CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

JUNE 2011 JUIN VOL. 32, NO.2

- Fukushima Disaster
- 32nd CNS Annual Conference
- W.B. Lewis Lecture
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Extreme Natural Disasters and Nuclear Safety

International standards are ever improving, but what happens when these modern requirements are assessed against older reactors that were designed to the standards deemed acceptable at the time? What happens when new evidence, possibly from archaeological analysis, that some natural disaster occurred 1000 years ago which, if repeated, could leave a nuclear power plant vulnerable? The International Atomic Energy Agency published standards to be used by member states. Their guide on site evaluation (NS-R-3), released in 2003, requires the collection and evaluation of not only historical data, but prehistoric information as well, including the potential for earthquakes and tsunamis. In the wake of the disaster in Japan, the IAEA standards are undergoing world scrutiny and will likely be made even more stringent.

Earthquakes, tsunamis, floods, forest fires and other natural phenomena are hazards for which safety standards apply to the design of any nuclear power plant, and have been in place since commercial nuclear power plants have been licensed in Canada. The magnitudes of these hazards, however, are determined from records applicable to the site, and the time period over which the records are considered. Records kept over the last 150 years or so are generally reliable and are used in computer modelling and risk assessments. However, how reliable is information dating back 3000 years?

The designers of the Fukushima stations in Japan built a tsunami protection wall based on reliable records since the 1896 Meiji-Sanriku earthquake in that region. (That earthquake was about a magnitude 7.2, but the ensuing tsunami was over 30 m, which killed 20 - 30 thousand people). The height of a tsunami can vary depending on the nature of the submarine earthquake (not all earthquakes produce a tsunami), coastal conditions and the slope of the seabed. Based on records since 1896 and analysis of the Fukushima Dai-ichi site, a seawall was built to 5.7 m to protect the plant, which is situated on an elevation of about 10 m above sea-level. The tsunami on March 11 was between 14 – 15 m when it reached the coast, inundating the site with at least 4 m of water, which flooded rooms with electrical equipment and the emergency backup diesel generators. This event was said to have been considered "sotegai" or "outside our imagination".

But if prehistoric information was considered, a different outcome may have played out. As recently as 2001 palaeontologists (K. Minoura et al., J. Natural Disaster Science, V 23, No. 2, 2001, pp83-88) reported analysis of sand samples showing that a major tsunami reached about 4 km inland (compared to about 2 km on March 11). This was the 869 A.D. Jogan tsunami deposit. Other evidence of major tsunamis, based on sand analysis, date back to about 500 B.C. The researchers estimated a major earthquake/tsunami return frequency of one per thousand years.

Nuclear regulators in all countries have required nuclear operators to review plant safety following the Fukushima catastrophe, and nuclear safety was an agenda item at the recent G8 Summit in France.

On the 25th anniversary of the Chernobyl catastrophe, Russian President Dmitry Medvedev called for binding international standards for all nuclear power plants in the world. There is no doubt, however, that the global nuclear industry will be much different in the future, with more regulatory transparency and possibly pop visits by an IAEA mission to examine compliance in any member country.

In This Issue

By far the worst nuclear disaster since Chernobyl, much attention has been on the events at **Fukushima Dai-ichi** and this is the lead topic in this issue of the Bulletin. There is a lay-person's description of the events as well as excerpts from the **IAEA Mission** to Japan. In a related essay by **Dr. Michael Edwards**, the psychology of the nuclear realm is discussed.

Another very successful Annual Conference to place in June at Niagara Falls, and we have an extensive report, as well as the Honours and Awards announced at the conference. The W.B. Lewis Lecture, presented by **William (Bill) Pilkington** is included as has been the tradition for many years.

The technical paper is a review of the Enhance CANDU 6 (EC6) and its features. In the CNS News Section is the report on the Annual General Meeting and statements from the outgoing and incoming Presidents. And last but never least; **Jeremy Whitlock's Endpoint** will rock you!

Comments and letters are always welcome!

From The Publisher

This issue of the *CNS Bulletin* was delayed by a number of anticipated events, such as the 2011 CNS Annual Conference, and by more unexpected problems and challenges. Perhaps there was some serendipity in the latter as it allowed us to include at least a short note on the sale of Atomic Energy of Canada Limited's engineering arm and for me to offer some comments.

2011 Annual Conference

The Society's premiere annual event, the Annual Conference, was held in Niagara Falls, Ontario, the first week of June. That was the first time it had been held there and it proved quite popular, drawing a near record attendance for an excellent program. Given the way things turned out later in the month it was almost ironic that the newly appointed (mid May) Minister of Natural Resources Canada (NRCan) accepted a last moment invitation to attend the opening reception on the Sunday evening even though he had to rush back to Ottawa for sessions beginning the next morning. It is unlikely his audience that evening suspected that in less than three weeks he would have concluded a deal to sell AECL's CANDU division.

Embedded in the Annual Conference were three important events: a workshop of the North American Young Generation Nuclear (NA-YGN) Canadian group; the presentation of the W.B. Lewis lecture; and the Nuclear Achievement Awards ceremony. And, immediately after the conference the newly formed Nuclear Education and Outreach group held an all-day event. *(All of these are reported in this issue of the* Bulletin.*)*

W. B. Lewis lecture

The series of W. B. Lewis lectures was created by the Advisory Committee on Research and Development to the AECL Board of Directors to recognize the major contribution of Dr. W. Bennett Lewis to the Canadian nuclear program and especially the development of the CANDU reactor design. Lewis was appointed head of research at the Chalk River Nuclear Laboratories in 1946 and became Vice-President of AECL when it was formed in 1952 retiring in 1973.

The lecture is given annually, in recent years during the CNS Annual Conference. This year the Advisory Committee chose William Pilkington, a senior vice-president of AECL and, most recently, the head of the team that conducted the remarkable repairs to the NRU reactor over 2009 – 2010. His presentation is reprinted in this issue of the *Bulletin.*

Honours and Awards

It is important to recognize those who have made significant contributions to society. In our nuclear community we do it through the Nuclear Achievement Awards. These are managed through a joint task force of the CNS and the Canadian Nuclear Association. For several years the awards have been presented during the CNS Annual Conference. A report on this year's awards is included in this issue.

The Canadian Nuclear Scene

In 2009 Prime Minister Harper declared that the government should not be in the nuclear business and essentially stopped AECL from entering into any new ventures. The company was put up for sale. Initially there were indications of interest by domestic and foreign companies but nothing ensued and the AECL CANDU division was left in a state of limbo.

Admittedly AECL's track record had not been strong. The MAPLE project to produce isotopes had been cancelled a couple of years earlier after seven years of what many observers believed was very poor project management exacerbated by an intransigent regulator. The retubing of the Point Lepreau reactor fell into a similar pattern with the calandria tube replacement program continuing long after it was recognized that rolled joints were faulty.

Now, less than two months after winning a majority position in the House of Commons, the government (should I say Prime Minister) decided the time had come to divest at least part of AECL. By this time there was only one bidder and what some would call a "sweetheart deal" was agreed with SNC Lavalin for its subsidiary, CANDU Energy, to take over AECL's CANDU division.

At least, the government is respecting its obligations in the several refurbishment projects in which it is involved and has agreed to have SNC Lavalin complete those tasks under contract. So, for its $15 million investment, CANDU Energy will immediately have a stream of income.

From a personal viewpoint the most troubling aspect is the 800 or more highly skilled individuals who will be dismissed from AECL Sheridan Park.

For the time being the Chalk River Laboratory has been spared, although the government has stated it is looking for a new form of management. Perhaps that will be similar to the Department of Energy laboratories in the USA which are managed under contract with large commercial organizations or universities. From personal observations it is unclear to me if that will result in better programs and more accountability or not.

All that leaves the future very cloudy for all those working in the Canadian program or studying to join it.

Fred Boyd

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~ Cover Photo ~

Aerial view of the damaged Fukushima Dai-ichi Nuclear Power Station.

Photo source: Tokyo Electric Power Company (TEPCO)

CANADIAN NUCLEAR SOCIETY

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ISSN 0714-7074

The *Bulletin of the Canadian Nuclear Society* is published four times a year by:

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Toronto, Ontario, Canada, M5G 2K4
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Le Bulletin SNC *est l'organe d'information de la Société Nucléaire Canadienne.*

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La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. Les frais d'adhésion par année de calendrier pour nouveaux membres sont 82.40$, et 48.41$ pour retraités.

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The comments and opinions in the CNS Bulletin are those of the authors or of the editor and not necessarily those of the Canadian Nuclear Society. Unsigned articles can be attributed to the editor.

Printed by The Vincent Press Ltd., Peterborough, ON

Canada Post Publication Agreement #1722751

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The Great East Japan Earthquake by RIC FLUKE

More formally called the Tohoku-Chihou-Taiheiyo-Oki Earthquake of March 11, 2011, it was the ensuing tsunami that caused the most death and destruction to the north-east coastal region of Japan. It is also what caused the multiple meltdowns at Fukushima Dai-ichi. Reactor Unit 1, ironically, was scheduled to be permanently shut down for decommissioning just two weeks later.

The Fukushima Dai-ichi nuclear power plant has a tsunami protection barrier designed for the worst recorded tsunami in that area since 1896 – to a height of 5.7 m. The plant itself is on an elevated grade of about 10 m. The tsunami, reported to be 14-15 m, caused inundation of the entire site with at least four metres of seawater. The seawater flooded the turbine building and damaged electrical equipment including the emergency diesel generators, leaving the entire six-unit nuclear power plan without any source of AC power, known as the "station blackout scenario".

There are numerous reports available on-line at various sites. The Japanese Government report is frank and forthcoming on the causes and the lessons learned, and the IAEA Mission report is in-depth and well presented, not only as a factual account of the events but as a unified source of the conclusions and lessons learned. Photos of the catastrophe are available at the TEPCO web site: http://www.tepco.co.jp/en/index-e.html

In this edition of the Bulletin there is a "layman's" description of CANDU and BWR design in terms of the fundamental safety principles – Control, Cool and Contain as well as a description of how these principles were met, or not met at Fukushima Dai-ichi. Also, an excerpt from the IAEA Expert Mission is included.

We "technocrats" sometimes forget about the human aspects of a nuclear disaster. An essay by Dr. Michael Edwards is included entitled "Psychology, Philosophy and Nuclear Science".

Other references to the events appear throughout this edition.

The Fukushima Dai-ichi Catastrophe by RIC FLUKE

This article explains the accident at Fukushima Dai-ichi in terms of the fundamental safety principles and how these principles are achieved by design. Design differences between the reactors at Fukushima and a typical CANDU reactor are explained to illustrate how the safety principles can be achieved by different reactor designs. How these principles fared at Fukushima is explained. A detailed chronology of events is given in a separate table.

Safety Principles

In nuclear reactor safety there are three fundamental principles, known as the three C's – CONTROL, COOL, CONTAIN. They apply to all reactor types, although the means to achieve them may differ.

CONTROL refers to criticality and the chain reaction. It is the balancing of reactivity, where a positive insertion of reactivity (by removing neutron absorbing material) increases the fission rate and a negative reactivity insertion (adding a neutron absorber) will slow down the fission rate. In an emergency, control is achieved by a rapid insertion of neutron absorbing material which shuts down the reactor. Rapid insertion of "negative reactivity" is achieved by fast-acting shut-off rods and "poison" injection using a soluble neutron absorbing chemical such as boron or gadolinium. Shut-off rods and poison injection systems are always poised and act independently of the normal reactor control systems.

COOL refers to the removal of residual decay heat produced by decaying fission products in the fuel. About 1 second after shutdown, decay heat is about 6% of full power. It is about 1% of full power after a day, and about 0.5% after a week. Although small compared to full power, it still amounts to a lot of heat. An 800 MW (electric) reactor produces about 2500 MW of thermal power, so one day after shutdown it is still producing about 25 MW of heat that must be removed from the fuel. There are three components needed to maintain cooling: (1) inventory of coolant to absorb heat from the fuel; (2) flow to transport the heated coolant away from the fuel; and, (3) a heat sink to absorb the heat from the coolant.

CONTAIN refers to the containment of radioactive material in case of fuel failures.

Confirmation of these three safety principles requires the capability to MONITOR safety critical parameters.

Safety Principles and Reactor Design

The reactors at Fukushima are boiling water reactors (BWR) built by General Electric. Figure 1 is an illustration of a typical BWR station. The water is boiled in the reactor and the steam drives the turbine to generate electricity. The turbine exhaust

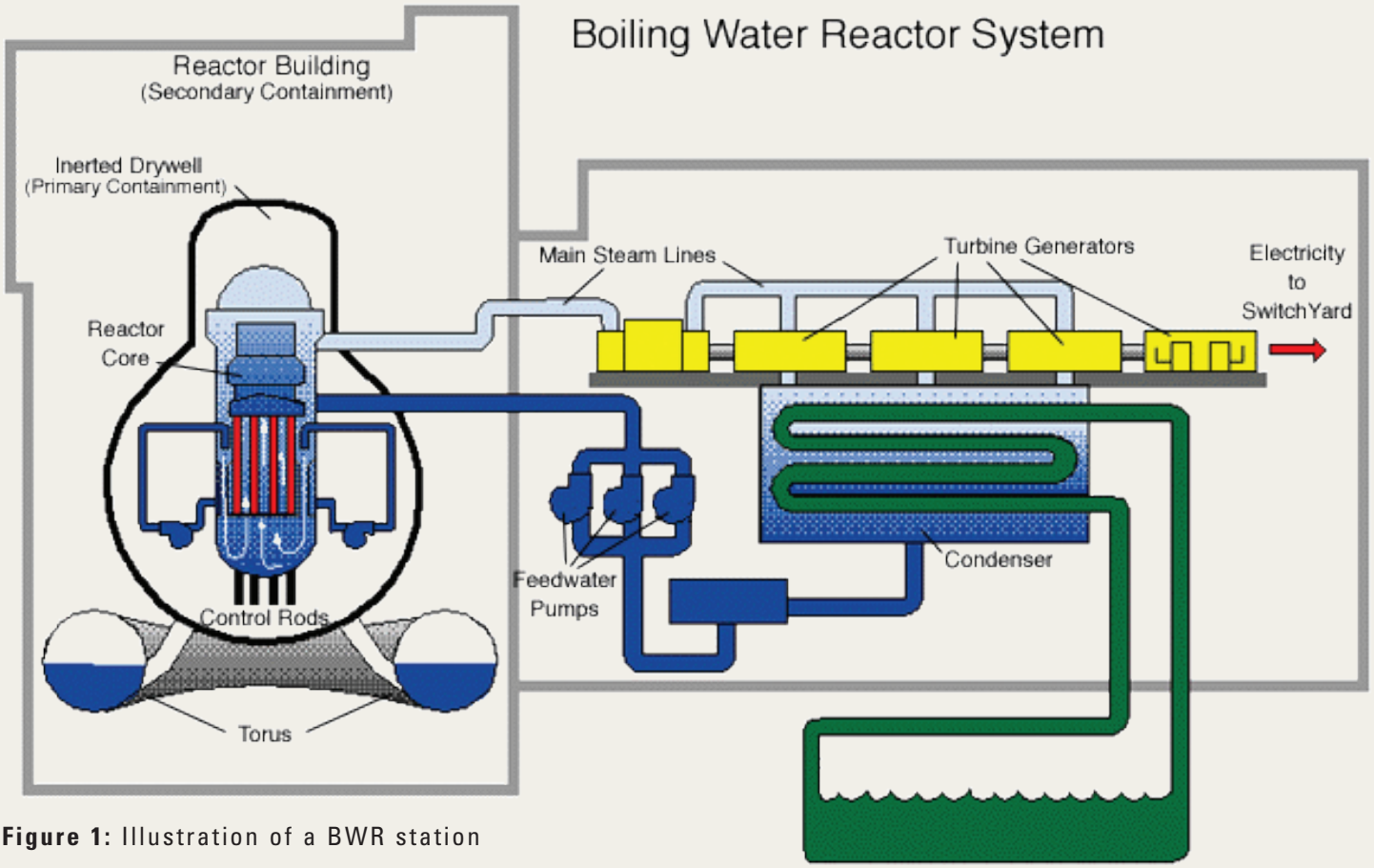

Figure 1: Illustration of a BWR station

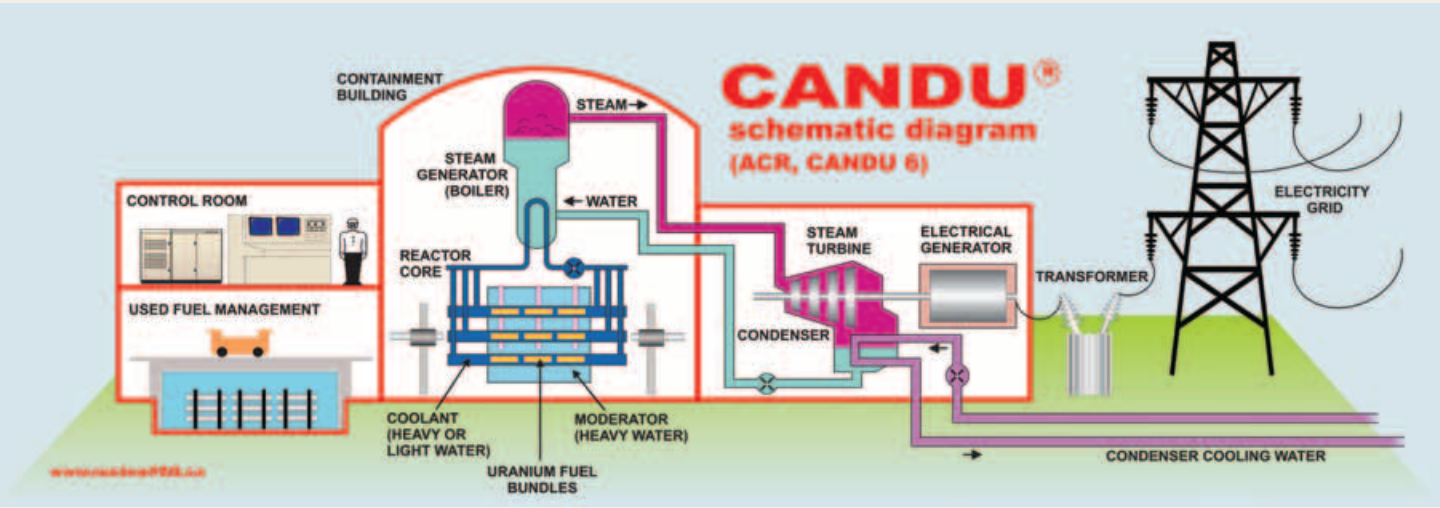

Figure 2: Illustration of a CANDU station

is cooled in a condenser and returned to the reactor. This is known as a direct cycle.

The CANDU reactor is a pressurized heavy water reactor (PHWR). Figure 2 is an illustration of a typical CANDU station. The pressurized heated heavy water is transferred to a steam generator (primary side) where it is cooled by a secondary side circuit and returned to the reactor. The primary side heat in the steam generator is transferred to the secondary side (ordinary water) through boiler tubes and the steam from the secondary side of the steam generator drives the turbine to generate electricity. The turbine exhaust is cooled in a condenser and returned to the steam generator feed. This is known as an indirect cycle.

Design differences are further elaborated in the discussion of how these designs meet the fundamental safety principles.

Principle #1: CONTROL

Reactor shutdown is achieved by two independent systems: shut-off rods and poison injection. In a CANDU, shut-off rods are dropped into the core from the top of the

reactor. For poison injection, gadolinium is injected into the moderator (which is in a low-pressure calandria vessel).

Because the BWR has moisture separators near the top of the reactor pressure vessel, the shut-off rods are pushed up from the bottom of the reactor. For poison injection, boron is injected into the coolant (which is also the moderator) inside the reactor pressure vessel.

Principle #2: COOL

CANDU

In a CANDU reactor the heavy water coolant transports heat from the fuel to the steam generators with the aid of circulating pumps. The steam generators provide the heat sink for the reactor fuel. The reactor heat sink is maintained by the secondary side, where steam drives the turbine and is then cooled by the condenser and returned to the steam generator by feedwater pumps. Because pumps are used, electricity is needed which is obtained from the grid. If the grid fails (loss of class IV power) then the reactor shuts down, the turbine trips and auxiliary pumps are used powered by standby diesel generators (class III power). The steam generators continue to provide the heat sink while flow is by natural circulation (thermosyphoning), which is effective because the heat sink is located at a higher elevation than the reactor. Because the turbine has tripped, steam from the steam generators can by-pass the turbine and the condenser continues to cool the secondary side.

If both class IV and class III power is lost, the auxiliary pumps stop and the steam from the steam generator can no longer be cooled by the condenser. In that case, steam is rejected to atmosphere by opening relief valves and the reactor continues to be cooled by natural circulation. However, the inventory of secondary side water is limited and will eventually need to be replenished. This is achieved by adding water to the secondary side from storage tanks and in the longer term by firewater connections using diesel driven pumps.

DC storage batteries are used to provide control of air-actuated valves and for monitoring safety critical parameters.

BWR

In a BWR, water removes heat from the fuel by boiling inside the reactor pressure vessel and the steam is cooled by the turbine condenser and returned to the reactor with feed pumps. If the grid fails the reactor will trip, the turbine will trip and the steam line to the turbine will be isolated. The turbine condenser is at a lower elevation than the reactor and hence natural circulation to use that heat sink is not possible.

Standby generators provide power to run the residual heat removal system. If both the grid and the standby generators are lost, then another cooling system is used that does not use AC power. The BWR has a Reactor Core Isolation Cooling (RCIC) system. Steam from the reactor drives a turbine and the exhaust from the turbine is cooled in the "torus" shaped water-filled suppression chamber. The suppression chamber is known as the "wet well" of the primary containment vessel. The turbine drives a pump to inject cold water into the reactor from either a storage tank or from the suppression chamber. The RCIC is operated by air-actuated valves using battery-operated solenoid valves.

Unit 1 at Fukushima Dai-ichi is an earlier version BWR and does not have a RCIC system. Instead it has an Isolation Condenser (IC) where steam from the reactor is condensed in a water tank located above the reactor so that natural circulation is established. The steam condenses and is returned by natural circulation to the reactor. The water in the condenser tank will boil and needs to be replenished by either the storage tank or via a firewater line using a diesel driven pump.

When the suppression chamber reaches saturation (boiling point) the RCIC is no longer effective. Diesel driven pumps can continue to inject water by sprays in the reactor pressure vessel and both the suppression chamber and the "dry well" space of the primary containment vessel. If sprays are not effective the reactor pressure will increase. In that case, safety relief valves can open (manually or on high pressure) to lower the reactor pressure by relieving steam into the primary containment vessel, either the suppression chamber or the dry well. As the primary containment pressure increases, its pressure can be relieved by venting to atmosphere via the standby gas treatment system.

Cooling spent fuel

In both a CANDU and BWR, used fuel is stored in a cooling pool. The pool is cooled by heat exchangers, but if all AC power is lost there is no immediate concern because the massive volume of water would take several days to heat up to saturation, after which make-up water can be added from various sources including firewater systems using diesel driven pumps. In a CANDU the pool is located below grade level in a separate building (with confinement and filtered exhaust), whereas in a BWR it is located inside the secondary containment of the reactor building above the elevation of the reactor fuel.

Principle #3: CONTAIN

In both a CANDU and BWR, radioactive fission products are contained in the fuel encased in a sheath made of zirconium. The fuel assemblies are contained in fuel channels (CANDU) or the reactor vessel (BWR).

A CANDU reactor is contained in a robust steel-lined concrete containment system. The BWR reactor is contained in a primary containment vessel (PCV) which is filled with nitrogen. The PCV is steel lined and surrounded by concrete. The PCV is surrounded by a secondary containment system as shown in Figure 3.

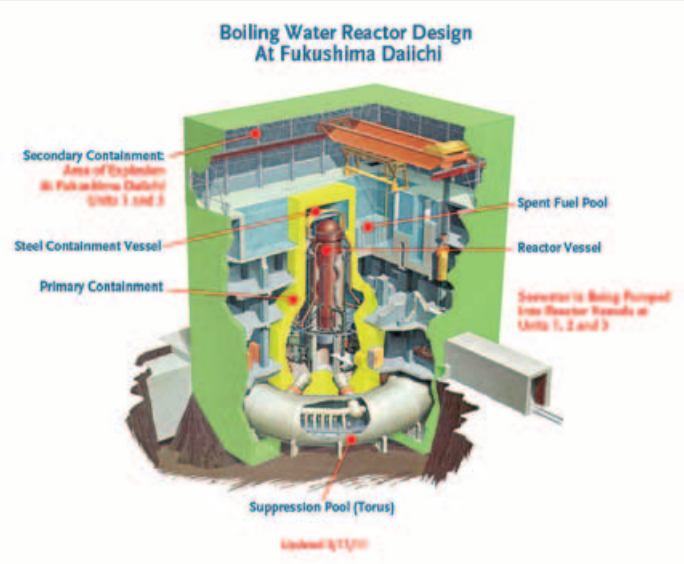

Figure 3: Illustration of the BWR design at Fukushima

What Happened at Fukushima

Principle 1: CONTROL

All three operating reactors, units 1, 2 and 3 shut down automatically at the time of the earthquake on March 11. The other three reactors were already shut down for inspection and maintenance. The fuel in Unit 4 was removed from the reactor pressure vessel (RPV) in November 2010, and was stored in the spent fuel pool of that unit.

