.

New Members Since 1996

Parva Alavi
Dilaver Arguner
Duncan Barber
Mike Bell
Zoran Bilanovic
Lisa Bortolussi
David John Boyer
Andrew John Brewer
David Buss
Sammy Chin
Michel Couture
Stuart Craig
Dejan Dikic
Brian duQuesnay
Ash Elkhodary
Hazen Fan
Jim Gauld
George Gavrus
Cezar Georgescu
Bing Gu
Hisham Hasanein
Donald MacGregor Hayter
Zhang He
Marcel Heming
Mark Hersey
Chris Heysel
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Jon Kiteley
Michael Klein
Andrew Kung
Pierre J.B. Lahaie
Mark Lake
Bruce A. Lange
Rhonda Lee Taryn Lawton
Albert Garland Lee
Yakov Liner
Guilio Manni
Sergio Martire
Mani Mathew
Alan Melnyk
Mark R. Milburn
Camber Muir
Yuksel Parlatan
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Neil Poulsen
Soedijono Prawirosoehardjo
Yueming Mike Qiao
Tarek Ramadan
Jeff Ramsay
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Doug Stevens
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Eduardo Tam
Huang Tang
Sunil Tantirige
Jack Vecchiarelli
Alexandre N. Viktorov
Lori Walters
George Weitzenfeld
Tony Williams
Ben Wong
Jae-Kyung Yi
Elias Zariffeh
Yahui Zhuang

DEADLINE

The deadline for the spring 1997 (Vol. 18, No. 2) issue of the *CNS Bulletin* will be May 15 for publication about the end of May.

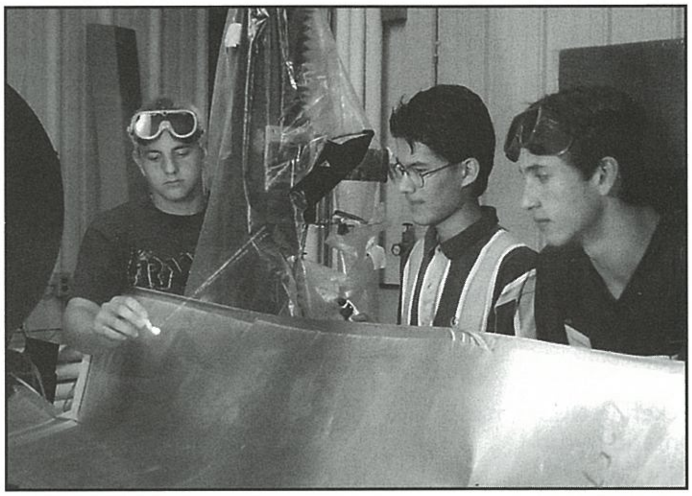
CANADIAN NUCLEAR SOCIETY
bulletin
DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

Deep River Science Academy Gets Real This Summer

by Louise Young, Principal, DRSA Whiteshell Campus

Summer is not far away and many students want to do something about their future, want to make a difference in their life, in their world, and they want to do it now! Well it could happen to them this summer.

Every summer, for the past ten years, the Deep River Science Academy (DRSA) has introduced bright, capable high school students from across Canada to the real world of science and engineering. This year the Academy is promoting a summer of Real Science, Real Research and Real Experience. Students who are seriously into science can discover what scientific work is all about. They can spend the summer doing real real research and making a contribution to leading edge science and engineering. As well, they can expand their minds with tutorials, workshops and informal lectures by distinguished scientists plus have fun with their peers in summer recreational activities.



High-school students Philip Hauser (Dunnville, ON), Steve Kudaka (Thompson, MB) and Scott Cressman (Winnipeg, MB) display the Phase Doppler Anemometer, they operated at Whiteshell Laboratories as part of the Deep River Science Academy's summer program. The emphasis is on hands-on experimentation, rather than on learning from textbooks.