The magnitude 9 earthquake, although devastating in several respects, did not cause damage that would impair any of the safety functions. In fact, the ground motion measured during the quake did not exceed what the reactor building and safety equipment were capable of withstanding[1].

Principle 2: COOL

Cooling requires three things: water inventory to absorb heat from the fuel, flow to transport the heat away from the fuel, and a heat sink to cool the water inventory. If any one of these quantities is lost, cooling is not achieved and fuel melting can occur.

Reactors

The earthquake caused a loss of off-site AC power due to transmission line damage. With all units shut down, on-sight AC power was only available from emergency diesel generators which started automatically. Reactor cooling and emergency functions operated properly. However, nearly an hour later, the tsunami inundated the site (4-5 m of seawater) and the emergency diesel generators were flooded and failed to function thereafter. There was no lighting in the control room and some monitoring capability was lost.

Main cooling and emergency cooling systems were unavailable due to lack of AC power. Reactor cooling at Unit 1 used the Isolation Condenser (IC) while Units 2 and 3 were cooled by the Reactor Core Isolation Cooling System (RCIC) System with battery backup.

Cooling was achieved intermittently for various times in each of units 1, 2 and 3. The IC and the RCIC Systems would trip automatically on RPV high water level, and were manually restarted when the water level dropped. Unfortunately, the control room was dark and level gauges were not reliable under these conditions. The operators did their best to keep the RCICS running, but unfortunately the battery backup drained on units 1 and 3, and the system failed on unit 2 for unknown reasons.

Cooling was achieved in part by pressure relief valves in the RPV, but this caused the water level to drop. By lining up fire trucks, freshwater was injected into the core through a fire suppression system until the source was depleted, and seawater was then used having no other alternative. A source of freshwater was brought to the site several days later and replaced the seawater injection.

Fire pumps have a limited pressure, and with the increasing pressure of the RPV it was difficult to confirm that water was being injected into the core. The water level measurement indicated that the level was below the Top of the Active Fuel (TAF). It was subsequently learned by replacing the level gauge that the water level was much lower than previously indicated.

The principle of COOL was not sustained and core melting occurred.

Without core cooling, the water level in the core dropped by boiling, which exposed the fuel to steam. The zirconium cladding absorbs oxygen from the steam thereby producing hydrogen gas. This is an exothermic chemical reaction which further heats the fuel to melting temperatures. The fuel melts from the top and drops to the bottom of the RPV like "candles burning". Without further measures, the molten fuel would eventually melt through the bottom of the RPV and fall into the Dry-Well of the Primary Containment System.

Spent Fuel Pools

Although no cooling was available, due to the large mass of water in the spent fuel pool there was no immediate concern for cooling. Because the Unit 4 pool had recently discharged fuel (removed from the RPV in November 2010), it could reach boiling temperature within a week. This assumes that there are no leaks caused by the earthquake. When a hydrogen explosion in Unit 4 occurred concerns arose that there had been exposed fuel in the fuel pool and the emergency priority changed to injecting seawater into the spent fuel pools.

Because the top of the building was removed by

1 Although the plant was designed to a magnitude 8.3 earthquake, it is the nature of ground motion that determines the damage, measured in "g" units for the horizontal and vertical directions. The measured "g" force was within the capability of the reactor building

Figure 4: A reverse flow check valve could have prevented the explosion in Unit 4.

the explosion, helicopters were use to drop seawater from large buckets into the fuel pool. This was very much a hit and miss operation, mostly miss, and was abandoned. Fire trucks could not get the sprays high enough to reach the fuel pool, nor were the police riot squad sprays. A concrete pump truck was brought to the site because it has a very long articulated "hose", and was successful in directing seawater into the pool.

It was several weeks later that it was confirmed that the fuel in the Unit 4 pool was not damaged. Both water samples from the pool and a visual inspection from camera mounted on a small remote controlled helicopter confirmed that the pool and its fuel were intact and not damaged. TEPCO has speculated that the cause of the explosion in Unit 4 was hydrogen released from adjacent Unit 3, which shares a common ventilation system. By reverse flow through the ventilation ducts into the Unit 4 building, hydrogen accumulated and exploded.

Principle 3: CONTAIN

The Primary Containment Vessels (PCV) of Units 1, 2 and 3 remained intact during the earthquake. However, due to deteriorating fuel cooling conditions and low water levels and rising pressure in the RPV, steam was vented through the safety relief valves of the RPV into the PCV. Without means for condensing this steam, the pressure was rising in the PCV. TEPCO decided to vent

Figure 5: Result of the first hydrogen explosion in Unit 1 on March 12.

this steam in a controlled manner through a filtered ventilation system, so as to prevent the PCV pressure from exceeding its design value. Unfortunately, there were long delays in initiating the venting because it required a manual local valve opening and radiation fields were too high to access the valves. An alternate source of compressed air had to be lined up in order to open the valves using an air actuator. This delay is thought to have caused more hydrogen to accumulate in the PCV. When the vent valves were finally opened in unit 1, it is likely that the ventilation system failed due to high PCV pressure or inability to throttle the steam discharge. As a result, the steam (and hydrogen) entered the secondary containment which had no means to discharge the gas. The hydrogen exploded (on March 12), blowing out the panels on the roof and upper side of the reactor building. Although the PCV remained intact, radioactive material in the vented steam was released due to the explosion. With the secondary containment now breached, there was a possibility of releases from the open spent fuel pool if fuel melting were to occur there.

This same situation was repeated in unit 3, where venting began on March 13 and the explosion occurred on March 14.

Unit 2 behaved differently during the intentional venting of the PCV. On March 15 a hydrogen explosion occurred in the location of the Wet-Well with apparent damage assumed because its pressure dropped quickly to atmospheric. TEPCO reported "slight damage" to the secondary containment, and later cut an opening in the top as a precaution to allow hydrogen to be vented so as to prevent another explosion. (It is not known if the previous failure of the RCIC System is related to this different behaviour in unit 2.)

The explosion in unit 4 (later in the day on March 15) was a complete surprise since the reactor was defueled. Further, it was unlikely that the pool would have evapo-

Figure 6: Massive damage at Unit 3 following the hydrogen explosion on March 14.

rated enough water to uncover the spent fuel. This led to widespread speculation that fuel was exposed, possibly due to leakage caused by the earthquake. Radioactive material was released during the explosion, supporting the notion that fuel damage had occurred. However, as previously mentioned, TEPCO now believes the hydrogen and radioactive material was actually from Unit 3 which shares a common ventilation system.

The PCV in Unit 1 (and probably Unit 3) remained intact, but the secondary containment was breached by the hydrogen explosions and radioactive material vented from the PCV was released. In Unit 2, it appears that the suppression chamber of the PCV was damaged by a hydrogen explosion, although in that Unit the secondary containment appears to have remained intact. As a precaution, TEPCO removed a panel from the building to allow any further hydrogen to vent and avoid another explosion.

Although the amount released is about 10% of the release at Chernobyl, the CONTAIN principle was not fully achieved.

Recovery

In the days following the earthquake and tsunami recovery efforts were at times curtailed by aftershocks of magnitude 7 and more tsunami warnings. Following the hydrogen explosions high radiation required temporary evacuations of the site. There was no lighting in the control room and several safety critical parameters could not be monitored.

Working conditions at the site were unthinkable. Workers were literally in the dark surrounded by debris everywhere, open man-holes and trenches and high radiation. After the storage batteries were depleted workers used car batteries to enable solenoids to operate valves or to take a measurement. The supply of compressed air needed to manipulate valves was depleted and alternate source had to be to lined up.

The decision to inject seawater into the RPVs and spent fuel pools was timely and prudent (given that there was no alternative and it was by then accepted that the reactors would never be restarted). Unfortunately the water injection created a long term problem – too much contaminated water with no place to store it. Contaminated seawater leaked into the Pacific Ocean with more than the allowable amount of radioactivity. A large storage facility is being built on-site to store, treat and decontaminate the some 100,000 tons of water.

In addition to portable diesel generators brought to the site a new power line was brought in to restart electrical systems. This required removing seawater from the basements, cable trenches and injection of freshwater into the reactors to displace the seawater.

A filtration system was installed in the reactor building of unit 1 to clean the air. This allowed entry into the building, and TEPCO was able to replace the RPV level gauge. Levels were lower than had been indicated previously, suggesting that more fuel had melted than previously thought. On Unit 2, because the reactor building was not seriously damaged, it had a relative humidity of close to 100% which prevented entry. It was thought that evaporation from the open spent fuel pool with a relatively air-tight secondary containment was the cause. However, after cooling the pool the humidity remained high, indicating that the source may be water from the damaged wet well in Unit 2.

TEPCO is constructing a cover for the damaged reactor buildings that will minimize future release of radioactive material. Efforts are continuing to restore operation of cooling systems to place the reactors in a safe cold shutdown condition.

Mass balance calculations based on volumes of water injected, production of steam, and revised water level measurements in the RPV suggest that water was leaking into the PCV. This could have been through failed gaskets, or through a hole in the vessel bottom caused by fuel melting through it. Analysis of the events using the computer codes MAAP and MELCORE indicate severe fuel damage and melting in all three units.

Perspective

The accident at Fukushima Dai-ichi is unprecedented. The accident at Three Mile Island in 1979 was a result of institutional failure which resulted in poor communication, poor operator training and human

errors. The accident at Chernobyl in 1986 was a result of a lack of safety culture in which rules were not followed. There have been significant improvements in safety culture since those two accidents and global sharing of operating experience and lessons learned. The accident at Fukushima, however, was different.

The accident was initiated by a rare natural disaster. It is known that the Fukushima site is located within 200 km of a geological fault where the Pacific plate is subducting below the Japan Trench. However, a magnitude 9 earthquake is rare and the height of the tsunami was underestimated when the seawall was built. In fact, the seawall crumbled under the force of the massive tsunami.

The impact on the industry world-wide will be significant, and indeed there will be more strict standards adopted internationally to place more emphasis on protecting against extreme natural phenomena including combined phenomena. There will be a stronger emphasis on examining not just historical records when considering a site, but the pre-historic events as well. Issues such as emergency back-up electric generators, fuel and water supplies, storage battery capacity, hardened emergency command centres, communication and emergency preparedness are obvious concerns that nuclear plant operators are addressing.

Present Situation

With more than 100,000 tons of contaminated water on site, three damaged reactors that need to be stabilized and three damaged reactor buildings with open tops, there is still a lot of work to be done. The following was provided in a recent CNSC Press Release.

Tokyo Electric Power Company (TEPCO) restarted its new reactor core cooling system after fixing faults in the piping. The utility has been forced to suspend the system's operations several times due a series of leaks. The cooling system is designed to decontaminate radioactive wastewater accumulating at the plant and reuse the treated water to cool the reactor cores. TEPCO says the system holds the key to stabilizing the reactors and reducing the amount of contaminated water.

TEPCO has begun injecting nitrogen in the Unit 2 primary containment vessel to prevent hydrogen explosions. The utility believes hydrogen may be building up inside the containment vessel. Nitrogen is already being injected into the Unit 1 containment vessel and there are plans to do the same with Unit 3, however high radiation readings are delaying the installation of the necessary piping. The injection of nitrogen into Unit 1, 2 and 3 containment vessels is scheduled to be complete by July 17.

TEPCO is now assembling the frame for a polyester shield over the Unit 1 reactor building that will prevent the spread of radioactive material. One of the largest cranes in Japan, capable of lifting 750 tons, has been brought to the site. It will first be used to remove debris from the roof of the Unit 1 reactor building. Then it will be used to lift into place the steel frame and polyester fibre panels, which are being pre-assembled offsite at the Onahama Port, some 50 kilometres away. TEPCO hopes to complete assembly of the cover by late September.

JAIF reports that Minister of Economy, Trade and Industry (METI), Banri Kaieda, released a statement June 18 calling for Japan's nuclear power plants to restart operations, saying that nuclear power was one of the four important elements in the country's energy future. After the March 11 accident at the Fukushima Daiichi NPS, METI directed Japan's electric power utilities to take emergency safety measures for the loss of all AC power supplies due to a tsunami. Based on its review of information provided by the utilities and on-site inspections of each nuclear power plant, METI has since confirmed that the required measures are being steadily implemented.

The IAEA Ministerial Conference on Nuclear Safety concluded five days of deliberations in Vienna on June 24. The Conference was called to identify lessons learned from the nuclear accident at the Fukushima Daiichi Nuclear Power Station in Japan that was caused by an earthquake and tsunami on March 11. The Canadian delegation was headed by Karen Ellis, Associate Deputy Minister, Natural Resources Canada, and included senior officials from CNSC, Health Canada and DFAIT, as well as from industry (AECL and OPG). The Conference adopted a Ministerial Declaration (PDF - http://iaea.org/Publications/Documents/Infcircs/2011/infcirc821.pdf) that called for improvements in global nuclear safety. The Ministers asked the Director General to prepare a draft Action Plan to address issues related to nuclear safety, emergency preparedness and response and radiation protection of people and the environment, as well as the international legal framework. For his part, IAEA Director General Yukiya Amano presented five proposals: (1) to strengthen nuclear Safety Standards; (2) to systematically review the safety of all nuclear power plants; (3) to enhance the effectiveness of national nuclear regulatory bodies and ensure their independence; (4) to strengthen the global emergency preparedness and response system; and (5) to expand the Agency's role in receiving and disseminating information.

The Action Plan will be submitted to the IAEA Board of Governors and General Conference in September 2011 for endorsement by Member States.

Report on the IAEA Mission

"IAEA International Fact Finding Expert Mission of the Fukushima Dai-Ichi NPP Accident Following the Great East Japan Earthquake and Tsunami"

On 24 May – 2 June 2011, an IAEA Expert Mission visited the site of Fukushima Dai-ichi and other nuclear power plants in the east of Japan to gather facts and to obtain lessons learned. Their 162 page report is posted on the IAEA website. The report includes 15 conclusions and 16 lessons. Below is an excerpt from the report.

One of the more significant conclusions relates to the cause of the accident:

Conclusion 3: There were insufficient defence-in-depth provisions for tsunami hazards. In particular:

- although tsunami hazards were considered both in the site evaluation and the design of the Fukushima Dai-ichi NPP as described during the meetings and the expected tsunami height was increased to 5.7 m (without changing the licensing documents) after 2002, the tsunami hazard was underestimated;
- thus, considering that in reality a 'dry site' was not provided for these operating NPPs, the additional protective measures taken as result of the evaluation conducted after 2002 were not sufficient to cope with the high tsunami run up values and all associated hazardous phenomena (hydrodynamic forces and dynamic impact of large debris with high energy);
- moreover, those additional protective measures were not reviewed and approved by the regulatory authority;
- because failures of structures, systems and components (SSCs) when subjected to floods are generally not incremental, the plants were not able to withstand the consequences of tsunami heights greater than those estimated leading to cliff edge effects; and
- severe accident management provisions were not adequate to cope with multiple plant failures.

In response to the accident there has been a call for international standards and regulations. This is reflected in Conclusion 11:

- There is a need to consider the periodic alignment of national regulations and guidance to internationally established standards and guidance for inclusion in particular of new lessons learned from global experiences of the impact of external hazards.

The lessons learned are as follows:

Lesson 1: There is a need to ensure that in considering external natural hazards:

- the siting and design of nuclear plants should include sufficient protection against infrequent and complex combinations of external events and these should be considered in the plant safety analysis – specifically those that can cause site flooding and which may have longer term impacts;
- plant layout should be based on maintaining a 'dry site concept', where practicable, as a defence-in-depth measure against site flooding as well as physical separation and diversity of critical safety systems;
- common cause failure should be particularly considered for multiple unit sites and multiple sites, and for independent unit recovery options, utilizing all on-site resources should be provided;
- any changes in external hazards or understanding of them should be periodically reviewed for their impact on the current plant configuration; and
- an active tsunami warning system should be established with the provision for immediate operator action.

Lesson 2: For severe situations, such as total loss of off-site power or loss of all heat sinks or the engineering safety systems, simple alternative sources for these functions including any necessary equipment (such as mobile power, compressed air and water supplies) should be provided for severe accident management.

Lesson 3: Such provisions as are identified in Lesson 2 should be located at a safe place and the plant operators should be trained to use them. This may involve centralized stores and means to rapidly transfer them to the affected site(s).

Lesson 4: Nuclear sites should have adequate on-site seismically robust, suitably shielded, ventilated and well equipped buildings to house the Emergency Response Centres, with similar capabilities to those provided at Fukushima Dai-ni and Dai-ichi, which are also secure against other external hazards such as flooding. They will require sufficient provisions and must be sized to maintain the welfare and radiological protection of workers needed to manage the accident.

Lesson 5: Emergency Response Centres should have available as far as practicable essential safety related parameters based on hardened instrumentation and lines such as coolant levels, containment status, pressure, etc., and have sufficient secure communication lines to control rooms and other places on-site and off-site.

Lesson 6: Severe Accident Management Guidelines and associated procedures should take account of the potential unavailability of instruments, lighting, power and abnormal conditions including plant state and high radiation fields.

Lesson 7: External events have a potential of affecting several plants and several units at the plants at the

same time. This requires a sufficiently large resource in terms of trained experienced people, equipment, supplies and external support. An adequate pool of experienced personnel who can deal with each type of unit and can be called upon to support the affected sites should be ensured.

Lesson 8: The risk and implications of hydrogen explosions should be revisited and necessary mitigating systems should be implemented.

Lesson 9: Particularly in relation to preventing loss of safety functionality, the robustness of defence-in-depth against common cause failure should be based on providing adequate diversity (as well as redundancy and physical separation) for essential safety functions.

Lesson 10: Greater consideration should be given to providing hardened systems, communications and sources of monitoring equipment for providing essential information for on-site and off-site responses, especially for severe accidents.

Lesson 11: The use of IAEA Safety Requirements (such as GS-R-2) and related guides on threat categorization, event classification and countermeasures, as well as Operational Intervention Levels, could make the off-site emergency preparedness and response even more effective in particular circumstances.

Lesson 12: The use of long term sheltering is not an effective approach and has been abandoned and concepts of 'deliberate evacuation' and 'evacuation-prepared area' were introduced for effective long term countermeasures using guidelines of the ICRP and IAEA.

Lessons 13: The international nuclear community should take advantage of the data and information generated from the Fukushima accident to improve and refine the existing methods and models to determine the source term involved in a nuclear accident and refine emergency planning arrangements.

Lesson 14: Large scale radiation protection for workers on sites under severe accident conditions can be effective if appropriately organized and with well led and suitable trained staff.

Lesson 15: Exercises and drills for on-site workers and external responders in order to establish effective on-site radiological protection in severe accident conditions would benefit from taking account of the experiences at Fukushima.

Lesson 16: Nuclear regulatory systems should ensure that regulatory independence and clarity of roles are preserved in all circumstances in line with IAEA Safety Standards.

Psychology, Philosophy and Nuclear Science

by MICHAEL EDWARDS, FRANZCP, MNucSci(ANU), MPsychoanalticStud1, AIDAN BYRNE, PhD(ANU), FAIP2

Ed. Note: Dr. Edwards is conducting research on the psychology of the nuclear realm. He is looking particularly at the deeper meanings people attach to nuclear technology, rather than just superficial attitudes or risk perception.

At first glance, one might wonder what psychology has got to do with nuclear science. On closer inspection, it is clear that nuclear science and technology have historically attracted controversy, and still today public and political opposition cloud its future, perhaps even more so with recent tragic events in Japan. A key focus for psychology has been an attempt to explicate public opposition to nuclear power, and this has been largely carried out by examining attitudes and risk perception. But it is easy to demonstrate that this has not been enough. There are also other important psychological issues that warrant greater attention than has been given.

In this paper, I will first give an overview of the "discipline" of psychology, including some inherent philosophical problems, before outlining specific psychological issues of relevance to nuclear science. I will then discuss whether these issues have been adequately addressed to date, before finally suggesting ways in which psychology might better respond to the questions nuclear science and technology raise.

What is Psychology?

Psychology is the study of "mind", "psyche" or "soul", and has origins in ancient philosophy. It can be argued that psychology is the fundamental science, as everything that we observe and theorize necessarily depends firstly on how they are psychologically perceived. To most modern psychologists, the phenomena of mind are equated with brain structure and function, although this assumption is philosophically problematic. The territory of psychology includes the study of consciousness, perception, cognitive processes, affects (or emotions), behaviour, intelligence and personality, as well as various pathological states such as extreme anxiety, delusional thinking and hallucinations. Psychology can focus on individuals, as well as on groups and organizations. Thus, social psychology is a branch of psychology that explores how psychological phenomena manifest in the social realm, and examines such things as group attitudes, fears and human aggression.

Philosophically speaking, modern psychological approaches are generally informed by the same paradigm as that of the sciences of the "objects" of the natural world – the "natural" sciences - which include physics. Here, the human person is seen as an object independent of a "neutral" scientific observer; complex human experiences are reduced into parts and psychological phenomena quantified and measured, permitting hypotheses to be tested through experimentation under controlled conditions. But there are immediate problems with this view: the issue of whether there can really exist a human "observer" independent of a human "object", as everything must take place in an *inter-relationship*; the scientific reduction of psychological phenomena into parts removes many essential existential qualities, making a natural science of the human realm unfaithful to lived reality; there is also the issue of how one mind can get outside of itself and study another mind.

Indeed, there have been challenges to this natural science orthodoxy in psychology, with some alternative paradigms endeavoring to be more faithful to the complexity of human experience. Instead of a science of natural objects (of which the human is seen as one example in the above paradigm), we have *a science of human subjectivity and lived experience*. In such "human sciences", the person lives in a world of complex and ever-changing perceptions and meanings and of inter-relationships with others, and these are described in all their given complexity. Observer and object (now called "subject", or even "co-investigator") are *inter-dependent*, and psychological phenomena are represented as "wholes" that are closer to lived experience. The psychologist here seeks to know *what it is like* to be someone or to experience something, and does not select artificially constructed components of existence for study.

At the beginning of the twentieth century, as the revolution in modern science and technology was well underway, and psychology was beginning to adopt the philosophy and methods of the natural sciences, another revolution in psychology was taking place – that of Psychoanalysis – founded by Sigmund Freud. Although Freud was a medical doctor, ambiguous in his philosophy of mind, he mostly concentrated on the detailed description of, and interrogation of the meanings behind, psychological phenomena, setting aside all presuppositions regarding their "causes". This enabled Freud to approach unusual phenomena such as

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dreams, "slips" (parapraxes) and bizarre psychological symptoms, which other observers found to be irrelevant, uncovering in them a richness of meaning that was astounding. Freud, and the post-Freudians who came after, created controversy by demonstrating that there is a "hidden" or "unconscious" side to our psychologies, and that our outward lives are in fact deceptive. Here, what we say is not necessarily what we mean, and how we behave outwardly belies our true inner feelings; living successfully in society comes at a great cost – the repression of our true sexual and aggressive natures, leading to a lingering discontent that could be related to our deep existential unhappiness and even to our propensity to large scale conflicts such as war.

Indeed, Freud and Einstein corresponded on such issues in the lead up to the Second World War, as Einstein contemplated the future implications for humanity of modern physics, and Freud contemplated what humans might be capable of inflicting upon one another with increasingly powerful weaponry. This correspondence took place before the first demonstration of nuclear fission. Later, psychoanalyst Carl Jung collaborated extensively with physicist Wolfgang Pauli on matters such as number theory and synchronicity. Pauli, deeply troubled by personal problems, also turned to Jung for psychological healing, with Jung analysing hundreds of Pauli's dreams. Historically, psychoanalysis and modern physics have had an affinity and mutual fascination. Psychologists here, in trying to address the real life concerns that modern physics was uncovering, needed to adopt a paradigm quite different from that of the natural sciences in order to truly make sense of the human experience taking place.

Key psychological issues in nuclear science

One question of a psychological nature often asked by nuclear professionals is "Why are many people opposed to nuclear power when it is relatively safe?". This question is typically approached by examining *attitudes*. For example, positive attitudes to nuclear power have been found to be associated with familiarity with the technology, such as might occur when living close to a nuclear reactor. Attitudes in general are related to age, gender, educational level and *risk perception*. Negative risk perception, in the case of nuclear reactors, seems to be associated with the involuntary nature of nuclear accidents (as opposed to car accidents – I choose to drive a motor vehicle), the lack of familiarity and knowledge of the technology, the potentially catastrophic, albeit rare, consequences of nuclear accidents, and the powerful role of the media such as cinema. One of the implications of this research is that increased familiarity and education should have an effect on attitudes, but this is not always the finding. Attitudes are fairly straightforward psychological constructs, but they generally ignore the "unspoken" and emotional factors that lay behind them.

It is sometimes claimed that certain people and groups are "irrational" when the facts of nuclear power are considered. It is true that some arguments are based upon inaccurate facts and faulty logic. But the claim of irrationality can be a tricky one for several reasons. Firstly, irrationality is sometimes implicitly used to refer to a particular person, group or viewpoint, rather than to a specific faulty argumentation. Secondly, many people with anti-nuclear views insist that their views are rational – they may claim that the views of the nuclear industry are irrational. Anti-nuclear proponents may argue that nuclear power is without sufficient justification, that there are many unsolved problems and potential dangers associated with nuclear waste, that there suitable energy alternatives, that the core issues at stake relate to political and economic control, and that ultimately in a democracy the public should be able to decide its own future. Thirdly, if a person or group is said to be irrational, this then implies a psychological deficiency with a particular "cause" that should be corrected, carrying with it serious ethical and political repercussions, such as concerns about "social control". Finally, when political forces are at play in any debate, the rationality versus irrationality argument ceases to have scientific meaning. There are of course important facts on both sides of the nuclear "debate", but it seems as though no-one ever "wins", and these fact-based arguments often turn into highly emotional ones, with accusations and counter-accusations. The powerful emotions involved indicate a problem in the relationship between the two sides, or perhaps something psychologically *unconscious* playing out - it is only on the surface that this debate is about facts. The focus for psychology here must therefore shift to involve the emotions, both conscious and unconscious, underlying the debate.

Related to the rationality versus irrationality issue is what some observers have termed "nuclear fear". Is this term of value? The term seems to imply an "irrational" fear of nuclear technology, particularly reactors and radiation, in a proportion of the population. We must first ask, however, whether any such anxiety or fear should be considered irrational considering the huge historical impact of nuclear weapons which seem so closely related to reactors in the public mind, and to the fact that the most direct experience the majority of people have had of nuclear reactors is from media coverage of Chernobyl, Three Mile Island and recently Fukushima, or from having watched *The China Syndrome*. There are also some understandable concerns, perhaps fears, surrounding waste disposal. In actuality though, the phenomenon of nuclear fear is far from clear in a definitional or descriptive sense. For example, do people actually experience the emotion of fear, or is it more closely related to *opposition* to nuclear technology (an attitude, perhaps sometimes based upon fear)? Should it include individual cases of what might be termed nucle-

ar *phobia*, with characteristic avoidance of, and extreme anxiety responses towards, a feared nuclear object, such as a movie with a nuclear theme? If it is more closely related to opposition rather than being a powerful emotion, it could not be considered irrational since so many people in the population hold this attitude. It could possibly be used to refer to a kind of irrational mass (group) fear, but what is the evidence for the presence of a mass nuclear *fear*? We do have historical evidence of group-based panic events, and physicist-historian Spencer Weart has demonstrated clear mass-cultural manifestations of reactions to nuclear technology, but whether aspects of this represent true *fear* is unclear. Until we have better knowledge of this phenomenon, it is difficult to explore it adequately.

Another consistent psychological theme that emerges in relation to nuclear technology is *trust*, or rather *mistrust*. Some researchers have found that trust is a powerful determinant of attitudes to nuclear power. Trust relates to confidence in the human operators, organizations and regulatory agencies of nuclear power plants to make public safety and wellbeing the priority, to be transparent, and to openly address any concerns. Indeed, the issue of mistrust has emerged as a strong theme with the recent events in Japan. In psychological research, trust is usually operationalized by converting it into a series of statements with which the subject agrees or disagrees, or rates – it can then be measured. The question here is whether such reduction to a set of assigned quantifiable variables captures the complete human experience of trust. Thus, do we really understand what someone experiences or means when she/he says "I don't trust the regulators of nuclear power plants because they are only human"?

It makes good sense that memories of Hiroshima and Nagasaki, the Cold War, nuclear weapons testing, recent talk of nuclear terrorism, and now Fukushima would be linked to peoples' psychological reactions to nuclear power. The psychological association also makes sense when one considers that civilian nuclear power was born out of military applications. It is strange, then, that these links have not been explicitly explored in the psychological literature, as if we were blind to the obvious. In my own research, when simply asked about associations to the word "nuclear", common responses include "bomb" and "destruction". The term "nuclear reactor" is often associated with "explosion", "meltdown", and "radiation". The experience and meaning of the Bomb is clearly related to other nuclear experiences, and yet current research into attitudes, risk perception and mistrust does not address this adequately, if at all.

A number of psychoanalysts such as Robert Jay Lifton have explored the experiences of living in the nuclear age. The focus of these scholars has been mostly on the experiences of surviving the nuclear bombing in Japan, and the experiences of living under the threat of nuclear Armageddon during the Cold War. The experiences of living with nuclear reactors or nuclear waste are yet to be directly addressed by psychoanalysts.

Not all of relevance to the interface between psychology and nuclear science relates to attitudes, risk perception, trust or historical traumas. For example, interesting avenues for further study also exist in considering the historical and contemporary experiences, and the meanings these experiences were given, by nuclear scientists. When Rutherford and Soddy first understood the mechanisms behind radioactivity, the images that immediately came to their minds were of alchemy and transmutation. Why? Psychoanalyst Carl Jung, who studied alchemy and the alchemists extensively, found that the real transformation being attempted by alchemists was one within the psyche – the coming together of opposing psychological forces, and the emergence of that "nuclear" core of the personality, the Self. Might this also be relevant for modern nuclear physicists? We just don't know. Upon witnessing the first atomic explosion near Alomogordo in 1945, Oppenheimer was compelled to invoke Hindu scripture. Spencer Weart, in charting nuclear history, found that nuclear energy has easily linked itself to old and recurrent psychological themes such as God, Armageddon, creation and destruction, good and evil, health and disease, the hero and the evil scientist, and utopian futures of eternal peace and endless supplies of energy. Interestingly, these themes were already in evidence well before the first demonstration of nuclear fission.

Modern day nuclear scientists might be expected to experience feelings of frustration and rejection by society in relation to their work, even though many feel that they are simply carrying out the practice of science, and perhaps dedicating themselves to improved knowledge and to the betterment of humanity. The experiences and feelings of this group have been largely ignored in the literature, as has the phenomenon of fascination that many experience in relation to the profound quantum world of the nucleus. Similarly, the experiences of people from the anti-nuclear movement, and the meanings they attach to nuclear technology, radioactive waste and the environment, for example, have been mostly ignored from a psychological point of view.

The adequacy of current psychological knowledge

So do we really have a good grasp of the psychology of nuclear science and technology? As discussed above, much of the research in this area focuses on attitudes, risk perception, trust and historical traumas. This manifest focus is dwarfed by the total available fields of relevant enquiry. Furthermore, the paradigms used miss out on the potential yield of human experiential data. Studies on attitudes toward nuclear power have mostly looked at how these vary between and within countries, as well as how they correlate with certain

demographic attributes such as age, gender, educational level and geographical location. Interestingly, a recent study has questioned the finding that people who live close to reactors are less fearful or opposed to nuclear power than those who live far away, suggesting that unconscious psychological mechanisms may be at play whereby local residents *deny* their true underlying feelings. An approach that can access these deeper feelings – the ones not necessarily expressed in surveys or quantitative studies - is needed.

As has been shown, most modern psychological studies have been based upon the natural science paradigm, leaving many unanswered questions. So, perhaps nuclear issues demand, in addition, alternative psychological approaches. As mentioned above, we can be confident that powerful emotions are involved because of the splits and tensions in the nuclear debate, with anti-nuclear leaders sometimes accusing nuclear professionals of being "cold", "rational" and "arrogant", and nuclear professionals sometimes accusing anti-nuclear leaders of being "irrational", "hysterical" and misrepresenting the "facts". Research that seeks to explore these emotions and the deeper psychological meanings of the nuclear debate is necessary, as there may also be unexpressed, unconscious or simply unexplored psychological issues behind these attitudes and perceptions.

A psychology based upon the same theoretical paradigm as physics and chemistry will have the unfortunate effect of reducing human experience to pre-assigned categories, often stripping it of meaning. Attitudes measure expressed responses to statements, not that which is left unexpressed. Research studies on nuclear risk perception lists possible "causes" of the high perception of risk, but do not prove a cause and effect relationship, nor capture many of the qualities of the lived experience of nuclear danger. The result is that we have an incomplete understanding of how people *really* feel about and experience nuclear technology, and what it *means* to them.

A psychology *for* the human experience of the nuclear realm

It is clear that we lack an adequate picture of the complex psychology of nuclear issues. I have argued that current theoretical paradigms in psychology are not on their own adequate for dealing with this task. In every field of enquiry, where we lack a good overall picture, the first task must be *descriptive*. A psychology for nuclear science could set as its first task a descriptive and yet methodologically rigorous *phenomenology* of the range of experiences of the nuclear realm and their associated meanings. This might include an exploration of what "nuclear fear" is, and an exploration of what people mean when they talk about "trust" in relation to nuclear issues. In the spirit of some of the great philosophers and psychoanalysts of the early twentieth century, this phenomenology must begin with the questions "what it is", "what it is like" and "what does it mean", without pre-existing theoretical assumptions.

The nuclear realm is so large, so fascinating and so important that a psychology for nuclear science must include the experiences of the physicists at Los Alamos as well as contemporary nuclear professionals, people who are strongly opposed to nuclear technology, members of the public who directly experience nuclear issues, including the unique perspectives of First Nation people, and anyone else who is engaged with nuclear issues. It must also take into account the intersubjective, cultural and historical contexts in which these experience take place, and through which their psychological meanings emerge. This psychology in the first instance must be *qualitative* rather than *quantitative* in nature.

This psychology might begin with an open-ended approach: "What was your experience like?". The methodology would seek to avoid theoretical presuppositions, be reflective of researcher bias, and follow the experience as it unfolds, right to the core of its meaning. The resulting narrative could then be analysed by employing a qualitative method of the analysis of "meaning units" and the later description of themes that emerge within and across individuals. Such an approach has been developed and is called *phenomenological psychology*.

A psychology for nuclear science will then be open to the whole experiential world of the "nuclear" in nuclear bombs, nuclear power, nuclear radiation, nuclear waste and so forth, enabling the deep psychological meanings of this realm to emerge. It may be, for example, that everything "nuclear" is linked by a core set of meanings. Once we have the various genera of nuclear phenomena and their species faithfully described, we can then set about the formation of hypotheses and the testing of these through experimentation.

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2011 Annual Conference a Great Success

by FRED BOYD

Close to 500 delegates, exhibitors and guests convened at the Sheraton on the Falls hotel in Niagara Falls, Ontario, from June 5 to 8, 2011, for the 32nd Annual Canadian Nuclear Society Conference They enjoyed an excellent line-up of plenary speakers, an extensive technical program, excellent meals and interesting exhibits.

As a last moment surprise the newly appointed Minister of Natural Resources Canada, **Joe Oliver,** attended the opening reception on the Sunday evening and gave a short address. *(See excerpts of his remarks in this issue of the* CNS Bulletin.*)*

Embedded was the 35th Student Conference sponsored by both the CNS and the Canadian Nuclear Association.

In addition, the North American Young Generation Nuclear organization (NA-YGN) ran an all-day professional development seminar on the Sunday before the actual conference and the Nuclear Education and Outreach group held their second workshop on the Thursday following the conference. *(See a separate report on the NEO event.)*

A fortunate few, who registered early, enjoyed a visit on the Sunday to the Peller Winery where the group observed some of the intricacies of making fine wine and enjoyed a pleasant lunch.

The conference proper began on the Monday morning with a welcome by CNS outgoing president **Adriaan Buijs** and introductory comments by **Wayne Robbins**, chief Nuclear Officer for Ontario Power Generation who was the Honourary Chair of the Conference.

Robbins noted the recently completed environmental hearing s for new units at Darlington. The [nuclear] industry is in a strong position to proceed, he stated. "We are at the threshold of exciting times", he said, "despite the challenges posed by the Fukushima event". The problems there are not a symbol of the world nuclear industry but we must learn from them, he commented.

Robbins then introduced the Ontario Minister of Energy, **Brad Duguid**, who delivered a keynote address.

Ontario is in a transformational role in rebuilding the electricity system and on the threshold of renewing its nuclear fleet, Duguid stated. Then he mentioned two leaders from the province in the international nuclear community – Duncan Hawthorne, CEO of Bruce Power, who is head of WANO (World Association of Nuclear Owners), and Tom Mitchell, CEO of Ontario Power Generation, who is chair of INPO (International Nuclear Power Operators). Nuclear remains a major part of Ontario's electricity plans, it is the "backbone" of the system he asserted. Refurbishments have created 25,000 jobs, he claimed, but expressed concern about the federal government's handling of the proposed sale of Atomic Energy of Canada Limited. Now that the federal election is over he hoped the newly elected government would move forward.

He closed with an unusual comment from someone in elected office - that in electricity planning we must not think in the short term, the challenges transcend the typical four-year life of an elected government.

The minister was followed by **David Novog**, of McMaster University, who provided a condensed review of the Fukushima event in Japan. He began by quoting the three words of the safety mantra – control, cool, contain. The tsunami that followed the Fukushima earthquake on March 11 destroyed all power sources so the station was in a complete blackout, he noted. That resulted in a prolonged loss of a heat sink. That led to fuel failure and extensive contamination, especially of the water. He noted that the Canadian Nuclear Safety Commission had requested each nuclear operator to review their plants and plans in light of Fukushima and stated that the response from OPG is on its website.

After a break the first Plenary session was held. This squeezed six speakers into a two hour period, each being limited to 20 minutes. Remarkably, they all met that constraint. (A package of their comments would make a good, concise overview of the energy picture in Canada.)

It began with a broad overview of the Canadian energy scene by **Greg Schmidt**, president of the Energy Council of Canada. Canada is one of just four high income countries that is also an energy exporter, he noted. The challenge is to achieve more production, more efficiency and less "greenhouse gas" (GHG).

Next was **Geof Munro**, Assistant Deputy Minister at NRCan, whose topic was *"Advancing Clean Energy Technology in Canada"*. The target is a 17 per cent reduction in GHG by 2020 compared to 2005. Then he noted that electricity generation is already 90 per cent GHG free. We need to conserve, develop more

renewable sources and reduce CO_2 emissions. To be a clean energy super-power we need more innovation. Governments can support research but private industry must do the application, he said, which implies a need for collaboration and access to capital.

Robert Walker, the recently appointed Senior Vice President, Nuclear Laboratories, AECL, took on the task of the *Future of Nuclear Technology*. Nuclear technology is complicated and complex, he noted, involving government, industry and society.

The Chalk River Laboratories have a six point program, he said, that involves: aiding industry capability; ensuring safety and security; developing clean, safe energy; producing isotopes; improving the environment; and encouraging innovation. He stated that CRL would be a "stand alone" entity but, to a question, did not clarify what he meant.

Electricity planning in Ontario was the topic of **Colin Andersen**, CEO Ontario Power Authority. He commented that a decade ago the electrical system in Ontario was in a poor shape. Now it is adequate. The role of OPA is to prepare a second long-term plan for the electrical system, taking into account the decision to terminate coal-fired generation by 2014. Considerable emphasis is being placed on renewable forms of generation and conservation. Nevertheless it has been decided that nuclear will continue to provide 50 per cent of the generation.

Jean-François Béland, Executive Vice-President AREVA Canada, offered a view of global nuclear energy developments. On the reaction to the events at Fukushima he commented that the decisions of Germany and Switzerland to phase out nuclear and that of Italy not to proceed were largely politically motivated. But nuclear regulators around the world are requiring reviews and, he predicted, there will be a decrease in the number of refurbishments.

The final speaker in this session brought a non-nuclear perspective. **Gilbert Bennett**, Vice-President, Lower Churchill, Nalcor Energy, spoke about the development of the Lower Churchill Falls in Labrador which, he said, will begin this year. The construction of the dam, plant and transmission lines will result in 45,000 person-years of employment. Initially the output will go to Newfoundland and Nova Scotia but, he said, there is potential for transmitting some of the power through Quebec to Ontario.

Following the lunch on this first day the *W. B. Lewis lecture* was presented. This year's lecturer was **William S. (Bill) Pilkington**, Senior Vice-President, AECL, and the person who oversaw the extremely difficult repairs to NRU over 2009 and 2010. He chose to speak about the history of the CANDU design from NPD to ACR 1000 and the Advanced CANDU 6. With a brief reference to the proposed sale of AECL engineering he commented that the delay is only helping the opponents. In closing he said he did not expect much impact globally from the Fukushima event but commented it emphasized that safety must have the highest priority. *(The full text of Pilkington's presentation is printed elsewhere in this issue of the* CNS Bulletin.*)*

The afternoon of the Monday, the morning of the Tuesday and the afternoon of the Wednesday were devoted to parallel technical sessions, each with five or six papers presented. The session titles were:

- Radiation Applications, Dose and Medical Isotopes;
- Reactor and Radiation Physics
- Thermalhydraulics
- PRA, Human factors and Reliability
- Advanced Reactors and Fuel Cycles
- Plant Life Monitoring, Life Extension, Refurbishment and Ageing
- Materials, Degradation and Issues
- Reactor Safety and Licensing
- Process systems, Measurement I&C and Chemistry
- Training, Infrastructure and Communication
- Nuclear Technology, fuel and Materials

Special technical sessions were presented on:

- Strategies to Manage Financial and Safety Risk for CANDU 6 Stations for an Extended Life
- Fusion
- CANDU Maintenance Conference: Industry Performance

At the end of the technical sessions on the Monday afternoon, there was a poster display of student papers combined with a wine and cheese reception. A large number of the conference attendees viewed the 55 posters and challenged the students to explain their complex subject in simple language. This was the largest student participation in many years, thanks to the efforts of Emily Corcoran and Cheri Ferrari.

The winners of the poster competition were:

Graduate:	David Hummel, McMaster University
Undergraduate	Francio Queneville, École Polytechnique
Summer school	Jay Harris, Bruce Power

The **Honours and Awards Ceremony** was held after the Tuesday lunch. *(See the separate report on that event.)*

The Tuesday plenary session began with a keynote address by **Michael Binder**, President of the Canadian Nuclear Safety Commission. Although titled *65 Years of Nuclear Safety in Canada*, in recognition of the creation of the Atomic Energy Control Board, the predecessor of the CNSC, in 1946, Binder chose to spend most of his time on the Fukushima event.

After briefly summarizing the effect of the earthquake and tsunami on the Fukushima – Daiichi nuclear plant, he called it a "wake-up call for the nuclear sector". The event raised a number of issues, he said, including location and stability of emergency backup systems and perceptions of radiation risk.

He summarized the reaction of the CNSC. An Emergency Operations Centre was immediately created and staffed around the clock for six weeks. A week after the event an order went out to all major nuclear facilities ordering them to: review lessons learned; re-examine their safety case; implement immediate actions; and report on long-term measures. All responded. He said the CNSC had continued confidence in the safety of Canadian facilities but there is always room for improvement.

Then he turned to the domestic scene noting that the CNSC had a heavy agenda with proposed new build and refurbishments, along with over 2400 nuclear substance licences, university laboratories, uranium mines, Port Hope clean up and more.

In closing he did refer to the 65th anniversary and invited everyone to look at the "living" history posted on the CNSC website.

Then followed two presentations on *Communicating the Nuclear Message.* The first was by **Sarah Thorne**, Principal, Decision Partners, consultants to the Canadian Nuclear Association who provided research on communication as input for the CNA 5 Year Strategic Plan. She spoke of one-on-one interviews with elected officials and public servants. The focus was a dialogue to achieve understanding, she said.

She was followed by **Kathleen Olsen**, Director of Communications at the CNA. She also spoke of engaging, listening and discussing with people with an objective to convince them that the nuclear industry is not what they expect it to be. She mentioned the CNA move into "social" media, using Facebook, Twitter and a group discussion site Talk Nuclear.

The last hour and a half was devoted to three presentations on *Isotopes and Research Reactors.*

Richard Coté, Vice President, Isotopes, AECL, began with a presentation *Molybdenum 99 Supply – A Global Issue.* He explained that nuclear medicine uses small amounts of radioactive material coupled to compounds that seek a particular part of the body. With radiation detectors and computation information can be obtained of the anatomy and function of various organs. Technetium 99m, a daughter product of Mo 99, has become the favorite isotope because of its short half life and appropriate gamma energy. In the USA (and most of the developed world, 96 percent of nuclear medicine scans use Tc 99m. primarily for heart and bone scans.

Up to recently five old reactors supplied 95 percent of the parent with NRU and HFR in Belgium each providing about one third of the world supply. He noted that two companies in the USA control the sale of Tc 99m "generators" so the Mo 99 produced at NRU is shipped to the USA before coming back in the generators.

He closed by quoting the Steering Committee of the OECD-NEA that the current economic structure is unsustainable, i.e., the cost is subsidized by government owned research reactors.

He was followed by **Shannon Quinn**, Program Director for Isotopes at NRCan, who spoke about *Canada's Isotope Strategy.* She provided a quick overview of the production of isotopes in Canada, which is primarily at the NRU reactor. It has been questioned, she said, whether or not it is appropriate for the government, through its research facilities, to play such a dominant role. The intention is to move towards a more market-based approach.

The final presentation was on a different topic, the need for a new research reactor. It was given by **Jeremy Whitlock**, Manager of Non-Proliferation and Safeguards, at AECL – CRL, who spoke from his role as coordinator for the report by the Canadian Nuclear Society on the need for a multi-use research reactor. Published in 2010, it augments the 2008 report by the Canadian Institute of Neutron Scattering which emphasized the importance of a strong neutron source for research and testing. Whitlock noted that the CNS report reviewed the importance of a versatile reactor for research on materials and systems and for critical safety-related experiments. (The full report, titled *Maintaining Excellence: Planning a New Multi-Purpose Research Reactor for Canada* is unsustainable. or a summary, titled just *Maintaining Excellence*, are available from the CNS.).

That evening almost everyone took the shuttle buses provided to go to the restaurant *Elements on the Falls* overlooking the Canadian falls for the conference banquet. There were no formalities, just much conversation mixed with pleasant background music to accompany an excellent dinner.

Wednesday morning saw the final two plenary sessions. The first, on *Alternative Energy Strategies,* was

chaired by **Murray Stewart**, who noted, in opening the session, that there are just three major sources of electricity generation; hydro, nuclear, fossil. There is a need for improved, more flexible grids, he commented.

The first paper was by **William Smith**, Senior Vice-President, Siemans Canada, who spoke about integrated systems, with a focus on electricity. Fossil fuels will continue to be used for electricity generation, he stated, because of the continuing growth of demand. Many of the electricity generating stations around the world are old and need to be replaced, he commented. He spoke of "smart" electricity with two-way, load-following, generation, including wind and solar. On the home front he foresaw smart metering and electric cars. However, nuclear will remain the "backbone" of electrical systems, he stated in closing.

Kerry Guy, Manager, Natural Gas Advocacy, Canadian Association of Petroleum Producers, spoke on the *Natural Gas and the Future of Shale Gas.* Canada has a 100 year supply of natural gas, he stated, and the cost, relative to oil, has decreased over the past few years. Production of gas in the USA is increasing because of the success in extracting shale gas, which has resulted in decreased exports from Canada.

He showed a map of North America indicting the widespread occurrence of shale gas. The problem has been how to tap it but the development of horizontal drilling and fracturing makes it possible to extract a significant percentage of the gas trapped in the shale. Because it is cheaper and cleaner he said he expects that gas will replace coal for electricity generation in the USA.

The third and last presentation in that session was by **Mike Monea**, Vice-President, Integrated Carbon Capture and Sequestration Project, Sask Power, who spoke about the Boundary Dam project. Approval to proceed was given in April 2011, he noted. The CO_2 recovered will be injected into old oil fields to recover more oil. Clean coal works, he said, the cost will be predictable and the resource large.

After a short break the final plenary session of the conference was held on New Nuclear Technologies, chaired by **Tony De Vuono**, Senior Vice-President and Chief Technology Officer, AECL.

It began with a review of the *Point Lepreau Refurbishment and Energy Developments in New Brunswick,* by **Blair Kennedy**, Vice-President, Nuclear, New Brunswick Power.

He began with general comments on the role of nuclear and NB Power's planned diversification of generation. For 2013 he predicted that Point Lepreau would provide about a third of the province's electricity and renewables about 20 percent.

On the refurbishment he first emphasized that safety was paramount. He predicted the retubing would be completed by May 2012 and the station returned to service in September 2012. At the time of speaking he said 57 calandria tubes had been reinstalled. Along with many other items he mentioned that the turbine had been upgraded to produce an additional 25 MW. Throughout the exercise they have been open and transparent, he commented.

The next speaker, **Phillip Moor**, Vice-President, High Bridge Associates, focussed on small nuclear plants. He noted the renewed utility interest in small plants which has resulted in a number of actual and proposed designs in different countries, such as: Hyperon; Star; ARC 100; Prism. There are some prototypes being built in various countries, such as Korea, Argentina, Russia and India, but not in North America, he noted. There is a need for a simpler and less expensive licensing process, he stated.

A different perspective was presented by **Jennifer Jackman**, Director General, CANMET Materials Technology Laboratory of Natural Resources Canada.in her presentation titled *NRCan Materials Research in Support of Nuclear Technology*. She began by noting their extensive new facilities in Hamilton with its advanced testing equipment. She then noted the important nuclear materials development work done in the former laboratories in Ottawa in cooperation with Chalk River back in the 1940s and 1950s. Current nuclear-related work is on materials for GEN IV proposed designs which involve high temperatures and high pressures. This involves international cooperation and partnerships with universities, she noted...