For about six weeks, 80 students from across Canada are assigned to projects that are part of current research programs at some of Canada's leading laboratories. They actively participate in research in biology, chemistry, physics, engineering and environmental science. The experience is unique in Canada and possibly the world. In recent summers, students have worked on a wide variety of projects, from genetic engineering to sub-atomic particle accelerators, from robotics to environmental science.

It's a summer that could help students sort out any confusion about their future. Maybe they're not sure what branch of science they would like to pursue. Is research where they belong or is engineering more their style? The Academy presents students with a realistic view of science and how it fits in today's world, helping them to develop a focus for possible university studies. Many students say it was their Academy experience that sparked their enthusiasm for a particular area of science and helped steer them into the right courses. Eighty-five percent of Academy "grads" go on to major in science or engineering at university. In 1994, the Academy received an award from the Conference Board of Canada for "Excellence in Business Education Partnerships". In 1995, it received the "Prime Minister's Award for Teaching Excellence in Science, Technology and Mathematics". In 1996, it received the Manitoba Sustainable Development Award for "Excellence in Education".

Students spend the weekdays working in pairs, under the guidance of an undergraduate-level university tutor, who is employed by the Academy as a research assistant at their lab. Their work is supervised by a laboratory staff researcher who is a professional scientist of engineer. Students live in residence under adult supervision for the entire six weeks. They eat together, enjoy varied recreational activities together and pursue common intellectual interests, which often produce lasting friendships among students. Coming from across Canada and from varied backgrounds, they all share a love of science. This summer could count towards their academic standing. Not only can it fast-track students toward their high-school diploma but it can strengthen their resumé. Imagine being able to say that you spent a summer doing research in one of Canada's top labs!

The Deep River Science Academy is a nonprofit, private, coeducational school with campuses at Deep River, Ontario, Pinawa, Manitoba; and Kelowna, British Columbia. It is run by volunteer boards of directors at both national and campus levels, including distinguished scientists and engineers. Each campus is staffed by qualified professional educators.

Students aged 15 to 18, who have competed at least one science course at or beyond Grade 10 level may apply. Generous financial and other support from government and industry sponsors covers nearly half the costs of each session. The $3,700 fee covers tuition, accommodation for six weeks, meals, recreational activities and transportation between campus facilities. Generous bursaries are available from the Academy Bursary Fund, for eligible applicants. Many students are also successful in obtaining bursary support from local sources once they have been accepted at The Academy. The Canadian Nuclear Society has contributed in the past to the DRSA Bursary Fund.

The Academy attracts more applicants than it accept, so apply early. There is an application fee of $50.00 that is refunded only if the applicant not selected by the Academy. Application forms are available from science teachers and guidance councillors across Canada or by calling 1-800-760-DRSA.

CALENDAR

1997

April 6 - 11
4th International Conference on Methods and Applications of Radioanalytical Chemistry
Kailua-Kona, Hawaii
contact: Sylvie Caron
CNS office
Toronto, ON
Tel: 416-977-7620 ext. 18
Fax: 416-979-8356

April 14 - 18
5th International Topical Meeting on Nuclear Thermal Hydraulics, Operations and Safety
Beijing, China
contact: Ken Talbot
Pickering NGD Ontario
Ontario Hydro
Pickering, ON
Tel: 905-839-1151

May 4 - 9
Course on Two-Phase Flow and Heat Transfer
contact: Dr. M. Shoukri
McMaster University
Hamilton, Ontario
Tel: 905-525-9140 ext. 24288
Fax: 905-528-4952

May 12 - 14
CANDU Reactor Safety Course
Sheridan Park, Mississauga, ON
contact: V.S. Krishnan or G. Harvel
AECL
Mississauga, ON
Tel: 905-823-9060
ext. 4555 or 4543
Fax: 905-823-2584
e-mail: krishnanv@aecl.ca

May 13 - 16
CRPA Annual Conference
Victoria, BC
contact: Wayne Greene
Vancouver, BC
Tel: 604-822-4218
Fax: 604-822-6650
e-mail: greene@safety.ubc.ca