The final plenary speaker addressed a particularly interesting development in his presentation *Alternative Fuels for CANDU Reactors – RU and Thorium Collaborative Initiatives.* **Zhang Zhenhua**, Deputy General Manager, Third Qinshan Nuclear Power Company Ltd. (TQNPC) in China, which has two CANDU 6 units, spoke about their successful test irradiations of bundles of fuel with recycled uranium (RU). RU is uranium separated from spent PWR fuel and then mixed with depleted uranium to match the composition of natural uranium. The spent fuel from four PWRs can fuel one CANDU, he commented. The original test was very successful and they are now planning a full fuelling with RU.

Because China has little uranium they are very interested in this approach and in the possibility of a thorium cycle in CANDU. Not only do their CANDU units offer 25 to 40 per cent better uranium utilization than PWRs, they also produce Cobalt 60, he noted.

Following the Wednesday lunch Wayne Robbins introduced **Rob Norris**, who wears many hats in the Saskatchewan government. Among them Norris is: Minister of Advanced Education, Employment

and Immigration; Minister responsible for Saskatchewan Power Corporation; Minister responsible for Uranium Development Partnership.

"Saskatchewan wants to play a significant role in the Canadian nuclear program" he said at the beginning of his talk. Then he outlined some of the many attributes about Saskatchewan. Among them he noted that the province has 50 per cent of Canada's arable land; 50 per cent of the world's potash; 25 per cent of the world's uranium. But, he commented, its greatest resource is its people. The population is growing and the economy is strong with 9,000 jobs to be filled.

In the nuclear field the largest federal grant for non-reactor production of Mo 99 went to the Canadian Light Source group and the province has provided $30 million for a new nuclear research centre at the University of Saskatchewan which already has a SLOWPOKE reactor. The province has submitted a proposal to the federal government to build a research reactor but has not received a response.

In closing he complimented the students for the excellent poster session and invited them all to go to Saskatoon for the CNS 2012 conference.

He closed by playing a video promoting Saskatchewan.

The conference continued Wednesday afternoon with three technical sessions and two special ones.

This very successful conference was organized and produced by a small army of mostly volunteers led by Frank Doyle who carried the title of Executive Chair. Those involved included: Ben Rouben; Ken Smith; Murray Stewart; David Novog; John Roberts; Emily Corcoran; Cherri Ferrari; Eric Williams; Richard Moffett; Anne Greve;' Krish Krishnan; Jeremy Whitlock; Melanie Sachar.

The NA-YGN program on the Sunday was organized by Christine John; Chris Waugh; and Natalie Sachar.

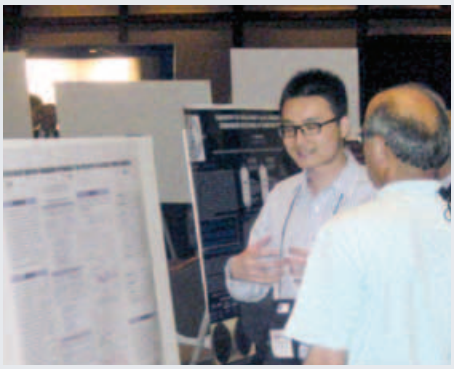
Without the sponsorship by many companies and organization it would be impossible to present such a full program and the amenities which made the conference so successful and enjoyable. The sponsors, in alphabetical order, were: AECL; AECON*; AMEC; ANRIC*; B & W*; Black & McDonald*; Bruce Power*; Cameco*; CNA; CANMET-MTL; CNSC*; Dessau-LVM; Energy Solutions Canada*; GE Hitachi*; Genivar; Hitachi*; Hydro Québec; HSL Nuclear*; Kinetrics*; NB Power; NLI*; OPG; Power Workers Union; SNC Lavalin Nuclear*; Wardrop; Westinghouse*; Worley Parsons*; Zetec. (Those also having exhibits are marked with a *)

Other exhibitors were: Atlantic Nuclear; AREVA; Axiom; Candesco; Curtis Wright Flow Control Company; Ian Martin; Industrial Audit; Kanata Electronic Services; Mirion Technologies; NA-YGN; OCI; UNENE.

A CD with all of the technical papers and most of the plenary presentations will be available from the CNS office.

The 2012 CNS Annual Conference will be held in Saskatoon, Saskatchewan, June 10 – 13, 2012

Scenes from the Conference



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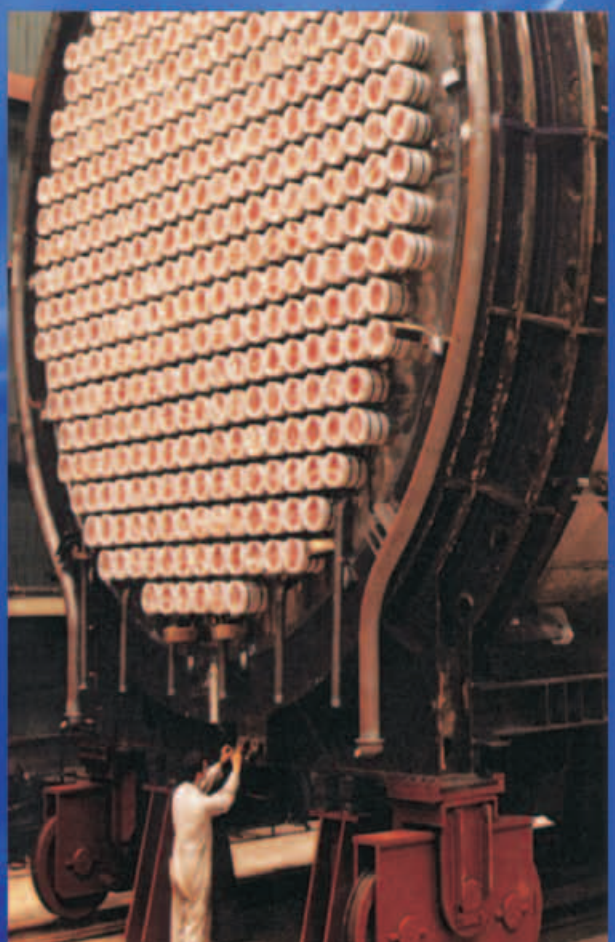

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New Minister at Conference Opening

Although appointed only two weeks earlier, the new Minister of Natural Resources Canada, Joe Oliver, accepted a last moment invitation to attend the opening reception of the 2011 CNS Annual Conference in Niagara Falls on Sunday, June 5, 2011.

After a short walk around the exhibits (which had just been set up) he offered some welcoming remarks. Following are excerpts from his presentation.

I offer sincere thanks to the Canadian Nuclear Society for the opportunity to speak with you this evening.

As you know, I'm new at federal politics. So I'm really pleased to have a chance to get to know some of the people in the nuclear industry so early in my mandate.

It's only been a couple of weeks since Prime Minister Harper invited me to join his Cabinet as Minister of Natural Resources. To be entrusted with the kind of responsibility that comes with this job is a tremendous honour. It's also a tremendous challenge.

I'm proud to belong to a government that is addressing issues that had been sitting on the back burner far too long – such as dealing with our legacy waste and restructuring of AECL.

For many Canadians, AECL is synonymous with the nuclear industry in Canada. Nevertheless, it has been clear for some time that AECL needs to be repositioned for success. We have started by focusing on the CANDU Reactor Division.

We aim to conclude this process soon. I have already been in discussions with Hugh MacDiarmid, the President and CEO of AECL, and Glenna Carr, the Chair of AECL's Board, and have AECL's support.

Once we have set a clear course for the CANDU Reactor Division, we will turn our attention to AECL's nuclear laboratories. These labs are truly special. They were the birthplace of Canada's nuclear industry: where Nobel Prize-winning neutron scattering technology was pioneered; where we advanced the use of isotopes for medical treatment and imaging; and where CANDU technology was created.

Work is underway to position the labs for the future with a focus on innovation through performance and stakeholder engagement. We will examine the mission of the labs and the options for their effective long-term management.

Now, let me turn to safety.

The effects of the earthquakes and tsunami on Japan's Fukushima Daiichi reactors remind us of the importance of maintaining and improving a sound safety culture.

Seeing these events strengthens our commitment to making the health, safety and security of Canadians, and of our environment, our highest priority.

We have a solid, stringent nuclear safety regime, administered by a regulator – the Canadian Nuclear Safety Commission – whose independence is paramount.

One of my first priorities as Minister was to meet with Michael Binder, the President of the CNSC, and to assure myself that our nuclear facilities are safe and secure.

I am assured that our [nuclear] facilities have the capacity to respond to a wide range of events. Since the events in Japan, the CNSC is reviewing the safety cases for all of Canada's nuclear facilities. I look forward to seeing the CNSC report in August.

Part of our commitment is to provide for the safe and secure management of our nuclear legacy. This is essential for the sake of present and future generations.

The Nuclear Legacy Liabilities Program addresses the risks and liabilities accumulated from the early years of research and development conducted on behalf of the Government of Canada.

We are fully engaged in the Port Hope Area Initiative – a major undertaking to provide safe cleanup and secure, long-term management of the low-level radioactive waste in that community.

As Minister of Natural Resources, I am responsible for overseeing NWMO's activities. I will be watching with great interest as the NWMO moves forward with its process to select a site for a long-term management facility.

Of course, no discussion of health and safety is complete without talking about medical isotopes.

The briefings I've had so far have included a good deal of information about NRU. I have a real appreciation for the expertise deployed to resume and sustain its operation.

We know that the 54-year-old NRU is not the long-term answer. The outages in 2009–2010 have shown that there are vulnerabilities in the isotope supply chain. We are supporting AECL's work to re-license NRU to 2016, to allow time for new sources of isotopes to come on stream, and we are investing in the development of new sources.

A few months ago, the government committed $35 million over two years to support the research, development and demonstration of new, non-reactor-based technologies for the production of the key isotope, technetium-99m. These investments will help create a more diversified supply chain – one that is more robust and less vulnerable to disruption.

We are acting domestically, but this is a global issue. Canada has taken the lead in what has been an unprecedented international effort to better co-ordinate the global isotope supply chain.

In conclusion I am looking forward to meeting and working with the members of our nuclear community here in Canada.

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Nuclear Achievement Awards

For several decades the Canadian Nuclear Society has joined with the Canadian Nuclear Association to honour individuals or groups that have made significant contributions to the Canadian nuclear program. The awards have been presented at a special ceremony held during the CNS Annual conference. This year the award ceremony followed the lunch on the second day of the 2011 CNS Annual Conference in Niagara Falls, June 7.

The call for nominations goes out in the fall and during the spring an Honours and Awards Committee, with representatives from both organizations, reviews the submissions and decides on the awards. The chairman of the H & A Committee for the past two years has been Dr. Krish Krishnan, a former president of the CNS.

This year: three Outstanding Achievement Awards were granted; three John S. Hewitt Team Achievement Awards; an innovative Achievement Award; two Education and Communication Awards; one R. E. Jervis student award; and one CNS member named as a Fellow of the Canadian Nuclear Society.

Outstanding Achievement Award

The *Outstanding Contribution Award* was established in 1989 by the Canadian Nuclear Association. It recognizes Canadian-based individuals, organizations or parts of organizations that have made significant contributions in any field related to the beneficial uses of nuclear energy. These contributions may be either technical or non-technical. Contributions toward improved public safety are specifically included. There are two categories of the award, one for individuals and another for organizations or parts of organizations. The award is in the form of an engraved brass plaque mounted on a wood panel.

Three awards were granted this year.

Paul Spekkens

Citation

Dr. Paul Spekkens received his Bachelor's degree in Chemistry from the University of Ottawa and his Ph.D. in Chemistry from McMaster University. Paul started his career at Ontario Hydro (OH) with the Research Division in 1977. In 1993, he moved to the Nuclear Technology Services Division at the head office as the Manager of the Chemistry & Metallurgy Department. He moved rapidly up the ranks and is presently the Vice President of the Science and Technology Development Division at Ontario Power Generation (OPG).

In his early years, Paul conducted research on the chemistry control of key CANDU Systems, such as the Moderator and the Heat Transport System, to minimize material degradation due to corrosion processes. He also conducted research on decontamination technologies to minimize radiation dose to operating and maintenance personnel. Later, he was responsible for managing the Chemistry Program, and the life cycle management of Steam Generators, Feeders and Fuel Channels. He has helped to establish UNENE (University Network of Excellence in Nuclear Engineering) and has played a key role in managing OPG's R&D Program.

Paul has won many awards including the WANO Nuclear Excellence Award in 2003 and the McMaster University Faculty of Engineering Leadership Award in 2010. Paul is a mentor and an inspiration to many young nuclear professionals. He has made fundamental and long-lasting contributions not only to OH/OPG but also to the Canadian nuclear industry at large.

Mike O'Neill

Citation

Mike O'Neill started his career with Ontario Hydro in 1980. He spent the first 20 years working in reactor physics safety analysis. In 2000, he was made the Manager the of the Reactor Safety Engineering Department at Pickering B. From 2005 until his retirement in 2011 he was the Manager of the Nuclear Safety Analysis and Technology Department. In this he also assumed leadership of the OPG Reactor Safety Program, the Risk and Reliability Program and the Fuel Program.

Mike O'Neill has made numerous outstanding contributions to reactor operational safety. Some of these are: uncertainty analysis for maximum channel and bundle power; rod-based guaranteed shutdown state; leadership of the industry nuclear safety committee; championing the development of the best-estimate and uncertainty analysis methodology; and resolution of the heat transport aging management issue by implementing enhancements to neutron overpower analysis methodology.

Throughout his career, Mike O'Neill has been sought for his sage advice by working-level staff and by senior managers, within OPG and by other Canadian Nuclear Operators.

Mike O'Neill's commitment to excellence, selfless devotion to his staff, his colleagues and the industry have earned him a very high level of respect from all echelons within OPG and the broader nuclear industry.

Derek Lister

Citation

Dr. Derek Lister is a Professor Emeritus at the University of New Brunswick. He has been involved in the Canadian nuclear community for over four decades, dating from 1969 when he first came to Canada from the UK to work for AECL at Chalk River. Over his 23 years at AECL, Derek solidified his position as one of the leading world experts in activity transport in reactor coolant systems, a topic that relies on fundamental understanding of materials corrosion and disposition of corrosion products.

Upon moving to academia in 1992 as the NSERC Chair in Nuclear Engineering at UNB, Derek established a world-class nuclear research laboratory at UNB. He continued investigating in the areas of activity transport, heat exchanger fouling mechanisms and flow-accelerated corrosion in CANDU feeders and feed water systems. He has supervised the research of over 50 students.

Even in retirement he continues his leading-edge programs at UNB and continues to train students. He sits on numerous nuclear-industry boards and expert panels including the AECL Advisory Panel, the Advisory Council to the Canadian Nuclear Waste Management Organization, the UNENE Board of Directors, and the Expert Panel for the NRCan Generation IV Reactors Technology Program. He has been an active member of the Power Plant Chemistry Working Group for the International Association for the Properties of Water and Steam.

John S. Hewitt Team Achievement Award

The *John S. Hewitt Team Achievement Award* was established by the CNS in 1994 to recognize outstanding team achievements in the introduction or bringing into effect new concepts or the attainment of difficult goals in the nuclear field in Canada. The award is named in honour of a founding member of the Canadian Nuclear Society, who gave strong support to the Society over many years.

Three awards were presented.

AECL MFMI Team

The objective of the Molten Fuel-Moderator Interaction (MFMI) experiments conducted by T. Nitheanandan, G. Kyle and R.F. O'Connor was to address one of the very low probability postulated accident events in CANDU reactors. The program was the first of its kind in the world that looked at the behaviour of molten corium ejected from a pressurized vessel. The program provided numerous technical challenges and required extensive communication and interaction between the experimenters, industry sponsors and the CNSC, all of whom were involved in establishing the requirements for the tests.

The experiments demonstrated that, if molten fuel is ejected at high pressure, the melt particles experiments will be finely fragmented when they interact with the surrounding heavy water, resulting in a gradual energy transfer and a modest rate of pressure increase that would not pose a risk to the calandria vessel integrity.

The experiments convincingly demonstrated the inherent safety of currently operating CANDU reactors and successfully provided a positive answer to a generic safety concern.

The dedicated effort of the MFMI team over eight years, despite technical, regulatory and logistical challenges, was instrumental in the success of the work.

2009-2010 NRU Return-to-Service Team

On May 14, 2009 the NRU reactor at Chalk River Laboratories was shut down due to loss of electrical supply from the provincial grid. Subsequent investigation revealed a leak of heavy water at the bottom of the reactor vessel.

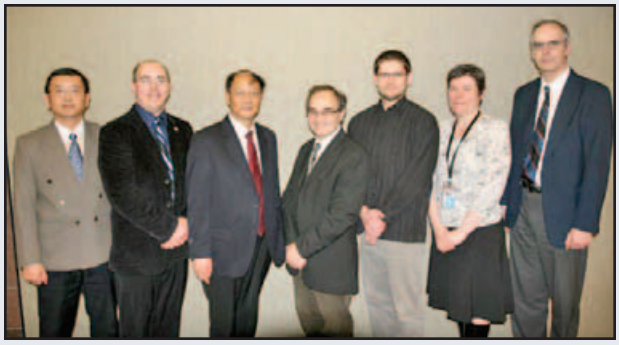
For the next 15 months a small army of engineers, skilled trades, operators, managers and support staff laboured at one of the most complex, unique, and time-pressured repair jobs ever attempted in industry. Through the dedication and skill of this team, which included between 300 and 400 AECL staff in addition to several hundred staff from supplier organizations fulfilling over 40 separate contracts, the NRU was successfully repaired and restarted to high power by August 17, 2010.

The successful return-to-service of NRU involved no single line of management, no single technical discipline, and no single company. It was a coordinated effort involving hundreds of individuals on demanding schedules (often 24/7), working with skill and pride toward a common goal.

This award specifically recognizes the following corporate contributors to the NRU 2009-2010 Return-to-Service, which are considered to be the major players: **AECL, Promation Nuclear Ltd., The Welding Institute, Eclipse Scientific, CentreLine (Windsor) Ltd., Liburdi Automation Inc., Goldak Technologies Inc., and ODIM Numet**. In addition, over 30 other companies contributed to the NRU 2009-2010 Return-to-Service team.

CNSC NRU Return-to-Service Team

During the 15-month unplanned outage of the NRU reactor, the Canadian Nuclear Safety Commission (CNSC) formed a small team to ensure that AECL had clear requirements and expectations for its multi-faceted work program. This core group of 10 CNSC personnel had to adapt requirements to the unique technical



challenges of the NRU repairs, and sought out process efficiencies to ensure the CNSC remained off the "critical path" for the restart of the reactor.

The CNSC group demonstrated outstanding performance, thus inspiring the rest of the project team. Good communications were also required and the team ensured that team members and CNSC Management had up-to-the-minute information at critical times. As well, there was open dialogue on technical issues allowing the CNSC to provide a clear and early feedback to AECL.

The core team took the leadership role from the beginning, defying both technical challenges and time constraints, contributing to the success of the project, with new ideas, efficient new processes and extremely hard work.

The core group of the CNSC NRU Return-to-Service Team comprised the following staff: Miguel Santini, Etienne Langlois, Reuben Marini, Jamie MacDonald, Ben Prieur, Nathalie Riendeau, Blair Carroll, Zhaojing Zeng, Sue Liu and Xuejun Wei.

Innovative Achievement Award

The *Innovative Achievement Award* was established by the CNS in 1991 to recognizes significant innovative achievement or the implementation of new concepts, which display clear qualities of creativity, ingenuity and/or elegance, and embody an impressive accomplishment in the nuclear field in Canada".

One award was presented.

Liburdi NRU Team

The Liburdi NRU Repair Team comprised seventy-five professional engineers, engineering technologists/technicians and specialists from Liburdi Automation Inc. They worked together in a coordinated effort and under extreme pressure in order to return the NRU to public usefulness as quickly as possible.

Between June 2009 and April 2010, the Liburdi NRU Team was responsible for creating the repair procedure, including the design and manufacture of specialized, one-of-a-kind tooling to execute the repair, which returned NRU safely back to service in August 2010. This included critical consideration to key elements of the repair tools, such as functional, mechanical and performance requirements inside the reactor, vision systems, electrical systems, and control and instrumentation. Tool delivery systems through a narrow access point, design of the weld build-up tool, and contingency tooling were also important.

The Liburdi NRU Repair Team designed and developed the repair tools to conduct the horizontal and vertical repair welds inside the reactor. The team introduced or brought into effect new concepts in the attainment of a difficult goal in the nuclear field in Canada, namely the returning of NRU safely back to service in just a little over a year from the date the team became involved in the project.

Education and Communication Award

The *Education/Communication Award* was established by the Canadian Nuclear Society in 1997. The award recognizes significant efforts in improving the understanding of nuclear science and technology among educators, students and the public".

Two awards were presented.

Bryan White

Bryan White is a former chair, long-time member, and tireless supporter of the CNS Education and Communications Committee. Addressing a significant gap in the teaching and comprehension of radiation, Bryan designed, developed, and implemented a comprehensive, yet user friendly, radiation workshop which he and others have presented to high school science teachers across the country.

Called "Be Aware of NORM" (Naturally Occurring Radioactive Materials), the workshop provides teachers with a physics review of radioactivity, and introduces them to a series of classroom experiments. Realizing that both teachers and students alike are becoming numb to "virtual" experiments Bryan has effectively re-introduced the sense of awe and discovery to students by utilizing the AWARE RM-80 Geiger counter, coupled to computer display software, which has allowed students to make real, live measurements from a variety of sources.

Bryan also recognized the need for sensitive measure-

ment equipment in the classroom, and developed a Geiger kit for distribution to high school science teachers, complete with Geiger, radioactive sources, instructions, experiments, and a feedback channel. Requests to the CNS for this kit have been numerous.

Through Bryan's determination, vision, technical expertise, and selfless dedication to the improvement of science education, the CNS is today able to offer an accessible, reasonably affordable, and sorely needed curriculum resource to the Canadian high school classroom.

Igor Pioro

Dr. Igor Pioro is an Associate Professor and Graduate Program Director in the Faculty of Energy Systems and Nuclear Science at the University of Ontario Institute of Technology (UOIT) in Oshawa, Ontario. He has developed and taught courses in nuclear engineering that cover a broad range of areas, including laboratory methods and experiments. He has taught courses at the University of Ottawa and the National Academy of Sciences, Kiev, Ukraine.

Dr. Pioro has (co-)authored several books that have made significant contributions to nuclear engineering education. This includes the book entitled "Heat Transfer and Hydraulic Resistance at Supercritical Pressures in Power Engineering Applications" (2007).

His book entitled "Transfer Processes in Two-Phase Thermosyphon Systems - Theory and Practice" (2005) was awarded the First Prize from the National Technical University of Ukraine as the Best Technical Book of 2007.

Dr. Pioro has made significant efforts in improving the understanding of nuclear science and technology among educators, students and the public. His contributions have been recognized nationally and internationally through awards and honours. Dr. Pioro has received enthusiastic feedback from his students. He has contributed significantly to graduate level education in his capacity as the Director of Nuclear Engineering Programs at UOIT.

Fellow of the Canadian Nuclear Society

CNS members who are appointed *"Fellows of the Canadian Nuclear Society"* belong to a membership category established by the Society in 1993 to denote extensive contributions to the Society and meritorious service to the nuclear field in Canada.

One member was appointed.

Jim Harvie

Jim Harvie started his work career at the AECL Chalk River Laboratories. In 1974 he moved to the Atomic Energy Control Board as Project Officer at the Bruce Nuclear Power Development. In 1991 he was made the Director General of the Research and Safeguards Directorate, becoming deeply involved with the IAEA and Canada's international partners in Safeguards and Non-Proliferation.

From 1996 until his retirement in 2002, Jim was the Director-General of Reactor Regulation at the Canadian Nuclear Safety Commission. He dealt firmly and wisely with a number of significant issues. On the international front, Jim was Canada's head of delegation at the first review meeting of the signatories of the International Nuclear Safety Convention.

Jim has been a strong contributor to the CNS for many years. He spent two years as Chair of the Ottawa Branch before he was elected to the position of Treasurer of the CNS in June 2005. He continued on the CNS Executive through 2010, and was CNS President for the Council year 2008-2009.

R.E. Jervis Award

The *R.E. Jervis Award* recognizes excellence in research and development as well as in overall academic achievement by full-time graduate students in nuclear engineering or related fields. The Award was established in 1992 by former students of Professor Robert E. Jervis of the University of Toronto, and the CNS to honour his achievements. In the past the award was administered by the University of Toronto. It is now sponsored and administered by the Canadian Nuclear Society.

One award was granted.

Kevin Daub

Kevin Daub is a graduate student in the Department of Chemistry at The University of Western Ontario. His graduate research work is in the area of oxide growth and conversion on metal surfaces in the extreme aqueous environments created by ionizing radiation and high temperatures. His work focuses on the impacts of these conditions on the corrosion of nuclear reactor materials.

Kevin's research efforts have led to very valuable results and to published technical reports. He has presented his work in prestigious conferences, including as an invited speaker at the Gordon Research Seminar

on Aqueous Corrosion and as an invited plenary speaker at the 8th International Radiolysis, Electrochemistry and Materials Performance Workshop. His presentations have won poster prizes at the CNS/CNA Student Conference and at the Surface Science Division of the Canadian Society for Chemistry. Already requests have been received from national and international laboratories for his participation in collaborative projects.

Kevin's work is giving valuable insights into the types of corrosion films that can be generated in reactor systems and the conditions that control the film type and growth rate. Understanding this will help to optimize reactor operations and maintenance, including the procedures and chemical control to maintain protective oxide films.

Young Generation hold Successful Seminar

Ed. Note. The following report is based on a submission to "TalkNuclear.com" by an unknown participant of the NA-YGN seminar.

On the Sunday immediately before the 2011 CNS Annual Conference, June 5, 2011, the Canadian arm of North America – Young Generation Nuclear (NA-YGN) held a seminar in the conference hotel in Niagara Falls.

With the theme *"Nuclear Knowledge and Leadership"* this successful event was attended by 65 enthusiastic members from the 6 Canadian chapters of NA-YGN.

After a warm welcome by Chris Waugh, NA-YGN Canadian Regional Lead, the attendees enjoyed a fun filled ice-breaker session to encourage networking. The session consisted of wearing Burger King crowns and playing the "headbands" icebreaker game where participants had to ask each other yes or no questions to guess the picture attached to their crown. Each picture was related to the nuclear industry. This exciting icebreaker was well facilitated by Natalie Sachar and the team from the AECL Chalk River chapter.

The seminar then continued with a very tasty lunch sponsored by Cameco Corporation menu consisting of pastas, salads and desserts. NA-YGN thanks Cameco and the Sheraton on the Falls staff for their excellent service.

After lunch the attendees gathered back in the seminar room for a humorous and interesting presentation by Dr. Jeremy Whitlock, Research Physicist, AECL Chalk River and the author of the website www.nuclearfaq.ca. Canadian nuclear facts and frequently answered questions were discussed in addition to some tips on how to best communicate with our friends, family and general public about the nuclear industry. He finished off by touching on the unfortunate events at the Fukushima – Daiichi site in Japan.

An innovative approach to professional development was taken by Gwen Rousseau, Process Engineering Manager at AECL Mississauga with a presentation entitled "The People Puzzle." The session focused on identification of personalities and how our personalities affect our interaction with others. Gwen developed an immediate rapport with seminar attendees and engaged her audience from start to finish.

After enjoying a short coffee break to allow for further networking, there was a four person panel on the topic of *"MBA vs. M.Eng: What's the Value Proposition"*. This panel members were: Shehab (Sunny) G. Mustafa, M. Eng. P. Eng.; Mayur Upadhyay, MBA P. Eng.; Arin Gharakhanian, E.I.T. M. Eng.; and Zeeshaan Mustafa, MBA, P. Eng., all from the Durham chapter They spoke about their personal experiences of completing the University Network of Excellence in Nuclear Engineering (UNENE) M. Eng. program and the University of Toronto Rotman School of Management MBA program. The panelists left a key message – graduate degrees are very rewarding but make sure to find the right school, the right program and make sure to be doing it for the right reasons!

The final insightful presentation was entitled *"Sustainable Development – A Uranium Mining Perspective"* by Dara Hrytzak-Lieffers, Corporate Social Responsibility Manager at Cameco Corporation and the chapter lead for the Cameco chapter. The audience was educated on the stakeholder engagement in Cameco's decision- making process as well as key initiatives for ensuring a sustainable fuel source is continually being developed for the nuclear industry.

The seminar concluded with a wonderful message by Duncan Robinson, NA-YGN's President. He encouraged the young professionals in nuclear to continue participating in conferences and PD seminars sessions as a way of educating ourselves and developing our professional networks. He deeply appreciates the efforts that were made by the NA-YGN Canadian team and hopes to support similar PD seminars and other regional events in the future. He advocated for greater participation from members of the NA-YGN Canadian chapters in all aspects of NA-YGN, including running for a position on the Core executive team, joining one of the various committees that NA-YGN offers or simply volunteering at the local chapter level.

This professional development seminar was a fabulous opportunity to learn new skills and meet new people. Thank you to the Canadian Nuclear Society and the many volunteers of NA-YGN for ensuring this event was a success!

For any questions about NA-YGN in Canada, please e-mail Christine John (Canadian Affairs Chair) and Chris Waugh (Canadian Regional Lead) at canada@na-ygn.org.

W.B. Lewis Lecture

by William (Bill) Pilkington, Senior Vice-President, AECL.

I'd like to thank the R&D Advisory Panel to AECL's Board of Directors, and the CNS, for this opportunity to speak to you today. I am here to share my perspective on a number of issues facing the Canadian nuclear industry and the CANDU® reactor design. I emphasize that these are my personal views and these are issues that, one way or another, affect everyone in this room.

I have a strong personal bias that I will declare up front. I have spent my entire 33 year nuclear career working with CANDU technology. I have come to appreciate the talent and capability in all segments of this proud industry. I have had the good fortune to see the industry from more perspectives than most and it has given me an integrated picture of our technology, a technology that must be preserved, a technology that will be the source of future value for Canada with exciting career opportunities for Canadians.

I have spent most of my career in a period of consolidation in the nuclear industry. There have been no new construction starts in Canada in that 30 plus years, and few globally. Why? Certainly there have been economic factors, but the main issue has been public confidence in our industry. I entered the industry in 1978 during a period of expansion with Pickering B, G2 and Lepreau all in the later stages of construction and commissioning. Bruce B was in the middle of construction and Darlington in an advanced design stage. The accident at Three Mile Island occurred during my first year in the nuclear industry. It led to delays in completing existing projects across North America, cancellation of projects, even in advanced stages of construction – the Shoreham plant on Long Island was in low power testing when it was cancelled and it was never restarted. For the most part, Canadian units got in under the wire. There were challenges meeting regulatory requirements in an environment of heightened sensitivity. Although hard to quantify, they did contribute to some start-up delay. The Darlington project faced greater challenges. Slow load growth, technical issues and the politics of the day led to work slowdowns and stoppages/re-starts. The result was a long and costly delay. Today, as the industry moves forward with an unprecedented number of new build projects, with developing countries leading the way, events at Fukushima will undoubtedly result in pause and consideration of what more our industry must do to reduce its future impact on society.

Let me go back and briefly trace the development of CANDU technology over the last half century. Following the success of the 25 MWe Nuclear Power Demonstration Unit (NPD) at Rolphton Ontario, Douglas Point was built as the first commercial scale CANDU plant, with a gross output of 220 MWe. Although Douglas Point faced many first-of-a-kind performance issues, it remained in service from 1968 to 1984 with a lifetime capacity factor of just over 50%. Although it was never replicated in Canada, it did lead to a fleet of similar units in India, and passed on many design features to the KANUPP plant in Pakistan. It also resulted in partnership between AECL and Ontario Hydro to facilitate nuclear expansion and growth that would provide long term stimulus to Canada's fledgling nuclear power industry.

Pickering A followed with 4X540 MWe units entering service between 1971 and 1973, and Bruce A with 4X800 MWe units in service between 1977 and 1979. The early success of both plants led to four "B" units at each site, similar, but with design improvements over the "A" units. As the industry expanded in Ontario, Ontario Hydro developed a large Nuclear Construction Organization and took over much of their plant design from AECL.

In parallel with the Ontario Hydro "B" units, AECL designed and built the initial CANDU 6 fleet with single units at Point Lepreau and Gentilly2 entering service in 1983, and eventually a CANDU 6 fleet totaling 11 units, with 9 of them off-shore.

Darlington followed the Ontario Hydro "B" reactors with 4X935 MWe units coming into service between 1990 and 1993.

Overall, if one looks at the operating performance of the existing CANDU fleet, it is clear that successive new build projects have resulted in continuous improvement of the CANDU design by addressing recognized reliability issues, adopting technology advances and taking advantage of economies of scale. If one looks at lifetime capacity factor alone, the CANDU 6 has the lead at 89% for the fleet, and if operating cost is the measure, the Darlington and Bruce B multi-unit stations rank first due to economy of scale in both staffing and unit size. Darlington is notable for having the most aggressive outage plans in the CANDU industry.

From an operator's perspective, there are several performance issues that must be addressed to optimize

lifetime performance. Some aspects can be applied to the existing fleet, and all must be addressed for future CANDU plants.

Fuel channel life and mid-life refurbishment cost and schedule provides the greatest opportunity for lifetime performance improvement. The goal must be to achieve longer service life for calandria tubes and pressure tubes, more efficient deconstruction/ reconstruction programs, and reduced labour intensity/dose requirements. Feeder thinning has also led to costly repairs impacting outage critical path on some units. Extended feeder life must be assured going forward.

To date, the current set of refurbishment projects on CANDU 6 and Bruce A units are succeeding technically, but have not met schedule and cost targets. Wolsong Unit 1 is well into start-up and is currently undergoing low power testing. Bruce Unit 2 is preparing to load fuel. In all cases, there have been improvements in tooling and processes as the work has progressed. Capturing these lessons learned and applying them to future refurbishment projects can result in cost effective life extension programs for the utilities and a profitable line of business for the successful service provider.

Maintenance program effectiveness /planned outage frequency and outage duration make up the second greatest area of opportunity for improvement. For all units built in Canada prior to Bruce unit 8, fuel channel spacer location and repositioning has dominated outage critical path, reducing capacity factor and adding to maintenance costs. In total, it has been costly to the Canadian nuclear industry and has significantly reduced operating performance of CANDU units later in life.

Safety System maintenance and testing can be improved to allow for longer operating intervals, reduced post-outage testing, and less production risk for on line maintenance and testing. Single point vulnerability and critical component reliability must be improved by design and through utility implementation of effective Plant Life Management (PLiM) programs. Overall, more consideration must be given in the design stage to the operability and maintainability of the plant.

Other areas where improvement can be made include increased fuel handling system reliability, tritium management strategies and avoiding loss of ROP margin/ de-rate late in life due to pressure tube diametral creep.

Design changes to implement significant performance improvements to operating units, are hard to justify. They seldom yield the expected payback, consume scarce resources and create complexity which, in the end, adds to the overall cost of operation, maintenance and training. The best time to implement fundamental design improvements is during the design of new units. At this stage, improvements can be properly integrated into the overall design process, the plant layout, and all of the documents supporting the design and operation of the facility.

In the tradition of continued evolution and improvement, AECL currently has two CANDU reactor designs available for new build; the Advanced CANDU Reactor®, (ACR-1000®) and the Enhanced CANDU 6® (EC6®).

The ACR-1000 is the most advanced CANDU reactor as a 1200 MWe class Gen III+ design. The ACR-1000 design has been reviewed by the CNSC which concluded there are no fundamental barriers to licensing in Canada. Design features include:

- Increased economy of scale with gross output of 1165 MWe
- Heavy Water Moderator and light water coolant for economy, simplicity and tritium management
- Higher Primary Coolant Operating temperature and pressure for increased thermal efficiency
- Slight fuel enrichment for improved physics, burnup and fuel flexibility
- Fuel channel design for 60 year plant life with a planned mid-life replacement
- Re-designed fuel handling systems
- A modern distributed control system
- Design and layout improvements for operability, maintainability, and testing
- Designed for a 3yr outage frequency and minimum outage duration
- Enhanced protection and mitigation for Beyond Design Basis Events

Simply put, the ACR 1000 design addresses every item on my list of CANDU performance issues.

The reference CANDU 6 as built for Qinshan is a high performance machine capable of 90%+ capacity factor right out of the box. The EC6, upgraded to meet Gen III criteria for passive safety features, process control and operating performance offers a product of proven constructability in the 700 MWe class. It is the only proven product available in the mid-sized range, and also has fuel-cycle flexibility. Safety and operating performance are enhanced by adapting a number of the design features and performance features developed for the ACR program. Some of these design enhancements include:

- Designed to meet current Canadian regulatory requirements (RD-377, RD-360)
- Robust steel lined containment
- Seamless calandria tube and target 60 year plant life with mid-life fuel channel replacement
- Modern distributed control system
- Design for three-year outage frequency and minimum outage duration
- Computerized safety parameter display system, safety

system testing and online risk monitor
- Enhanced protection and mitigation for Beyond Design Basis Events

The design enhancements of the EC6 also address the items on my list of CANDU performance issues. That said, improvements to mid-life refurbishment, fuel handling systems and tritium management are less than the advances achieved on the ACR-1000. It's important to note the improvements made to the EC6 do not introduce risk to performance or constructability when compared with the successful CANDU 6 reference plant.

In my discussion on ACR and EC6, I have only briefly mentioned fuel flexibility since I don't believe this is currently an important consideration in evaluating new build options in Canada. I judge safety margins, bundle cost and burn-up to be the main areas of interest with nuclear fuel. It is worth noting that internationally, there is a growing interest in CANDU technology using recovered uranium and thorium cycles, particularly in China.

Discussion on the features of the current CANDU product line raises the question of how CANDU technology will make the next step forward in innovation. Gone are the days when AECL could maintain a continuing reactor development program and undertake new designs without a certain market. In my view, the most successful path forward for continued CANDU evolution will be through international collaboration. In reality, this is already occurring in the Generation IV reactor program (e.g., Super Critical Water Reactor–SCWR), and is the model being followed for advanced fuel cycle development. Additional investment will be required if Canada is to be a credible partner in these programs and the question I leave open is how that research and development funding will be made available in the future.

The most important opportunity for CANDU technology at this time is the plan for nuclear new build in Ontario. I'm sure all of us were elated to hear the opening remarks of Tom Mitchell, President and CEO of OPG, at the CNA Conference in February of this year when he spoke to the merits of continuing to use CANDU technology and the merit of building enhanced CANDU's at the Darlington site.

Why should Ontario choose CANDU for nuclear new build at Darlington? It all comes down to net benefit to the province in terms of maximizing jobs, and to providing reliable base load power at the lowest cost to consumers.

Looking first at jobs, the Conference Board of Canada published an independent study in March 2009 titled "The Economic Impact of New Nuclear Investments in Canada". They estimated AECL would source up to 90% of their expenditures on a Darlington new build project in Canada, with the most of that spend in Ontario. This compared to 40% to 60% for a foreign reactor supplier. Also, a successful Darlington project would increase the likelihood of additional reactor sales in Canada and internationally. These future sales would use many of the same suppliers resulting in sustained investment in Canada and particularly in Ontario.

Providing reliable low cost power to consumers results from demonstrated reliability with continuous improvement throughout the evolution of the CANDU design, confidence in the licensing process, experienced CANDU operators, and a competitive Levelized Unit Energy Cost (LUEC).

LUEC analysis would conclude, if built on time and on budget, the ACR-1000 will produce electricity at a lower cost than EC6. However, for nuclear, the original capital cost is the dominant factor in the LUEC calculation, and the additional costs associated with building First Of A Kind (FOAK) can have a dramatic impact on the overall economics of a nuclear plant. For example, although both the CANDU 6 and Darlington designs proved successful, both came in at more than double the original estimate, for reasons which I spoke of earlier. The current cautionary example would be the EPR construction at Olkiluoto in Finland.

Failing to go with the newest technology can also result in missed opportunity. I worked on Pickering B commissioning early in my career, and moved from there to Point Lepreau where I marveled at the relative simplicity of the CANDU 6 design. At that time, CANDU 6 was unproven, and I've already pointed out there was a FOAK penalty to be paid, but three CANDU 6 units could have replaced four Pickering B units. The lifetime performance of Pickering B is about 77% compared with the median performance of the CANDU 6 fleet at 89.9%.

There is room to debate how much of the ACR-1000 design is incremental evolution and how much is fundamental innovation when compared to the EC6. I simply recommend that OPG be rigorous in their technical assessment of ACR to avoid overstating the FOAK risk.

Let me now talk about the future of AECL and the potential sale of AECL's commercial business. I believed, and many of us hoped, the restructuring of AECL would be complete by now, and my talk could look forward to the synergies created by the new investor(s) and the opportunities that lie ahead for AECL's Commercial Business. Well, we are still in limbo. The negotiation process continues behind closed doors and progress remains confidential, as it must.

It's a very complex situation with the Government of Canada and the potential new investor or investors determining the future direction for both AECL

Commercial Operations, and the Nuclear Labs at Chalk River and Whiteshell; creating a new relationship between these organizations and the 5000 people who are the AECL of today. Other key stakeholders include the Government of Ontario - through Infrastructure Ontario and OPG, the Organization of CANDU Industries (OCI), the CANDU Owner's Group (COG) plus AECL's customers, partners and collaborators around the globe. Finally, we must not forget the opponents of nuclear technology, who see the current circumstances as an opportunity for Canada to move away from nuclear technology and nuclear power production. I encourage the federal government to move forward expeditiously with restructuring, to preserve the value of both components of the current Crown Corporation.

The Nuclear Labs at Chalk River currently have a strong focus on CANDU technology. That capability is essential to supporting the current CANDU fleet, and the source of innovation to continue to evolve the technology, supporting the current AECL Commercial Operations. The nuclear utilities are focused on the near term as they should be; on reliable low-cost generation from the facilities they currently operate. Most of the support they need is in solving materials and chemistry issues encountered with plant aging and in advancing specialized CANDU reactor inspection systems. It is important to maintain a critical mass of scientists and engineers, experts in their field, available to address issues as they emerge to assure the highest levels of safety and reliability are maintained in the CANDU fleet. The availability of well-equipped Hot Cells to examine irradiated reactor components and fuel is also a must as is maintenance on the suite of unique CANDU computer codes that support plant operation and the design safety basis.

COG must be recognized as an important bridge between the utilities and the research community and also serves to keep AECL product development in step with utility-initiated R&D. COG has evolved into an effective forum to focus utility research dollars on directed R&D to address common issues and manage joint projects. Until now, AECL has enjoyed voting membership in COG in a dual role of supplier and participant customer. The restructuring of AECL is bound to disturb the balance between COG members and will require patience and effort by all stakeholders to preserve and enhance the benefits COG programs bring to the CANDU industry worldwide.

Having delved into the cautions in restructuring, I'm confident it will drive to a successful completion. There are many opportunities that lie ahead for the new commercial company that will evolve from AECL. One could argue that a private company would have approached life extension projects differently than AECL has, perhaps with more favorable results coming earlier. A more thorough assessment of the schedule and cost risks years ago could have led to greater up-front investment in tooling and process qualification for risk mitigation. Different contract structures and alliances for project execution might have yielded a higher level of performance. All of those possibilities are now water under the bridge, but the lessons learned at Bruce, Wolsong and Lepreau will serve the new company well. I am confident the hardest lessons have been learned, and what lies ahead represents an opportunity to turn them into successful projects going forward. The projects completed and in progress to date represent only the first wave of life extension, with opportunities at G2 and Embalse Argentina, at Bruce Units 3&4, the four units at Darlington, the Bruce B units, more international CANDU 6's... life extension is a long term line of business.

Restructuring during the time when new nuclear build is being pursued for Ontario at Darlington also represents a broad opportunity for many stakeholders. A new investor bringing proven capability in large project management, can improve the efficiency of delivery of AECL's design, and result in a win for Ontario as the customer, Ontario workers and the Organization of CANDU Industries as suppliers, and Canada overall, with a much needed boost in the high tech manufacturing sector. A new shareholder will take over the business with a healthy order book, in all likelihood having a major new build project to deliver, and the Canadian Government has a viable exit strategy from its role as a nuclear vendor. Having an enhanced design of a proven product under construction in Ontario will also provide the new investor with an attractive product and potential for additional sales in Canada and abroad, building on the overall benefits of CANDU technology.

I know everyone in this room was saddened by the recent events in Japan. Information on the sequence of events and response to the emergency both on and off site are still being compiled. The Initial response of regulators world-wide has been to require utilities to review and report on their level of preparedness for beyond design basis accidents involving external events including seismic events, flooding, fire and other natural disasters, and total station blackout as a generic issue. In addition, licensees are required to review their severe accident management plans and mitigation currently available to respond to these events. An initial review by the Canadian industry has not found any serious flaws in CANDU station safety systems and safety support systems design; however off-site response capability and procedures to deal with severe accidents can be improved. CANDU reactors have large cores with relatively low

decay power densities, and relatively high heat capacity due to the large volumes of water in the moderator, shield tank /end shields and reserve water tank. These features allow for longer response times for operators to establish alternate sources of cooling to avoid severe core damage.

Fully assessing the learning from Fukushima and taking any necessary compensatory measures for CANDU plants will occur over a span of several years. Initial assessments in response to directives from the CNSC and WANO SOER 2011-2 don't indicate an immediate impact on Canadian units currently in operation. In the short term, improvements to on-site and off-site emergency response capability are likely to be required. This may involve additional equipment on site or available to site and supporting infrastructure. In the longer term, extensive design changes are not predicted, but even modest changes to permanent plant equipment and systems will take several years to design and implement effectively.

The greatest impact of Fukushima is expected to be a reduction in public acceptance of expanded use of nuclear power. This will undoubtedly lead to delay in some jurisdictions to commit to new nuclear projects until the potential for public opposition is understood and any additional regulatory requirements and associated costs are known.

To summarize in just a few words, we are at a time of great opportunity with new build and major life extension projects at hand. We are also at a time of change, and it is up to us as the Canadian Nuclear Community to make it a positive change. The tragedy at Fukushima adds to our challenge and serves to remind us of our responsibility to society to make safety our first priority in everything we do.

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Enhanced CANDU 6 (EC6): A Proven Mid-Sized Reactor with Fuel Cycle Capability

by JERRY HOPWOOD, MICHAEL SOULARD and IAN J. HASTINGS[1]

[Ed. Note: The following paper was presented at the 2011 Annual Canadian Nuclear Society Conference held in June at Niagara Falls, ON.]

Abstract

Atomic Energy of Canada (AECL) is finalizing development of the Enhanced CANDU 6â* (EC6â*), which incorporates the CANDU 6's well-proven features, and adds enhancements that make the reactor even more safe and easier to operate. The EC6 is the only mid-sized reactor (700 MWe class) with a proven pedigree that meets modern reactor expectations and regulatory standards. It is sized for smaller grids and also has outstanding fuel-cycle capability. Changes are incremental and consistent with the CANDU 6 project approach. The EC6 utilizes modern computers and a distributed control system housed in an advanced control room which, along with automated testing and on-line diagnostics, make the plant easier and safer to operate, with minimal operator intervention. Containment and seismic capability are upgraded to meet modern standards. The first deployment of the EC6 is anticipated in Canada; international markets are also being pursued. AECL is performing a comprehensive review of the EC6 design in the wake of the Fukushima accident, will review lessons learned, and incorporate any necessary improvements into new build design.

1. Introduction

The Enhanced CANDU 6 (EC6) [1] is a 700 MWe-class, heavy water moderated, pressure tube reactor, designed to meet modern regulatory requirements and provide safe, reliable, nuclear power. In the EC6, the CANDU 6 design continues its product evolution since the initial construction of the plants at Point Lepreau, Gentilly-2 and Embalse; safety and operational improvements have been incorporated in subsequent projects at Wolsong and Cernavoda, then further enhancements at Qinshan. The EC6 reactor builds on this success of the CANDU 6 fleet by using the project, operational, and feedback experience to upgrade the design and incorporate improvements to meet modern safety standards. Well-proven CANDU reactor strengths, retained in the EC6, include:

- Neutron economy
- Modular, horizontal fuel channel core
- Separate low-temperature and -pressure moderator
- Reactor vault filled with light water surrounding core
- Onpower refuelling
- Two independent passive, safety shutdown systems

Further advantages accruing to the EC6 are proveness, track record (low project risk), unique size and operating performance. The EC6 satisfies modern safety and plant criteria, typically characterized as Generation III.

Also, the EC6 can use a variety of nuclear fuels in addition to the standard natural uranium. High neutron economy, on-power refueling, a simple fuel bundle, and the fundamental CANDUâ* fuel channel design provide the EC6 with flexibility in accommodating a range of advanced fuels and fuel cycles [2].

2. EC6 Design Features

2.1 Reduced Project Schedule

AECL and its partners have already demonstrated on-time, on-budget project performance with the CANDU 6. The EC6 first-concrete-to-in-service project schedule is targeted for 57 months, with a second unit to follow six months later. These targets will be achieved by the use of additional modularization, open-top construction using a Very-Heavy-Lift crane as demonstrated at Qinshan Phase III, pre-ordering of long lead-time items, and standardization of equipment such as valves, tanks and piping.

2.2 Extended Plant Life

The EC6 target design life is 60 years, with replacement of critical equipment, such as fuel channels, around mid-life. All life-limiting factors have been evaluated and addressed, supported by extensive R&D. The objective is achieved by elongating the fuel channel bearings, thickening the pressure tube, increasing the feeder wall thickness, using improved equipment and materials, better plant chemistry, and more active monitoring of critical plant parameters. Doubling the useful life of the reactor assures the plant owners of a long-term supply of electricity, with an improved return on investment.

2.3 Simplified Operability and Maintainability

AECL utilizes feedback monitoring, receiving input from operating plants (OPEX) and incorporating it into the design of CANDU reactors. Based on this feed-

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back, AECL is modifying systems to simplify maintenance and reduce operator workload. For example, the cooling water system design has been improved to have dual trains that enable interconnections of these trains during maintenance or plant upset conditions. Also, automated safety system testing will be incorporated. This will not only reduce the testing workload but will also eliminate human errors that can cause inadvertent reactor trips. In addition, AECL has developed plant health monitors that will be incorporated, or added as retrofits to existing plants.

2.4 Modern Computers and Control Systems

The EC6 has enhancements that modernize the plant and address equipment obsolescence. These features simplify plant displays, reduce the amount of wiring runs and save construction effort and costs. The Digital Control Computers will be replaced with a modern, state-of-the-art Distributed Control System (DCS), designed to control and monitor systems such as reactor operation, power-generation equipment, fuel-handling and auxiliary systems. The DCS supports both group and device control, reducing the need for individual group controllers.