June 1 - 5
ANS Annual Meeting
Orlando, Florida
contact: American Nuclear Society
La Grange Park, Illinois
Tel: 708-352-6611
Fax: 708-352-6464

June 1 - 5
Embedded Meeting 2nd International Topical Meeting on Advanced Reactors Safety
contact: Dr. Rusi Taleyarkhan
Oak Ridge, TN
Tel: 423-576-4735
Fax: 423-574-0740
e-mail:
zrt@cosmaill.ornl.gov

June 8 - 11
CNA/CNS Annual Conference
Toronto, ON
contact: Sylvie Caron
CNA/CNS
Toronto, ON
Tel: 416-977-7620 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

August 17 - 21
International Conference on Neutron Scattering
Toronto, ON
contact: Dr. W.B.L. Buyers
AECL Chalk River Lab.
Chalk River, ON
Tel: 613-584-3311
Fax 613-584-1849

Sept. 7 - 9
Nuclear Simulation Symposium
Niagara-on-the-Lake, ON
contact: V.S. Kirshnan
AECL
Mississauga, Ontario
Tel: 905-823-9060 ext. 4555
Fax: 905-823-2584
e-mail: krishnanv@aecl.ca

September 22 - 24
5th International CANDU Fuel Conference
Toronto, ON
contact: Dr. J. Lau
AECL - SP
Mississauga, ON
Tel: 905-823-9060 ext. 4531

September 30 - October 4
NURETH-8, 8th International Topical meeting on Nuclear Reactor Thermal Hydraulics
Kyoto, Japan
contact: Dr. Jerry Cuttler
AECL - Sh. Pk.
Mississauga, ON
Tel: 905-823-9060 ext. 2556
Fax: 905-855-0945
e-mail: cuttlerj@spkb.candu.aecl.ca

October 5 - 10 — **Global '97 International Conference on Future Nuclear Systems**
Yokohama, Japan
contact: Dr. Jerry Cuttler
AECL - Sh. Pk.
Mississauga, ON
Tel: 905-823-9060 ext. 2556
Fax: 905-855-0945
e-mail: cuttlerj@spkb.candu.aecl.ca

October 6 - 10 — **International Conference on Mathematical Methods and Supercomputing for Nuclear Applications**
Saratoga Springs, NY
contact: Dr. M.R. Mendelson
Knolls Atomic Power Lab
Schenectady, N.Y.
Tel: 518-395-7046
Fax: 518-395-4422

October 14 - 18 — **2nd International Conference on Isotopes**
Sydney, Australia
contact: Dr. Clarence Hardy
Australian Nuclear Assoc.
Peakhurst, NSW, Australia
Tel: 61-2-9579-6193
Fax: 61-2-9570-6473
e-mail:
cjhardy@ozemail.com.au

November 16 - 20 — **ANS Fall Meeting**
Albuquerque, New Mexico
contact: American Nuclear Society
La Grange Park, Illinois
Tel: 708-352-6611
Fax: 708-352-6464

November 16 - 18 — **4th CANDU Maintenance Conference**
Toronto, ON
contact: D. Iafrate
Ontario Hydro
Darlington, ON
Tel: 905-697-7496

Dec. 8 - 10 — **International Conference on Plant Life Management**
Prague, Czech Republic
contact: Alan Wagstaff
c/o Nuclear Engineering International
Dartford, Kent, England
Fax: 44-1322-273748

1998

May 3 - 7 — **11th Pacific Basin Nuclear Conference**
Banff, Alberta
contact: Ed Price
AECL Sheridan
Tel: 905-823-9060 ext. 3066
Tel: 613-584-3311
Fax: 613-584-1849
e-mail: pricee@candu.aecl.ca

June 7 - 11 — **ANS Annual Meeting**
Nashville, Tennessee
contact: American Nuclear Society
La Grange Park, Illinois
Tel: 708-352-6611
Fax: 708-352-6464