In addition, a Plant Display System (PDS) to manage operator interactions with the DCS will be included. The DCS/PDS also will include the functionality required to manage plant annunciation and support on-line procedures. The EC6 incorporates the above features in a modern Advanced Control Room. Safety system operation is retained as a hardwired function. Computerized testing and displays have also been added to ease the operator's workload.

2.5 Optimized Plant Outages

To improve the EC6 capacity factor, AECL performed a detailed assessment of the requirements for planned maintenance outages. Periodic short-duration maintenance outages of 30 days once every 36 months are planned. The increased interval will be achieved by automating tasks such as shutdown systems testing. Most of these tasks can be undertaken with the reactor at power. Additionally, Reliability Centered Maintenance techniques are used extensively, and plant health-monitoring equipment predicts impending equipment problems, which can be acted upon immediately, avoiding forced shutdowns.

2.6 Containment Design

The EC6 features a reactor building with a 1.8m thick wall/dome, with a steel liner, in line with current industry practice. This provides protection against aircraft strikes (malevolent acts) and other external events. Further hardening of the safety systems and improvements to the spatial separation of essential safety systems are being built into the design. Group 2 safety systems, which offer a redundant path to shut the plant down safely. Depending on the location of the plant, the EC6 can also be designed to meet tornado protection.

2.7 Seismic Response

Also in line with modern industry practice, and a Gen III/III+ expectation, the EC6 is designed for seismic 0.3g peak ground acceleration, with a 10^{-4} frequency of occurrence. This is achieved via a thicker base slab and rock anchors. Other systems are also strengthened: calandria support, thicker pressure tube/calandria tube, stronger spacer and positioning assembly, hardened fuelling machine and upgraded piping material.

2.8 Severe Accident Response

To further improve EC6 plant safety, the design incorporates features to mitigate core degradation and contain the consequences of severe accidents. Such features include provisions for additional heat sinks as well as a cooling system to manage the containment temperature and pressure. The number of penetrations is reduced and the steel-lined containment structure strengthened to meet a higher design pressure. All radionuclide releases following any severe accident will be confined within containment.

AECL has already been enhancing the performance for CANDU 6 reactors under postulated severe accident conditions that go beyond the normal design basis for nuclear power plants. The heavy water moderator surrounding the fuel channels in the calandria vessel effectively mitigates the consequences of such postulated severe accidents. In addition, the moderator is surrounded by a shield tank, which also absorbs decay heat should moderator cooling fail. These features ensure fuel cooling even if both normal and emergency cooling systems are unavailable.

The EC6 will further build on these inherent passive safety features by improving the reserve water tank to supply cooling water by gravity to key systems in case of a severe accident. Also, there is the addition of a low-flow containment spray, and passive autocatalytic combiners. Postulated severe core damage accidents progress slowly, giving ample time for accident management and implementation of counter measures.

AECL is performing a comprehensive review of the EC6 design in the wake of the Fukushima accident. Post-Fukushima, the Canadian Nuclear Safety Commission made a presentation [3] to the Convention on Nuclear Safety on Canada's response, including re-affirming the CANDU two-group philosophy against common mode failure, and the presence of numerous, diverse heat sinks to manage severe accident conditions. Also noted was

that AECL would review lessons learned, and incorporate any necessary improvements into new build design.

3. Fuel Cycle Options

AECL has had a continuous fuel cycle program and vision [4, 5] for more than 40 years, including: reactor physics and core design, fuel design and fabrication, irradiation and demonstration, reprocessing and separation, cycle optimization and commercial deployment options. The advanced CANFLEX™ fuel bundle [6, 7] has been developed as the optimal fuel-cycle carrier. AECL anticipates that the first step in the evolution of CANDU fuel cycles will be the introduction of Recovered Uranium (RU), and its variants, derived from conventional reprocessing.

3.1 Recovered Uranium

Recovered Uranium (~0.9% enriched) from reprocessed LWR fuel can be used in CANDU without re-enrichment–offering access to a potentially economical supply of LEU fuel at the optimal enrichment level [8]. The enrichment level is dictated primarily by the limit placed on fuel discharge burnup. Benefits of RU include potentially low fuel costs, because, until recently, RU has been considered a waste product and a further reduction in spent fuel volumes.

A low-risk CANDU RU variant that is being currently demonstrated envisages a combination of RU and Depleted Uranium (DU), both waste streams, giving an NU equivalent (NUE). With favourable RU and DU prices, this is the most economic option, requiring no changes in the reactor or licensing and utilizing 100% waste products from other reactors. With equivalency of the RU/DU mixture to NU established, impact on the reactor core will not be different from that in current CANDUs. This fuel cycle–providing the ability to burn two former waste products (RU and DU)–differentiates CANDU plants from all other reactor options. CANDU plants offer the simplest and most cost-effective way of burning these products.

An NUE demonstration irradiation [9] is currently underway in the Qinshan Unit 1 CANDU reactor in China. Of 24 test bundles, four have already been removed; initial examination has revealed no unexpected behaviour. The next stage in this process is a full-core NUE transition.

3.2 Thorium Cycles

Thorium is a key element in AECL's fuel cycle vision for CANDU and represents a low-uranium-consumption fuel cycle option [10, 11]. Thorium capability is attractive to countries with thorium reserves but no uranium–addressing the need for energy self-reliance.

In a short-term strategy, the low-risk approach to initiating the thorium fuel cycle in a CANDU reactor is by adding the fissile component as LEU in separate elements in a mixed LEU/Th fuel bundle, using an existing fuel design. The enrichment of the LEU elements can be varied to give the desired burnup, which can be gradually increased with experience. The *in-situ* fissioning of the U-233 produced through neutron capture in Th-232, also builds up a strategic resource of ^{233}U.

However, the major benefit is achieved via closed thorium fuel cycles. In the medium term, the plutonium from reprocessed LWR fuel can be used as the fissile component in a homogeneous Pu/Th CANDU fuel bundle. A full core of Pu/Th fuel could further increase the energy derived from utilizing thorium, require no new natural uranium, and produce additional U-233 in the used fuel for future recovery and recycling. In the longer term, a self-sufficient thorium fuel cycle would be the most economically attractive, breeding enough ^{233}U that–through its recycle–could keep the fuel cycle running indefinitely, without the need for an additional, external supply of fissile material. In the future, a CANDU-FBR synergism could allow a few expensive FBRs to supply the fissile requirements of less-expensive, high-conversion-ratio CANDU reactors, operating on the thorium cycle.

Currently, AECL is exploring the feasibility of a multi-bundle thorium demonstration irradiation [9], employing the low-risk option described above. The next logical step would be a full-core demonstration. At the same time, AECL is initiating the conceptual design of a purpose-designed thorium-capable CANDU reactor, based on the C6/EC6 platform.

4. Other Fuel Cycles

AECL is continuing to develop other fuel options–including MOX and actinide waste. CANDU's ability to use low-fissile fuels also makes possible a unique synergism with light water reactors (LWRs). Recently, there has been considerable attention paid to CANDU as a "burner" of the transuranic (TRU) actinide waste that comes from reprocessing used LWR fuel [12-14]. Many TRU actinides are long-lived (e.g., Am, Cm, Np) and produce decay heat long after being discharged from the reactor. This decay heat provides waste management challenges, including the management of extended heat loading of storage/disposal facilities. CANDU's neutron economy results in a high TRU destruction rate, and on-power fuelling permits the optimum location and residence time of actinide targets.

5. Summary

Capitalizing on the proven features of CANDU technology, AECL has designed the EC6 to achieve high safety and performance standards consistent with

customer expectations. Changes have been made to meet current licensing requirements. The resultant EC6 reactor product provides a low-risk evolution of the Qinshan CANDU 6s, while providing safety, maintainability and operability enhancements. We have presented the basic EC6 design enhancements; AECL works with its customers to assess their individual design requirements.

AECL is performing a comprehensive review of the EC6 design in the wake of the Fukushima accident, will review lessons learned, and incorporate any necessary improvements into new build design.

In fuel-cycle development, AECL anticipates Recovered Uranium and Thorium will be first new fuels used in CANDU, thus introducing low-uranium consumption cycles. AECL is also developing other fuel options–with a focus on destroying actinide waste. The CANFLEX fuel bundle is the optimal carrier, tailored for individual fuels.

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Ed Note: Below is an artist's conception of a two unit EC6 station.

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GENERAL news

(Compiled by Fred Boyd from open sources)

SNC Lavalin takes over AECL CANDU

On June 29, 2011, just as this issue of the CNS Bulletin *was about to be printed, the Canadian government, through Natural Resources Canada, and the SNC Lavalin Group, announced the sale of the CANDU reactor division of Atomic Energy of Canada Limited to SNC-Lavalin's subsidiary CANDU Energy.*

CANDU Energy, a wholly-owned subsidiary of SNC-Lavalin Group Inc. has agreed with the Government of Canada to acquire certain assets of Atomic Energy of Canada's (AECL) commercial reactor division for a purchase price of $15 million and royalty payments from future new build and life extension projects. AECL will retain its past liabilities.

Both organizations stated that approximately 1,200 employees will be transferred from AECL to CANDU Energy. *(There are reportedly about 2,000 employees at AECL Sheridan Park, in Mississauga, Ontario, where the bulk of the commercial reactor division is located.)*

CANDU Energy will take over the provision of services to the existing fleet of CANDUs, execution of life extension projects and reactor new builds. While the price of the business was just $15 million the Canadian government will receive royalty payments from future new build and life extension projects and also retain ownership of all CANDU intellectual property. The government will provide a licence to CANDU Energy to grow the business. AECL will retain its past liabilities.

The Canadian government has been looking to restructure AECL since 2009, and SNC-Lavalin - which has a long history of partnering AECL in construction projects - has long expressed interest in purchasing the commercial arm of the state-owned corporation. SNC-Lavalin's executive vice-president for global power, Patrick Lamarre, said that the acquisition would require "concerted and coordinated efforts" to make it a success but was upbeat about future projects.

The reactor engineering and development arm of AECL was created in the late 1950s. It moved to its present location at Sheridan Park, an industrial complex in Mississuaga, a suburb of Toronto in the early 1960s. Since its establishment it has been involved in 34 nuclear power units built in seven countries, including Argentina, China, Romania and South Korea.

CANDU Energy has identified new build projects in Ontario and overseas in countries including Argentina, China, Jordan and Turkey as targets for the new company.

Also, since CANDU reactors require refurbishment and replacement of core components after about 25-30 years of operation, life extension projects will be a key part of the business. The new company will complete the remaining obligations under ongoing life extension projects at Bruce Power, Point Lepreau and Gentilly 2 in Canada and Wolsong in South Korea through subcontract service agreements with the Canadian government.

The government has pledged up to $75 million to support CANDU Energy as it works towards completing the Enhanced CANDU 6 development program.

The acquisition is expected to be finalised in the early autumn of 2011.

CNSC Task Force on Lessons from Fukushima

The Canadian Nuclear Safety Commission (CNSC) has created an operational task force to evaluate the operational, technical and regulatory implications of the March 11, 2011 nuclear event in Japan in relation to Canadian nuclear power plants.

Chaired by the Director-General of Nuclear Power Plant Regulation, Dr. Greg Rzentkowski, the task force is comprised of senior CNSC subject matter experts in reactor design, safety assessment, and emergency preparedness and response.

The task force members will review licensees responses to the CNSC's earlier request to re-examine the safety cases of their respective nuclear facilities, the underlying defence-in-depth against external hazards, severe accident scenarios and emergency preparedness procedures and guidelines.

The task force will recommend short- and long-term measures to address any significant gaps at Canadian nuclear power plants, and whether any design modifications are needed. It will determine priorities for the implementation of corrective actions based on the lessons learned and the need, if any, for further examination.

Finally, the task force will recommend, as appropriate, potential changes to CNSC regulatory requirements, inspection programs and policies for existing CANDU and potential new nuclear power plants.

The CNSC task force will present this information to the Commission in a public forum at a date to be determined.

Funds pledged for Chernobyl confinement

The damaged unit 4 at the Chernobyl plant (Image: ChNPP)

At a conference in Kiev in April, 28 countries pledged a further €550 million ($786 million) to complete the New Safe Confinement (NSC), a vast structure currently being constructed over the wrecked unit 4 of the Chernobyl plant. The NSC building will allow the dismantling and cleanup of the damaged reactor in a controlled environment.

The NSC is an arch structure that will be erected adjacent to the damaged reactor building (the 'sarcophagus') and then slid into position to environmentally isolate the unit while future cleanup operations continue. The structure is scheduled to be moved over the sarcophagus and confine the remains of the plant from the outside world for about 100 years. It is expected to be completed in 2015.

The pledges will also help to complete the construction of a storage facility on the site for the used fuel from the three other Chernobyl units, which continued operating after the 1986 accident. The facility will provide dry storage for more than 20,000 used fuel assemblies on completion in 2014-5.

However, a further €740 million ($1.06 billion) is still needed from the international community in order to complete the major projects on the site by 2015, according to the European Commission.

The EC has so far committed some €470 million ($670 million) to Chernobyl-related projects, mainly for nuclear safety, but also on programs to help the local population and provide affected families with access to quality healthcare.

US plant has refurbishing problems

The US utility, Progress Energy, has run into some unforeseen hurdles in the refurbishment of its 34 year old Crystal River, 860 MWe PWR, nuclear power plant in Florida. The company has applied for a licence extension to take it to 2036.

From 2008 to 2010, it invested some $284 million in an extended power uprate project, which is intended to increase the gross output by 180 MWe, or 20%, upon its completion. In September 2009, the plant was shut down for a routine maintenance and refueling outage that also included the installation of two new steam generators and a new turbine generator. However, when the reinforced concrete containment structure (1.07 m thick) was cut open to replace the steam generators, delamination of the concrete was discovered. This led to a major and prolonged repair task costing $150 million, plus $290 million for replacement power to December 2010.

Then in March, 2011, as the repaired structure was being retensioned, another delamination was discovered. The company has hired an engineering consultant to assess its options, mainly focused on repairing and restarting the plant, though including the possibility of writing off the upgrade and decommissioning it.

Bird Challenges Darlington Security

In mid June 2011 an event happened at the Darlington NGS that might have the security people at the CNSC worried.

Reminiscent of a story by Stewart McLean on the "Vinyl Café" radio show, hundreds of "birders" descended on the plant when it was reported that a rare Artic ptarmigan had breached the security zone and landed on the controlled ground.

According to reports the last time a member of that rare breed was sighted in that area of Ontario was 114 years ago.

Concerned about the crowd flocking to the secure area around the reactors, Ontario Power Generation staff organized an expedition on the Sunday, June 12. Armed escorts took three busloads of spectators (after security checks) into the area for a once-in-a-lifetime chance to see the bird up close.

Reportedly, the bird strutted around before the crowd for about 20 minutes, giving the birders ample time to take photographs.

Crowd of birders at Darlington.

Arctic ptarmigan

NRU back in service

On June 16, 2011 Atomic Energy of Canada Limited reported that the National Research Universal (NRU) reactor had returned to operation from its planned extended outage.

Vessel inspection results to date confirm that there are no detectable changes to the vessel wall, no detectable corrosion, and that the inspected welds, applied during the 2010 repairs continue to be sound.

The purpose of the outage, conducted over 32 days, was to perform maintenance and inspection work designed to enhance the reliability of NRU and to fulfill AECL's commitment to the Canadian Nuclear Safety Commission (CNSC).

This was the first annual planned extended outage for NRU. It was a complex endeavour, consuming over 25,000 hours of planning and execution. Contributions were made from over 120 individuals representing AECL's skilled trades, technicians, engineers, radiation protection specialists, and project staff. In addition to AECL staff, 50 contract employees representing seven Canadian companies also contributed to the completion of the project.

During the outage, AECL completed over 1,400 work activities. Activities included preventative maintenance, inspections, and condition assessments as well as equipment repairs, upgrades, and replacements in priority areas critical to the safe and reliable operation of the NRU.

Inspection activities examined the five highest priority vessel sites, including three sites that were inaccessible prior to the development and use of first of a kind inspection tooling. While improving accessibility, the tooling also allowed the vessel to remain fuelled and filled with heavy water during inspections.

Inspections and other activities not completed during this outage, such as lower level preventative maintenance, have been deferred to future scheduled short duration outages. New data gained during subsequent inspections will be analyzed and the results will be included in the NRU Fitness for Service report. The completed report will be issued to the CNSC by September 2011, fulfilling AECL's regulatory requirements to inspect the NRU vessel, confirm vessel and repair conditions, and establish plans for required annual inspections.

Fuel loading begins at Bruce 2

After a long and arduous refurbishment Bruce unit 2 is being refuelled. The Canadian Nuclear Safety Commission gave approval on June 29 after determining that all requisite actions had been taken and that the reactor was in an Over-Poisoned Guaranteed Shutdown State (OPGSS).

OPGSS is a guarantee administered by the Bruce Power Duty Shift Manager, that the reactor cannot go critical once fuel loading commences. This is done by adding a large quantity of neutron absorbing poison (gadolinium nitrate and boron) to the moderator system.

Operators use distinctive red 'reactor shutdown guarantee' (RSG) tags to identify valves, flanges and other components that must remain closed and locked to provide the necessary assurances.

The fuel load tables are installed on both faces of the reactor, and the necessary closure plugs and shield plugs, 240 in the east ends of the new fuel channel assemblies and 240 in the west ends are also installed. Once OPGSS was achieved, operators began manually loading fuel from both ends of the reactor simultaneously.

A similar exercise will take place on Unit 1 in early 2012.

An aerial view of the Bruce A station.

NWMO discussing repository with eight communities

The Nuclear Waste Management Organization reports that it is in various stages of discussions with eight different communities regarding the siting of a deep geological repository for used nuclear fuel. Five of the communities are in northern Ontario and three in Saskatchewan.

When a community first expresses an interest the NWMO conducts an initial screening of the potential technical suitability of the area, This involves examining five criteria:

- Sufficient land for surface and underground facilities
- Being outside protected areas, heritage sites, provincial and national parks
- Not containing known groundwater resources at repository depth
- Not containing known economically exploitable natural resources
- No known geologic or hydrogeologic conditions that would make the area unsuitable

The eight communities have passed those criteria

and are now in different stages of learning about the Adaptive Phased Management approach that NWMO is following. NWMO offers independent consultants to assist a community to conduct a visioning exercise about its long-term aspirations.

In June 2011 NWMO invited officials from two Swedish communities to share their experiences with the interested Canadian communities.

The NWMO issues periodical reports on its activities. Go to its website: *www.nwmo.ca* for more information.

Another NPP for Finland

The Finnish utility, Fennovoima, has invited Areva and Toshiba to bid for the construction of a new nuclear power plant in Finland.

The invitations are for bids for the delivery and construction of reactor and turbine islands. Infrastructure works early in the construction phase and other preparatory works are excluded from the bids. A final decision on the plant supplier and the model of delivery will be reached in 2012-2013.

Fennovoima signed technical development agreements with both vendors in December 2010 to ensure that Areva's EPR and Toshiba's ABWR reactor designs would meet Finnish safety requirements and the company's own technical requirements.

Two alternative greenfield sites, Pyhäjoki and Simo, both in northern Finland are being considered. The final site selection will be made after the country's supreme administrative court has ruled on appeals over the regional land use plans of the sites. Preparatory site work could begin at the end of 2012.

Fennovoima was granted a decision-in-principle for the plant in May 2010, ratified by parliament in July 2010. Operation is anticipated to begin around 2020.

Four reactors already provide some 30% of Finland's electricity and the country's fifth reactor, Olkiuoto 3, the first-of-a-kind EPR by AREVA, is expected to enter commercial operation in 2013.

France plans $1.4 billion on new nuclear projects

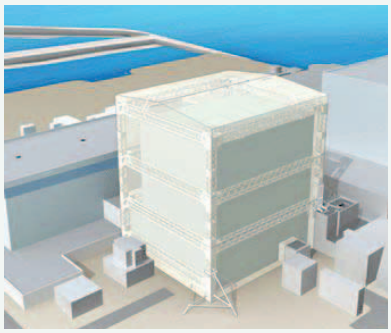
On June 27, 2011, French President Nicolas Sarkozy confirmed plans to invest €1 billion ($1.4 billion) in future nuclear programs including fourth generation reactor research.

As well as the €1 billion on future nuclear programs, Sarkozy said that France would free up significant resources to strengthen nuclear safety research, a field in which he said France was already a 'recognised leader'.

The majority of the French funding earmarked for future nuclear projects, nearly €652 million ($933 million) is to be spent on the research and development program for the proposed Astrid fourth-generation sodium-cooled fast reactor, which is led by France's CEA (Commission of Atomic Energy and Alternative Energy, formerly the Commissariat a l'Energie Atomique). Final decisions on construction of a 600 MWe Astrid prototype are expected to be made in 2017.

The second major beneficiary is the Jules Horowitz research reactor, which is receiving €250 million ($358 million). This reactor, which is under construction in Cadarache in southern France, will be able to contribute "significantly" to world production of the medically important radioisotope molybdenum-99, according to the French government.

Cover for Fukushima 1



(Image: Tepco)

Tokyo Electric Power Company (Tepco) plans to complete the construction of a cover over the stricken Fukushima Daiichi unit 1 by the end of September, according to a progress report submitted to the Japanese nuclear safety agency.

The cover is being installed over the unit 1 reactor building, which was damaged by a hydrogen explosion on 12 March 2011.It is a temporary measure intended to reduce the release of radioactive materials to the atmosphere as well as to prevent the ingress of rainwater. Preparatory work, such as levelling the ground, began in mid-May. Crawler cranes are being used to minimize the exposure dose of workers and shorten the work period.

According to a report on the construction plan submitted by Tepco to the Nuclear and Industrial Safety Agency (NISA) on June 24, construction is scheduled for completion by the end of September,

The cover will be able to accommodate an accumulated snow load of 30 centimetres, wind speeds of up to 25 metres per second, and a horizontal seismic load of 0.2. All the wall panels will have a flameproof coating, and the structure will have a filtered ventilation system capable of handling 10,000 cubic metres per hour through six lines, including two backup lines. The cover structure will also be fitted with internal monitoring cameras, radiation and hydrogen detectors, thermometers and a pipe for water injection.

William Cross

Ed. Note: The following is a slightly edited version of an obituary prepared by Noreen Shanahan.

William (Bill) Cross, a long-time researcher at the Chalk River Laboratories of Atomic Energy of Canada Limited died on April 10, 2011, in Deep River, Ont., after a bout of pneumonia. He was 88.

William Cross, who retired in 1991, was a highly disciplined and extremely focused nuclear physicist. He specialized in radiation hazard protection at the health physics branch of CRL. As an expert in the field of radiation symmetry, he discovered ways to measure low-level radiation exposure experienced by workers at nuclear plants.

One of Cross's inventions was a low background counter used for counting minuscule levels of radiation in food.

Cross published hundreds of papers on radiation hazards that continue to be standard references used internationally. He advised the Nuclear Energy Commissions of Venezuela and Chile and was a member of numerous societies, including the Health Physics Society, the American Physics Society and the Nuclear Track Society.

He chaired scientific committees, panels, and working groups from the International Atomic Energy Agency and the International Commission on Radiation Units and Measurements.

He was born in a Detroit hospital on Oct. 1, 1922, because his parents believed that medical care was better across the river from their Windsor home. The family settled in Toronto when Bill was a tiny boy. He graduating from the University of Toronto Schools in 1939 and obtained BA in physics from U of T in 1943. He barely had time to finish his last exam before heading off to Britain as a radar officer in the Royal Canadian Naval Reserve. Within weeks, he was seconded to the British Navy.

After demobilization he returned to school, obtaining a Masters degree from the University of Toronto in 1947 and a doctorate from Harvard University in 1949.

Following retirement Cross worked for another decade as an emeritus scientist, keeping his seat on committees and continuing to update the reports that circulated among international audiences.

William Cross leaves his sons John, Gordon, Peter, Robert and David, as well as their families, including grandchildren Miriam, David, Alexandra, Eric, Elizabeth, and Jennifer. He was predeceased by his wife, Eleanor, in 1998.

Colin A. Mawson

Colin Mawson, a pioneer in environmental and biological research at the Chalk River Laboratories of Atomic Energy of Canada Limited, died in Toronto, July 2, 2011, in his 103rd year.

Born in Sheffield, England he obtained a Ph.D. in physiology, from the University of Victoria, in Manchester, England, and headed the Biochemical Laboratories at the Berkshire Hospital in Reading, England from 1937 to 1949.

In 1949 he and his wife Eleanor, moved to Deep River, Ontario and Colin was appointed as a Senior Scientist, at what was then the Chalk River Nuclear Laboratories of the National Research Council. In 1956 (after the creation of AECL in 1952) he was appointed head of the Environmental Research Branch, a position he held until his retirement in 1973.

Colin was one of the original members of the Reactor Safety Advisory Committee (RSAC) created by the Atomic Energy Control Board, the regulatory agency, in 1956 and remained an active member until his retirement.

Cremation and internment in Deep River is being arranged.

Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities

September 11-14, 2011
Marriott Toronto Downtown Eaton Centre

Now Available:
Preliminary Conference Program
www.cns-snc.ca

This Conference is intended to provide a forum for discussion of the status and proposed future directions of technical, regulatory, environmental, social, and economic aspects of radioactive waste management, nuclear facility decommissioning, and environmental restoration activities for Canadian nuclear facilities. Although the conference will focus on activities pertaining to Canada's nuclear industry, many of the technical issues involved have a broader relevance, therefore papers on the topic of the conference from outside the nuclear industry, and insights into how other countries are dealing with similar issues will also be presented.

Sponsoring Societies

The Conference is being organized by the Canadian Nuclear Society in cooperation with the International Atomic Energy Agency, and is co-sponsored by the American Nuclear Society, the Argentina Nuclear Technology Association, the Atomic Energy Society of Japan, the Chinese Nuclear Society, the Indian Nuclear Society, the Korean Nuclear Society, the Nuclear Energy Agency of the OECD and the Romanian Nuclear Energy Association.

This three-day Conference is organized into plenary sessions and six concurrent technical tracks that will interest waste management, decommissioning and environmental technology practitioners; delegates from industry, academia, and government agencies and regulators; consulting engineers; financial and legal experts; and other specialists working in the field.

For all Conference information go to **www.cns-snc.ca**

Technical Program Enquiries:
Mark Chapman
E-mail: CNSP2011@aecl.ca

Conference Registration Enquiries:
CNS Office
Tel.: 416-977-7620
E-mail: cns-snc@on.aibn.com

General Enquiries:
Elizabeth Muckle-Jeffs
Conference Administrator
The Professional Edge
Tel. North America toll-free: 1-800-868-8776
Tel. International: 1-613-732-7068
Fax: 613-732-3386
Email: Elizabeth@TheProfessionalEdge.com

Two post-Conference Technical Tours are planned: one to the Ontario Power Generation Deep Geologic Repository (DGR) and Western Waste Management Facility (WWMF) at Kincardine, Ontario and the other to the Port Hope Area Initiative (PHAI) Welcome Waste Management Facility , Port Hope, and Ontario Power Generation's Darlington Waste Management Facility, Clarington, Ontario.

Optional Day Trips for accompanying guests to various attractions in the Toronto and Niagara regions will also be offered. Details will be posted on the Conference website.

The Canadian Nuclear Society greatly appreciates the financial sponsorship of the Conference from the following organizations. Sponsorship opportunities are still available. Please refer to the Conference web site for details and updates.

Annual General Meeting

The 14th Annual General Meeting of the Canadian Nuclear Society Inc. was held in Niagara Falls, Ontario on Sunday afternoon, June 5, 2011, just before the opening of the Society's 32nd Annual Conference with 46 members present.

(The AGM dates from 1998 when the Society was incorporated while the Annual Conference numbering dates from the first conference held by the Society while still under the umbrella of the Canadian Nuclear Association.)

The minutes of the 13th AGM, held in Montreal in the wings of the 31st Annual Conference were presented and approved.

Then followed a verbal report from the outgoing president, Adriaan Buijs. His written report is included in this issue of the Bulletin.

To accommodate potential nominations from the floor, the slate of nominees prepared by the Nomination Committee, chaired by past-president Dorin Nichita, was presented. After repeated calls for nominations from the floor received no response, the slate was declared elected by acclamation. *(See box.)*

Mohamed Younis presented his Treasurer's Report along with the audited financial statement for 2010. *(Copies of the audited financial statement are included in the mailing of this issue of the Bulletin for members only.)* In 2010, the Society ended up with a net revenue of $48,560 compared to a predicted loss, due to greater revenue from conferences than predicted.

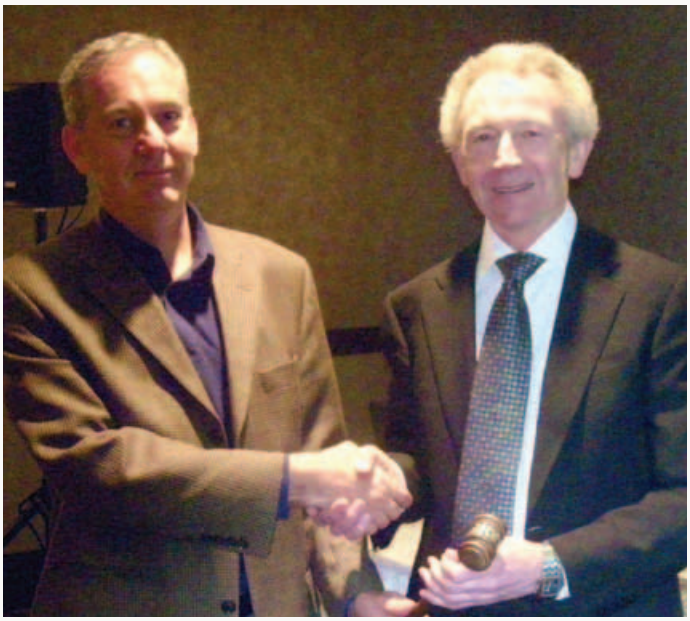
Following acceptance of his report the treasurer moved that the Society continue to retain the services of Timothy Wright as auditor. This was quickly endorsed.

Then followed reports from some Committees, Branches and Divisions. The extensive report on Branch activities prepared by Syed Zaidi is reprinted in this issue of the Bulletin.

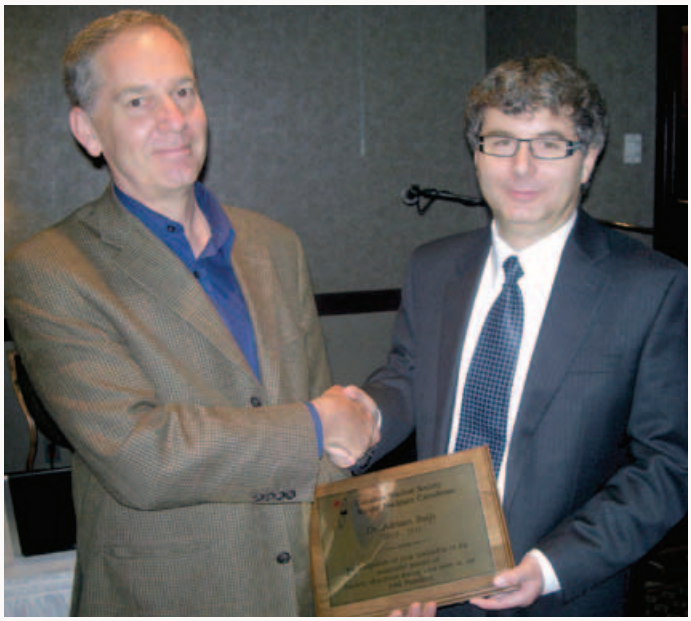
With the business essentially completed outgoing president Adriaan Buijs then presented the symbolic gavel to Frank Doyle, president for 2011 – 2012. The new president then gave a short speech on his view of the coming year, which is reprinted in this issue of the Bulletin.

Finally, past president Dorin Nichita presented Adriaan Buijs with a plaque commemorating his role as president in what turned out to be a challenging year.

The AGM was then adjourned, just in time for members to attend the opening reception of the Conference.



Outgoing CNS president Adriaan Buijs (L) hands the traditional gavel to new president Frank Doyle at the Annual General Meeting in Niagara Falls, June 5, 2011



Past CNS president Dorin Nichita (R) presents a plaque to Adriaan Buijs to commemorate his presidency during 2010 – 2011, at the end of the Annual General Meeting in Niagara Falls, June 5, 2011

Outgoing President's Report by ADRIAAN BUIJS

Preamble

The Canadian Nuclear Society witnessed a tumultuous year in the world-wide nuclear industry. In spite of the effects of the tragic events in Japan, the Society had a full year of activities in the pursuit of its objectives, the exchange of information in the field of nuclear science and technology.

The Annual Conference

The 2010-2011 year (June to June) started with the very successful CNS Annual Conference and CNS-CNA student conference in Montreal, which for the occasion had adopted a tropical climate. The plenary and technical sessions were interesting and informative as usual, and the exhibitors provided a showcase of the industry's capability in terms of products and services. A total of 440 delegates, with a sizeable contribution from Québec, attended the conference. Acting on feedback from last year, we modified the format of the student conference. We sponsored over 30 students to attend the conference, and to present their research in a poster session disguised as a wine-and-cheese event. This was so well received that we decided to repeat it in 2011 in Niagara Falls, where we registered over 50 students. The venue for next year's conference will bring us to Saskatoon.

Other Conferences, Courses and Workshops

Following the 2010 CNS Annual Conference, a Nuclear Education and Outreach conference was held at the University of Calgary. This new conference was dedicated to exploring ways of conveying the nuclear message to the public. It was well received and followed up by a one-day workshop after the 2011 Annual Conference in Niagara Falls.

In October, a truly international conference was organised, on the Water Chemistry of Nuclear Reactor Systems (NPC-2010), followed by the 8th International Radiolysis, Electrochemistry & Materials Performance Workshop. This conference was part of an international series of conferences, known as the Bournemouth Conference Series, originating in 1977. This very successful conference was attended by 277 participants of whom 207 from outside Canada.

The 11th International Conference on CANDU fuel was held in October in Niagara Falls under the motto "Flexible Fuel for a Greener Future".

The 50th anniversary of the ZED-2 reactor was celebrated at a workshop on small research reactors in Ottawa in November. At this occasion, the American Nuclear Society recognized the ZED-2 research reactor as a Nuclear Historic Landmark.

In the spring of 2011 the traditional CANDU Reactor Safety Course was held. Also, after many years, a Reactor Physics Course was organised in Toronto. More than 40 participants eagerly followed the lectures on the main feature that distinguishes nuclear power plants from their fossil cousins.

Society Developments

Within the Society, a number of activities were undertaken: management of the successful Geiger-counter program was contracted to a private firm; a professional librarian was engaged to perform a preliminary study of documents (in AECL's possession) relating to Canada's nuclear history in the period 1942 to 1952; the preparation of the Nuclear Canada Yearbook was taken over from the CNA and the Yearbook was successfully issued prior to the 2011 Annual Conference with the support of several contracted parties. These activities follow the Society's trend of relying increasingly on professional support to conduct its business, as mandated by our strategic initiative. However, we did not succeed in hiring an executive director to oversee all the Society's activities yet. Within the framework of the CNA-initiated N6 group (CNA, CNS, WiN, COG, OCI, UNENE), the CNS participated in discussions on sharing the responsibilities for covering the various aspects of education and outreach in Nuclear Canada.

Closing Remarks

In closing, I am returning to the events at Fukushima. I want to thank all those members of the CNS who stepped up to the plate informing the public of the situation at the power plant as they understood it, in interviews and the written media. In most cases, this was not under the banner of the CNS, which made the CNS as an organisation seem passive in the crisis to some. However, one has to keep in mind that the CNS cannot dispatch manpower at will, but relies, as with everything, on volunteers. And these volunteers certainly came forth.

Overall, the CNS can look back on a successful year of activities, providing value to its membership.

Cuttler awarded by International Dose Response Society

Jerry Cuttler, a former president of the Canadian Nuclear Society and a continuing active member, has been presented with the Outstanding Career Achievement award by the International Dose Response Society.

Following are excerpts from the citation.

Dr. Cuttler received his BASc-Eng degree (1964) in engineering physics from the University of Toronto and his MSc and DSc degrees (1967-1971) in nuclear sciences and engineering from the Israel Institute of Technology.

He joined Atomic Energy of Canada Limited in 1974. Over the years he led the design and procurement of the reactor control, safety systems and radiation monitoring instrumentation for the first CANDU-6 reactors, the four-reactor Pickering-B station and the four-reactor Bruce-B station. He was resident engineering manager for the Cernavoda project in Romania and manager of AECL services to the eight-reactor Pickering station.

After retirement he continues to provide consulting services to Ontario Power Generation, Bruce Power and AECL.

Dr. Cuttler has been an active member of Professional Engineers Ontario, Canadian Nuclear Society (president 1995-1996), American Nuclear Society, American Physical Society, Canadian Nuclear Association, Health Physics Society, Canadian Radiation Protection Association and the International Dose-Response Society.

Since 1995, Dr. Cuttler has been assessing the health effects of ionizing radiation and drawing international attention to radiation hormesis. He has presented papers at many conferences pointing out that low exposures are stimulating for curing infections, extending life and reducing the incidences of cancer and congenital malformations.

He organized adaptive response sessions at nuclear energy conferences, inviting renowned radiobiologists to present remarkable evidence. He has urged many oncologists to use total-body low-dose radiation in cancer therapy. He has intervened with regulators with submissions that identify beneficial effects following low doses and debunk the LNT assumption.

CNS Council members for 2011–2012

Officers:	
President	Frank Doyle
1st Vice-President (president elect)	John Roberts
2nd vice-President	Len Simpson
Secretary	Colin Hunt
Treasurer	Mohamed Younis
Members at Large	
Parvais Akhtar	Jacques Plourde
Parva Alvavi	Jad Popovic
Emily Corcoran	Ben Rouben
Juris Grava	Melanie Sachar
Krish Krishnan	Natalie Sachar
Peter Lang	Nick Sion
Dorin Nichita	Gordon Tapp
Dave Novog	Jeremy Whitlock
David Malcolm	Syed Zaidi

Chalk River Branch at Renfrew Fair

The CNS Chalk River Branch joined with the Deep River Science Academy (DRSA), the Algonquin Chapter of the Professional Engineers of Ontario (PEO), the Renfrew County Science Fair, and the Ontario Association of Certified Engineering Technicians and Technologists (OACETT) to set up a booth at the Renfrew County Expo 150 held June 9 to 12, 2011 at the Pembroke and Area Airport.

Expo 150 was a large 4-day exposition held in celebration of the 150th Anniversary of the creation of Renfrew County, in eastern Ontario, attracting over 40,000 visitors.

Thanks and appreciation are extended to CNS-CRB members Dave Wilder, Blair Bromley, Marcel Heming, Colette Taylor, Dave Wang, Shaun Cotnam, and others who volunteered to keep the information booth staffed continuously.

Blair Bromley and Dave Wilder speak with a visitor at the CNS information booth at the Renfrew County Expo 150, held June 9 to 12, 2011, at the Pembroke and Area Airport.

New President's Comments

Thank you for the privilege of serving as your Canadian Nuclear Society President for 2011-12. I am both humbled and honoured by this opportunity to help foster the continuing growth of the nuclear industry in Canada, and particularly the sustained growth of the Society.

I look forward to working with the new Executive and Extended Council during my one year term of office to evolve the strategic direction set out by my predecessors. Collectively, your new Council will continue to develop this strategic direction which will help achieve our member's objectives in a sustainable manner going forward. I am committed to advancing that goal and I encourage all of you to help as well. In particular, I will encourage the new council to take up the challenges of the CNS vision for the future, set out in 2010, to put the infrastructure and support in place to achieve the goals established for branch growth and engagement, as well as program delivery.

The Society is strong and vibrant as we enter into our 33rd year having grown 50% to 1200 members since the turn of the century, and by an order of magnitude since our founding in 1979. We currently provide education and support to people working in the Canadian nuclear field, and indeed from around the world, through our courses, workshops, seminars and conferences. These nuclear professionals are served by dedicated teams of CNS volunteers who participate in the various organizing committees, branch and division programs, as well as educational and outreach activities. Volunteers have served the best interests of the Society, and indeed the entire Canadian nuclear community, for decades. The CNS succeeds because these volunteers succeed and you can be proud of your, and the Society's, many significant accomplishments over the years.

We have just completed a very successful year delivering conferences, seminars, courses, and educational programs, as discussed in the yearbook issued in June 2011. The transition from 2010-11 to the new year was marked by the successful Annual Conference held at Niagara Falls in early June and described elsewhere in the Bulletin. I was privileged to have been the Executive Chair for the conference and to have had the pleasure of serving with exceptional committee members who worked tirelessly to coordinate the details of the program.

The future for the nuclear industry in Canada is upbeat, notwithstanding the devastating impact of the natural disasters in March, 2011 in Japan. Ontario is committed to continue refurbishing existing units and to build two new units. New Brunswick is well into its refurbishment program and Quebec is scheduled to start refurbishing in 2012, on the 50th anniversary of production of first electrical power from nuclear in Canada. Saskatchewan is investing in infrastructure and facilities for research and development, as well as production of medical isotopes, and both Saskatchewan and Alberta continue to evaluate small modular reactor concepts. The CNS will hold its Annual Conference in Saskatoon in 2012 and the year leading up to this event will be exciting, challenging and rewarding for the Society.

In closing, I would like to thank the 2010-11 Council and Dr. Adriaan Buijs for the strong stewardship of the CNS and I look forward to working with the 2011-12 Council to further foster the goals set out by previous Councils.

Frank W. Doyle

Nuclear Education and Outreach

The Nuclear Education and Outreach group of the CNS held its second workshop on Thursday, June 9 after the 2011 CNS Annual Conference in Niagara Falls, with about 60 attendees.

Jeremy Whitlock welcomed those present and explained that "education" in the title was aimed at students, while "outreach" referred to communication with the media and public. He presented five actions: be enthusiastic; do the right thing with the right resources; provide sound education (mentioning UOIT, McMaster, RMC); encourage students; and recognize that more can be done.

Referring to the Fukushima he said there are communication lessons to be learned as well as technical ones. There was a meltdown, he noted, but no significant consequences. However, there was a lack of information.

He outlined the day with the morning devoted to education and the afternoon to outreach.

John Roberts, the chair of the education session, then introduced Jason Donev who had been instrumental in creating the first NEO gathering in Calgary in 2010.

One of the outcomes of that previous workshop, Donev commented, was that there is a need for education about education. We need a "Nuclear 101" for educators, he asserted, to be used at events such as teachers' PD days. He noted that the CNS has poor communication with other technical societies.

He was followed by Claire Ripley who has been running an education program in New Brunswick for many years. He referenced workshops for science teachers and for journalists.

Basma Shalaby, chair of UNENE (University Network for Excellence in Nuclear Education) spoke of the need to maintain the knowledge base. UNENE offers a part-time program for an M.Eng. degree.

Scott Taylor, of CNA, mentioned a teacher resource package available on their website. It is aligned to the curricula of the provinces and contains specific lesson plans.

As Science and Environment Consultant to the District School Board of Niagara, Sean Hanna, commented that he recommends the CNA website to secondary level teachers.

The last speaker of the morning was George Bereznai, Dean of energy Systems and Nuclear Science, at UOIT. He mentioned a "training" program, as contrasted to "education" on Advanced Operation Overview for Managers at OPG. He commented that OPG does not have enough authorized shift managers to promote to senior positions.

Following the lunch break, Jay Ingram of CBC/s Quirks and Quarks radio program, noted widespread scientific illiteracy. Think about the audience, he stressed, it has not changed for decades. He referred to "climate change" and commented that stating nuclear does not produce CO2 does not get much "traction" with the public.

Dietwald Claus, of the CNA spoke of that organization's move into "social media" such as Facebook and Twitter as a means of reaching a wider audience. Ted Gruetzner of OPG commented that social media was useful for conveying information not suitable for the major media. Sonja Garton, AECL, mentioned that the NRU refurbishment got them using the web extensively. The special website they established had more than 70,000 visits, many extended in time.

Victor Snell, retired AECL now associated with UNENE, commented that the Canadian nuclear industry had been very poor in its response to Fukushima.

Bill Garland, retired from McMaster University and also associated with UNENE and CANTEACH presented a paper he had given at the 2008 CNS Conference, which he felt was still relevant. We learn by doing, he stated.

Doug Boreham, of McMaster University and Bruce Power gave a fascinating quick overview of the risk of radiation which he gives to new employees at Bruce

The day ended with animated discussion and the broad agreement to hold another workshop next year.

CNS Branch Affairs Annual Report

Ed. Note: The most extensive Committee report presented at the CNS Annual General Meeting held in Niagara Falls, 5 June 2011 was from Sayed Zaidi, chair of the Branch Affairs Committee. Following is a slightly edited version (for length) of his report. Although the CNS operates financially on the calendar year, the actual operation runs from AGM to AGM. The reports from the Branches reflect that duality.

ALBERTA Branch – Duane Pendergast

Alberta Branch was established in 2007 and has reached a membership of over 30. Quite a few members have been recruited from the student body at University of Calgary through the efforts of Jason Donev.

Branch members primarily communicate via the no – charge Google Groups facility, email and the occasional teleconference. Membership in the Google Group has reached 80. Membership includes CNS members from outside Alberta as well as a few guest members with an interest in nuclear energy. A good mix of nuclear experience is thus available within the Group.

During the year there has been little industry and government involvement with nuclear power in Alberta, somewhat lessening the demand for CNS involvement in reactive educational activities.

Nuclear Education and Outreach Workshop – Calgary

Several CNS Alberta Branch members participated in the CNS Nuclear Education and Outreach Workshop initiated by Jason Donev and Paul Hinman which was held in Calgary in June 2010. The conference was well attended with timely and pertinent presentations sparking interest in continuing with annual events.

McMaster Symposium

Jason Donev and Duane Bratt both made presentations to the "Human Health and the Biological Effects of Tritium in Drinking Water" symposium held at McMaster University on August 26, 27.

PTAC - Petroleum Technology Alliance of Canada

Cosmos Voutsinos participated in the Petroleum Technology Alliance of Canada, *"Resource Emissions Management and Action Plan Workshop"*, in Calgary on September 1. His participation initiated consideration of CNS cooperation with PTAC resulting in the preparation of a "white paper" for CNS Council on the benefits which might arise from working with PTAC. PTAC has received proposals from several companies interested in the use of nuclear energy for extraction and upgrading of bitumen.

Teachers Professional Development Day – Jason Donev

Jason Donev, in cooperation with local high school teachers hosted a professional development day in November for some twenty teachers from Calgary. They were introduced to nuclear energy and provided m access to factual information on nuclear technology.

ATA Science Conference 2010 – Rob Varty

The 50th annual "ATA Science Conference 2010" was held in the Fantasyland Hotel at West Edmonton Mall, from November 18 to 20, 2010. The conference was organized by the Science Council of the Alberta Teachers' Association (ATA). Three members of the CNS (Aaron Hinman, Pascal Mertins and Rob Varty) set up the CNS display booth on November 18, and they operated it on November 19 and 20.

Visit to Idaho National Lab May 2-3 – Jason Donev

CNS sponsored a tour to Idaho National Lab which was initiated by Jason Donev and Bob Cherry of INL. There were twenty five participants, mostly CNS student members from University of Calgary, but including Laurence Hoye, Shaun Ward and Duane Pendergast from Lethbridge. INL organized a most extensive and informative tour of some of their facilities. Participants were impressed with the broad scope of energy related research and development undertaken since the 1950's and learned a great deal about the kinds of activities undertaken at the facility.

Miscellaneous

In addition to these events, several members, including Paul Hinman, Aaron Hinman, Duane Bratt, Laurence Hoye, David Malcolm, Duane Pendergast, and Cosmos Voutsinos participated in such activities as letter writing, presentations, magazine articles, radio interviews and workshops throughout the year.

BRUCE Branch – John Krane

Presentations

1. ***Kevin Orr presented the Deep Geologic Repository (DGR) Project***

The Nuclear Waste Management Organization, on behalf of OPG, is seeking regulatory approval for the construction of a DGR for the long-term management of low and intermediate level radioactive waste on lands adjacent to the Western Waste Management Facility on the Bruce site. The presentation covered the science and geology behind the proposal.

Meetings

1. One general branch dinner meetings was held.

Education and Outreach

1. 2 CNS Achievement Awards presented at the 2011 Bluewater District Science Fair (Senior and Junior).

2. Major sustaining award ($2500) presented to the Bluewater District Science Fair Committee on behalf of the CNS.

CHALK RIVER Branch – Ruxandra Dranga

Executive Committee as of 31 May 2011

Chair:	Ruxandra Dranga
Treasurer:	Alex Trottier
Program Coordinator:	Geoff Edwards
Education and Outreach:	Ruxandra Dranga / Ashlea Colton
Membership:	Blair Bromley
Communications:	Amir Sartipi
Radiation Program at Algonquin College Liaison:	Mark Branecki
NA-YGN Liaison:	Natalie Sachar
PEO Liaison:	Dave Wilder
Members-at-Large:	Bruce Wilkin, Bryan White, Shaun Cotnam, Rob DeAbreu, Mahsa Jamsaz

Seminars Held:

- Deep River Science Academy joint lecture series in July 2010:
- Jeremy Whitlock, '*Splitting Atoms, Canadian Style*'
- Marylyne Stuart, '*Biological Effects of Exposure to Low Levels of Radioactivity*'
- Craig Stuart, '*The Role of Radiation Chemistry in Maintaining Reactor Integrity*'
- Bill Diamond, '*My Years as a Physicist at Chalk River Laboratories*'
- Dave Cox talking about the "*Repair of the NRU Reactor Vessel*"
- The ZED-2 50th Anniversary Dinner took place on November 2010. We had 74 people attending the event. Rick Jones was the guest of honor at the event, speaking on *"A History of ZED-2"*. The event was a great success!
- The CNS President's Dinner took place in February 2011. We had a total of 46 people attending the event, 11 non-members and 35 members.
- Don Wiles (Carleton University), '*Half a Century with Radioactivity*'

Education and Outreach

- The table below summarizes the awards, scholarships and programs that were sponsored this year.