June 14 - 18 — **12th International Symposium Zirconium in the Nuclear Industry**
Toronto, Ontario
contact: G.D. Moan
AECL
Mississauga, ON
Tel: 905-823-9060
Ext. 3232

June 21 - 24 — **3rd CNS International Steam Generator and Heat Exchanger Conference**
Toronto, Ontario
contact: R. Tapping
AECL-CRL
Chalk River, ON
Tel: 613-584-8811
Ext. 3219

October 18 - 20 — **CNS Annual Conference**
TBD
contact: Sylvie Caron
CNS Office
Toronto, ON
Tel: 416-977-7620 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

October ?? — **3rd International Conference on Containment Design and Operation**
Toronto, Ontario
contact: K. Weaver
Ontario Hydro
Toronto, ON
Tel: 416-592-4050

There's no Unemployment Insurance for Elephants

by Walter Keyes

Editor's Note: *Walter Keyes, a consultant and chairman of the CNS Saskatchewan has been on a number of assignments in Bangkok, Thailand, assisting authorities there in public communication on nuclear energy. The following article arises from his observations of the changing society in that country.*

Unemployment is usually seen as a human condition and yet it may be the greatest single threat to the survival of Asian elephants. Much like the Buffalo became extinct in North American in a few short years, life for the Asian elephant is not very promising these days. Rapidly industrializing economies of Asian countries has resulted in declining elephant populations. This is a cause of concern for many people who have revered the role of the elephant in their societies.

For centuries, the elephant was an integral part of the economy of many Asian societies. It was a wonderful worker, lifting heavy loads, dragging logs and other goods and providing power in a form that could be easily used in many pre-industrial societies. The elephant industry as one time was very large, tens if not hundreds of thousands of elephants were employed. Their utility was high because they lived up to 70 years and once trained were wonderfully adaptable to a variety of needs.

Kings rode on royal elephants, armies fought on elephants, expeditions to foreign lands were carried by elephants. Elephants became symbols of strength and integrity. Architecture, literature and religion all reflected the significance of this wonderful animal in various ways.

Elephants were trained from early stages by their Mahout, and the tradition was that the young Mahout and the young elephant would grow up together. Like a marriage, the Mahout and the elephant became a team and rarely did either switch partners. Because of the elephants long life, it was common that the Mahouts son would become an understudy and take over his fathers duties when he could no longer work or died. In this manner the elephant was an integral part of family life, usually spanning two or more generations.

With diminishing uses of elephants today there are no longer incomes being generated to feed and care for them. They have stopped earning a living for their Mahout and in the process they have stopped earning a living for themselves. Mahouts have been reduced to poverty by the elephants high food requirements and today these once noble beasts are reduced to performing in ceremonial affairs. A few work the streets of major cities like Bangkok as walking billboards and tourist attractions, begging for food and providing photo ops for tourists.

Sadly, there is no unemployment insurance for elephants!

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Toronto	Stephen Rogers	(416) 592-2799

CNS WEB Page

For information on CNS activities and other links

http://www.science.mcmaster.ca/cns/www/cns/cns.html

PBNC'98

11th Pacific Basin Nuclear Conference Banff, Canada, May 3-7, 1998

International Co-operation in the Pacific Rim for the 21st Century

Call for Abstracts: 1997 May 1

Final Paper Deadline: 1997 November 15

Session Topics

- Financing and Economics
- Safety Practices and Regulation
- Environmental and Resource Sustainability
- Operations and Maintenance
- Industry Infrastructure
- Public Information and Understanding
- Nuclear Technology

Call for Papers

Submit abstracts and papers to:

PBNC'98 Technical Program Committee
567 Roy Street, Pembroke, Ontario K8A 6R6 Canada
Tel: 613 732-7068 Fax: 613 732-3386 E-mail: confer@pbnc98.com

For more information see the conference website, http://www.pbnc98.com.

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