	Program/Award/Scholarship 2010 - 2011	Amount
1	Renfrew County Science Fair 2010 (3 students)	$ 900.00
2	Algonquin College Scholarship (Radiation Safety Program) (3 students)	$1,500.00
3	CNS High School Awards for Academic Excellence ($300 * 7 schools)	
	Opeongo H.S.	$ 300.00
	Madawaska Valley D. H. S.	$ 300.00
	Mackenzie H.S.	$ 300.00
	Bishop Smith Catholic H.S.	$ 300.00
	Fellowes H.S.	$ 300.00
	General Penet High School (Enrichment Fund)	$ 300.00
	Renfrew Collegiate Institute (Enrichment Fund)	$ 300.00
4	Deep River Science - CNS Prize for Excellence in Nuclear Research (2 students)	$ 500.00
5	CNS High School Essay Scholarship (competition)	
	1st price	$1,000.00
	2nd price	$600.00
	3rd price	$400.00
6	Algonquin College Sponsorship	$1500.00
7	Sponsorship for a student to attend the Shad Valley Program, summer 2011	$500.00
8	Math and Science Contests sponsorships (Mackenzie H.S. and Fellowes H.S.)	$500.00

Deep River Science Academy, 2010

- There were two winners of the CNS Award for the DRSA:
- Paul Seminsky
- Nancy Xiao
- Each was provided with an award of $250.

Renfrew County High School Awards, 2011

- 14 x $150 Grade 12 Awards for Academic Excellence were awarded to seven (7) high schools in the Renfrew County.

Renfrew County Science Fair, 2011

- Renfrew County Science Fair took place on April 9, 2011. Approximately 50 projects were reviewed. Three (3) CNS – CRB awards for Science and Innovation were presented:
- **Magnetic Rifle:** Mark Gharghouri , St. Mary's Secondary School
- **Homemade Solar Air Furnace:** Alyx Cousins , Helen Tunn, Rockwood Public School
- **Maximizing Wind Turbine Blade Efficiency:** Kelvin Leung, Highview Public School

Membership

- 166 members in good standing as of May, 2011:
- Anniversaries

CNS-CRB offers its congratulations and thanks to

the following CNS members who celebrate their milestone anniversaries:

- **5-year Anniversary (Joined in 2006)**: Mahmoud Karam, Darren Radford, Amir Sartipi, Carl Turner, Angela Weaver
- **10-year Anniversary (Joined in 2001):** Blair Bromley, Noel Harrison, Brian McGee
- **15-year Anniversary (Joined in 1996):** Duncan Barber, Herbert Feinroth, Marcel Heming, Lori Walters, Glen Wolgemuth
- **20-year Anniversary (Joined in 1991):** Roderic Delaney, Gerald McPhee, Kannan Tennankore
- **25-year (Joined in 1986):** Philip Simpson, Michael Stephens, Bryan White
- **30-year (Joined in 1981):** Gilbert J. Phillips, H. Allen Rose

GOLDEN HORSESHOE Branch – Dave Novog

Over the last 12 months the CNS Golden Horseshoe Branch has been very active in promoting nuclear energy to the public, as well as hosting a large number of technical talks (the most in recent memory). In addition to our support and involvement in the local science fair (led by Adriaan Buijs), our involvement in the Girl Guides day, and Women in Engineering programs, we were also heavily involved in fielding media questions and talks to sister societies related to Fukushima. Technical talks held at McMaster over the last year included:

- Lightsources for Nuclear Research
- Gen IV PT Concepts
- A Special Lecture on Osborne Reynold by Distinguished Prof. Jackson from Manchester University
- Extracting rare elements from fuel waste and fuel cycles
- Ultrasonic measurement techniques seminar
- Nuclear Knowledge Management
- Resistance Tomography Methods for Thermalhydraulics Research

We hope to continue this momentum into the new CNS year, and hopefully expand the role of graduate students in Branch Affairs.

MANITOBA Branch– Jason Martino

The CNS Manitoba Branch undertook a few actions to attempt to re-invigorate the branch.

Len Simpson agreed to serve as a event coordinator

Len and Blair Skinner made a presentation to Manitoba Hydro in support of consideration of a CANDU to be sited at Whiteshell Labs.

The Waste Technology Division has authored up to 16 papers for the CNS conference this fall, authors were reminded of the savings that comes with membership for conferences.

NEW BRUNSWICK Branch - Mark McIntyre

We were pleased to have 3 organized lectures in 2010-2011.

1. James Carter of Navigant Consulting discussed the importance and benefits of Small Modular Reactors in the nuclear mix of technologies.
2. Adrian Jackson, of Entergy's Vermont Yankee NPP discussed maintenance training initiatives to improve station performance.
3. Peter Corcoran of the CNSC discussed the complexities of CNSC reporting mechanisms.

Some NB Branch members also participated in the New Brunswick Regional Science Fairs in the Spring of 2011. Some members judged projects and others in the nuclear community provided financial prizes to the best energy related projects.

We were also saddened by the loss of one of our long standing members in 2011: Alec Hadfield. Several NB Branch members were present at his funeral service and a modest donation was made by the CNS to his selected charity: the palliative care unit of the Saint John Regional Hospital.

OTTAWA Branch – Mike Taylor

The Branch held six meetings, listed below, during the past operating year. Meetings are not held during the summer months.

The list reflects the new policy of co-operation with the CNSC, University of Ottawa and Carleton University in co-sponsoring speakers. So far, this has proved a positive step, in that we have provided members with a variety of high-calibre speakers and provided the speakers with a larger audience than the Branch alone could have mustered.

1. September 7, 2010/"Establishing the nuclear safety infrastructure in the United Arab Emirates" by Ian Grant/Lunchtime mtg. co-hosted by CNS Ottawa and CNSC in the latter's offices.
2. October 18, 2010/Presentation subject altered at last minute to WANO and INPO experience of speaker/Mike White, consultant/Evening meeting.
3. December 16, 2010/"NRU Repair" by Dave Cox, Director, Safety Engineering and Licensing, AECL-CRL/Lunchtime mtg. co-hosted by CNS Ottawa and CNSC in the latter's offices.
4. February 22, 2011/"Nuclear Energy in the Education of Sustainable Engineering Practices" by Professor Adriaan Buijs (current CNS President), McMaster University/Evening meeting.
5. March 28, 2011/"Sustainability of Nuclear Power" by Dr. David Torgerson, Snr. Technical Advisor (Emeritus), AECL/ Evening meeting co-hosted by CNS Ottawa and Carleton University.
6. April 21, 2011/" Nuclear Safety or Risky Nuclear" by Dr. Dan Meneley, Engineer Emeritus, AECL/ Evening meeting.

In addition to the regular meetings, members of the Branch have:

a) supported the CNS booth at the CNA annual meeting in Ottawa
b) staffed a CNS booth at the annual Ottawa Science Teacher's Fair
c) been judges at the local schools science fair and,
d) participated in the development of a new post-graduate course planned for Carleton University.

PICKERING Branch –Leon Simeon

There are currently 36 regular members and 2 retirees listed. We had 2 new members join the CNS in the last month and will be recruiting more this year.

We are currently in the process of transitioning the chair of the Pickering Branch from Marc Paiment to Leon Simeon who will be looking for support from the Pickering CNS members to reinvigorate the Pickering Branch.

Presentations and Meetings

1. Dr. Peter Ottensmeyer – Candu Nuclear Waste in Canada: a $36 Trillion Source for Electricity using Fast-Neutron Reactors. Thirty-six OPG staff and members attended this session.
2. Several CNS members from Pickering attended a CNS-UOIT session which was presented by Dr. Lorne McConnell. The topic was an Overview of the Global Greenhouse Gas Problem.

SHERIDAN PARK Branch – Peter Schwanke

July, 2010

- **Branch Seminar**:
  - Date: Thursday, July 15
  - Title: "Development of Zr-2.5 Nb Pressure Tubes for CANDU Reactors"
  - Presenter: Dr. Brian Cheadle
    - Retired – Head of the Reactor Materials Division, CRL

September, 2010

- **Branch Seminar**:
  - Date: Wednesday, September 8
  - Title: "CANDU Used Fuel "Waste" in Canada: A $36 Trillion Energy Resource in Fast Reactors"
  - Presenter: Dr. Peter Ottensmeyer
    - Professor Emeritus, University of Toronto

February, 2011

- **Branch Seminar**:
  - Date: Friday, February 4
  - Title: "Alternative Fuel Cycles for CANDU Reactors"
  - Presenter: Sermat Kuran
    - Director of Advanced Reactor Development and Fuel Cycles, AECL

April, 2011

- **Peel Region Science Fair**:
  - On April 15th, representatives from the Sheridan Park branch participated in judging the Peel Region Science Fair held at Louise Arbor Secondary School in Brampton. Awards were presented to three very unique and inspired projects relating to energy:
    - "How Will it Fuse", Matthew Smith and Arjaan Bujis, Mentor College
    - "Photoheterotrophic Bio-electrochemical Fuel", Sruti Arulmani, Tomken Road Middle School
    - "Wind Energy – Our Future", Chinmay Patel and Parthav Desai, Valleys Senior Public School

June, 2011

- **Branch Seminar and Luncheon**:
  - Date: Wednesday, June 1 – a light lunch was provided
  - Title: "Nuclear Energy in the Education of Sustainable Engineering Practices"
  - Presenter: Dr. Adriaan Buijs
    - CNS President and Professor at McMaster University

TORONTO Branch – Joshua Guin

Summary

For the period of 2010-2011 the CNS Toronto Branch has held quarterly committee meetings to promote more seminars and additional means of outreach.

The Toronto Branch has continued to promote the CNS and increase local membership.

Committee

The Toronto Branch general committee was reorganized in 2010. The following list of committee members were selected for 2010-2011:

- Chairperson: Joshua Guin
- Vice-Chair: Paul Gillespie
- Secretary: Khai Ngo
- Treasurer: (vacant)
- Utility Coordinator: Saad Khan
- University Coordinator: Edwin Chen
- Web Master: Joshua Guin
- General Committee: Mohamed Younis, Cory Linton and Andrew Ali

Seminars

The following seminars were held during the period of 2010-2011.

- **Peter Ottensmeyer** presented a seminar, **"CANDU Used Fuel "Waste" in Canada: A $36 Trillion Energy Resource In Fast**

Reactors", on February 3, 2011. Located at 700 University Ave, MZ, OPG Main Auditorium.

- **Jerry Cuttler** presented a seminar on "**Is the Supply of More Nuclear Energy to The People of Ontario Environmentally and Socially Acceptable**" on March 28, 2011. Located at 700 University Ave, MZ, OPG Main Auditorium.

WEBPAGE

The Toronto Branch webpage has been maintained with the most current information regarding seminars to date. Questions can be sent to *Toronto@cns-snc.ca*

UOIT Branch – Kale Stallaert

Executive Roster as of May 2011:

Chair:	Kale Stallaert
Co-Treasurers:	Bradley Rawlings and Jordan Tanner
Operations:	Terry Price
Secretary:	Michael Adderley
Members-at-Large:	Adam Caly, Eugene Saltanov and Jim Dermarkar

Membership:

As of May 1st, 2011, the UOIT Branch consisted of 92 members. The branch is composed primarily of UOIT students, faculty and staff.

Seminars Held:

- UOIT Health Physics Association joint lecture series in February 2011:
  - Thomas Johnson – Power Lines and Politices
  - Thomas Johnson – The "Front End" of the Fuel Cycle: Milling and Mining
- UOIT Health Physics Association joint lecture in April 2011:
  - Larry Romanowich – Development of the Dosimitry Model: (Bruce) Restart Alpha Event
- Lunch and Learn Seminar series in May 2011:
  - Lorne McConnell – Overview of the Global Greenhouse Gas Problem
  - John Froats – Lessons Learned from the Fukushima Event

Public Seminar on Nuclear Events in Japan:

The UOIT Branch organized a public information session as the events at the Fukushima Daiichi Nuclear Power Plant unfolded. Professors from UOIT's Faculty of Energy Systems and Nuclear Science were asked to present on the subject and sit on a panel to answer questions from the public. Dr. Eleodor Nichita and Dr. Anthony Waker presented and were joined by Dr. Ikeda and Dr. Rouben on the panel.

The event saw 200 members of the public, nuclear community and student body in attendance. CityTV, CBC, local newspapers and other members of the media were also in attendance. The event was streamed live with many online viewers.

To view a recording of the event and other related information please visit *http://www.cns-snc.ca/CNS/uoit/past-events/*

Science Rendezvous:

The University of Ontario Institute of Technology hosted a science awareness day for the public on May 7th. The UOIT Branch organized a display on Naturally Occurring Radioactive Materials (NORM). The display utilized two of the CNS's Naturally Occurring Radioactive Materials kits.

Book Review

Radioactivity

- What It Is and What It Does by DONALD R. WILES

Presses Internationales Polytechnique, 2009 ISBN 978-2-553-01430-7

Don Wiles is a retired professor of radiochemistry from Carleton University in Ottawa. In and outside the classroom he has been teaching and talking about radioactivity for decades.

The simple, direct title of this book belies the amount of information it contains.

Written for the intelligent, interested layman (or laywoman) the intention of this modest 150 page treatise is to explain radioactivity, its various characteristics and many positive applications. It contains many figures to illustrate the text.

The Chapter titles offer an insight to the approach taken:

Radioactivity: What it is

Industrial and Scientific Applications of Radiation

Medical and Health Applications of Radiation

Nuclear Fission and Nuclear Reactors

Radioactivity in the Environment

Who is Watching?

Major Nuclear Accidents

Nuclear Waste Disposal

Are We Completely Safe Now

This book would be ideal for the number of non-science undergraduate courses that have sprung up under headings such as "energy and environment". It would also be a useful guide for those of us in the nuclear program when we speak to general audiences.

Fred Boyd

Recently published - not reviewed

Confessions of a Greenpeace Dropout:

The Making of a Sensible Environmentalist By PATRICK MOORE

This is Patrick Moore's firsthand account of his many years spent as the ultimate Greenpeace insider, a co-founder and leader in the organization's top committee.

Moore explains why, 15 years after co-founding it, he left Greenpeace to establish a more sensible, science-based approach to environmentalism.

The book presents Moore's vision for a more sustainable world. From energy independence to climate change, genetic engineering to aquaculture, Moore sheds new light on some of the most controversial subjects in the news today.

Available as an e-book on Amazon or as a paperback.

Calendar

2011

Sept. 11-14 — **Waste Management, Decommissioning & Environmental Restoration for Canada's Nuclear Activities**
Toronto, Ontario
Call for papers
website: www.cns-snc.ca/eventswaste-management-decommissioning-and-environment

Sept. 25-29 — **14th International Topical Meeting on Nuclear Reactor Thermalhydraulics *(NURETH-14),***
Toronto, ON
Call for papers
website: www.cns-snc.ca/events/nureth-14/

Oct. 2-5 — **International Conference on Future of Heavy Water Reactors**
Ottawa, Ontario
email: ISSCWR5@cns-snc.aibn.ca
website: www.cns-snc.ca

Oct. 30-Nov.3 — **ANS Winter Meeting and Technology Expo**
Washington, D.C.
website: www.ans.org

Dec. 4-6 — **9th International Conference on CANDU Maintenance**
Toronto, Ontario
website: www.cns-snc.ca

2012

Feb. ?? — **CNA Nuclear Industry Conference and Tradeshow**
Ottawa, Ontario
website: www.cna.ca

Mar. 18-23 — **18th Pacific Basin Nuclear Conference**
Busan, Korea
website: www.nuclear.or.kr or www.kaif.or.kr/eng

Apr. 15-20 — **International Topical Meeting on Advances in Reactor Physics (PHYSOR 2012)**
Knoxville, Tennessee
website: www.physor2012.org

June 10-13 — **33rd CNS Conference and 36th CNS/CNA Student Conference**
Saskatoon, Saskatchewan
website: cns-snc.ca
email: cns-snc@on.aibn.com

June 24-28 — **ANS Annual Meeting**
Chicago, Illinois
website: www.ans.org

July 30-Aug. 3 — **ICONE 20 and ASME Power**
Anaheim, California
website: www.asmeconferences.org/ICONE20Power2012

International Conference on Future of Heavy Water Reactors (HWR-Future)

October 02 – 05, 2011

Ottawa Marriott Hotel, Ottawa, Ontario, Canada

Heavy Water Reactor (HWR) technology is uniquely suited to respond to the future needs because of its inherent technical characteristics and associated fuel cycle flexibility. With the looming renaissance of nuclear power, major plans for new builds have been established or considered in many countries.

In cooperation with the International Atomic Energy Agency (lAEA), the Canadian Nuclear Society (CNS) is organizing the International Conference on the future of HWR (HWR-Future) aiming to provide a forum for discussion of advancements and issues, sharing information and technology transfer, and establishing future collaborations on reactor design, fuel design, material and chemistry, thermal-hydraulics and safety, and operating experience for HWRs.

The official language of the symposium is English.

For further information and registration go to the CNS website: www.cns-snc.ca

Rock Me Fukushima

by Jeremy Whitlock

It rose from the depths of the ocean, thirty kilometres towards Hell. Without warning or remorse it silently overtook the coast and laid waste to reason in its path. A world stopped for weeks, gripped in fear.

This dark evil was Fukushima. A monster created of Mankind's ignorance and neglect. Powerful enough to divert a planet's sympathy from the fate of thousands killed by a nearby earthquake and tsunami. Or the millions of others whose lives changed forever in an instant.

Fukushima stalked those most vulnerable: the minds seeking to understand but receiving nothing intelligible from the trusted sources. Without sleep it rampaged through the media, the political leadership, the NGO observers, the scientific community, and the general population.

It grew stronger with each Facebook link and terror Tweet. It fed on social media and reached further, faster than any monster before it. Godzilla was a weekend nuisance by comparison, constrained to a mere movie medium. Mothra, Anguirus, Rodan, Gamera, and King Ghidorah fared no better.

Its tentacles, tipped with venomous dread, grew and multiplied through the fertile soil of CNN, inciting an army of morons to do its bidding. Even the greatest of all avengers, Uncle Sam, fell victim to its wiles. Marching before Fukushima, swinging its oversized American flag before it like a giant scimitar, the Samster chased logic into the hills, softening the ground ahead of its new master and lord.

"Run, Americans in Japan, run!", Samster cried, "Run or die!"

Too late and too few, a militia of educators stood their ground against the onslaught. Mercilessly they were cut down, their Powerpoint slides on radiation effects still gripped in their hands.

"Please!", their dwindling numbers called to all that would listen, "this creature is feeding on your fear! There is no deadly radiation!"

"Run or die", came Samster's dire cry, "Run or die! There is no water left in Unit 4's spent fuel pool!"

"Uh, but actually that's not true", warbled the rebels of reason, "as far as we know there is still water in..."

"LIES!", croaked the Samster, snapping off a handful of self-effacing heads with one swing of his great flag, "Who dares counter the word of Uncle Sam!"

With a sickening crunch the Samster then disappeared under the mighty foot of Fukushima, lurching from behind, ten times larger than before and no longer in need of the minion's petty favours.

A roar that reached around the world erupted from Fukushima's insatiable belly. People on all continents cowered in fear.

"What the heck is a milli-Sievert!", they screamed with consuming insanity, "Grays! Rems! Rads! Why do you torment us, Fukushima?!"

"The iodine is higher than allowable levels!", yelled the Administrators, their minds rent with confusion under Fukushima's spell, "The iodine, oh Lord, the iodine! But you're all safe! You see, the allowable levels are defined as..." Another resonant crunch and the wretched Adminstrators were bothered no more by the trials of scientific explanation. Fukushima roared with delight and disappeared over the horizon.

"The radiation cometh!" came the call to arms on Canada's west coast, heralded by the first nanobecquerels of advanced poison.

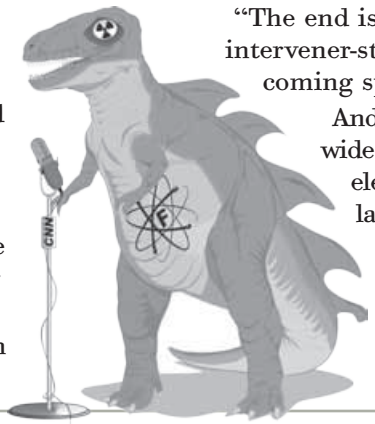
"Fear not! You are safe!", soothed the master protector Health Canada, even as it rushed a load of new radiation detectors to the shore. "There is no danger! And we can prove it with our machines!"

Crunch. Health Canada disappeared in a cloud of hysteria, and Fukushima landed on the west coast.

"Potassium Iodide! Potassium Iodide!", chanted the natives of the New World, embracing new gods to save their souls, delirious with CNN fever and the toxins of Facebook coursing through their veins.

Scientists danced on TV talk shows, politicians ran in circles, the great Green machine arose and lead its new lord Fukushima into the feeding grounds of weak hearts and minds. Germany collapsed and disappeared like a week-old puffball, as did Switzerland and Italy, while France rubbed its hands in glee and started drafting new cross-border electricity contracts. Everywhere the anti-nuke cultists bowed before the coming evil.

"The end is nigh!", they squeaked as they dusted off intervener-status application forms, ready to reap the coming spoils of Fukushima's terror.



And meanwhile, even as chaos reigned worldwide, back in a dark corner of the devastated electricity plant where Fukushima first made landfall, spent fuel pools sat full of water and reactors sat holding their fuel, though three cores had long ago melted, cooled and now sat in the dark, safely awaiting the return of reason.

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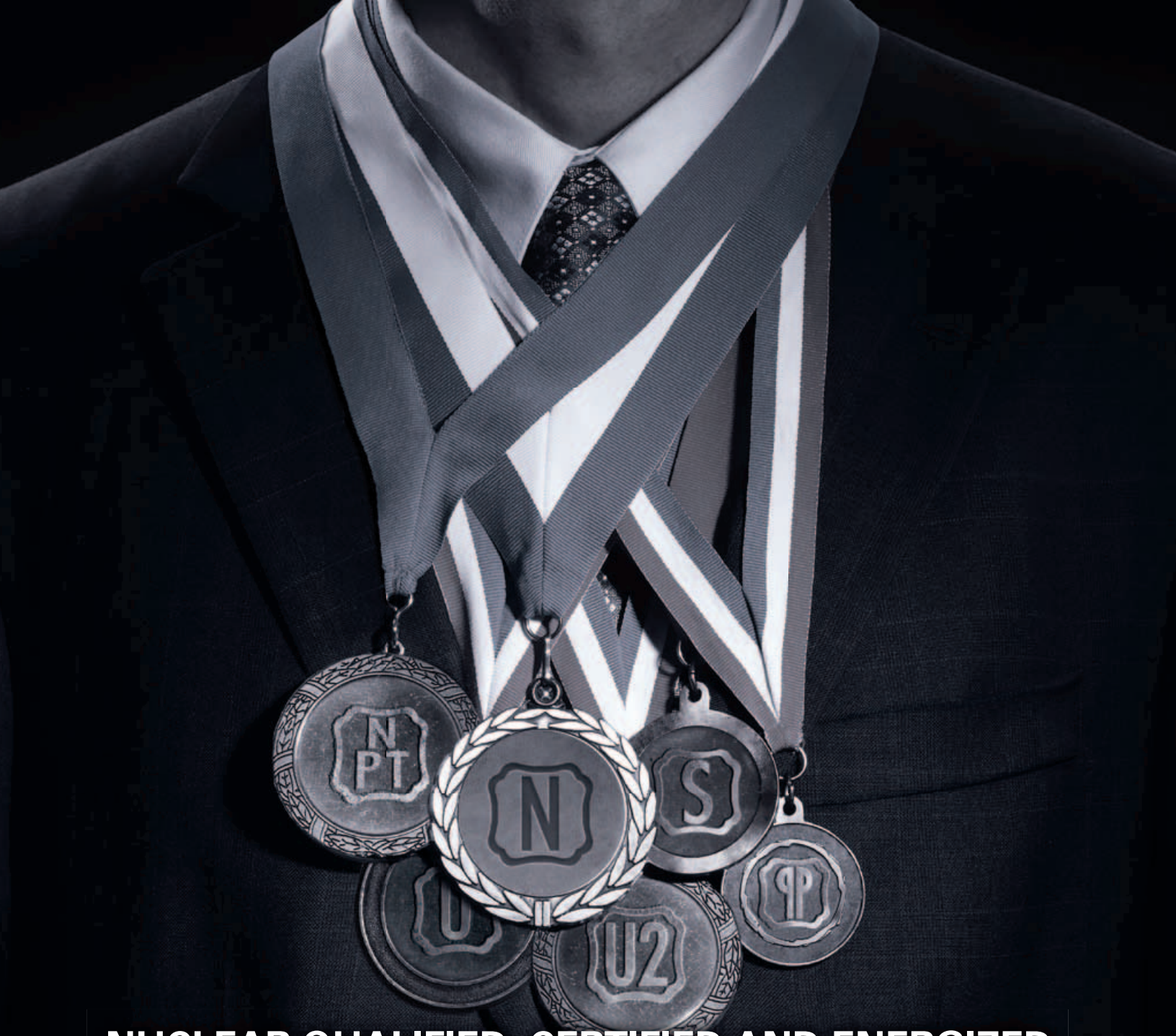
For information on CNS activities and other links – Pour toutes informations sur les activités de la SNC

http://www.cns-snc.ca



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