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The Canadian Far North: Diesel vs SMR

In the June 2016 edition of the Bulletin I commented on a presentation made in Yellowknife, by a vendor of a Small Modular Reactor (SMR). The presentation provided local residents information about a proposed design and the benefits of replacing expensive diesel with a clean technology. It is likely that the presenter was expecting, and was prepared for the usual questions raised about nuclear energy: costs, radiation, accidents, nuclear waste, licensing and so on.

But the meeting went south when attendees raised concerns about something that had nothing to with the presentation, the vendor, the reactor, or anything related to nuclear energy. The meeting went downhill when a Dene, one of many First Nations people in the NWT audience asked "What about Dehcho?"

The issue was related to the contaminated Giant Mine near Yellowknife. The large corporation came to First Nations people promising jobs and benefits only to extract the gold and leave behind a legacy of toxic waste; Giant Mines walked away with $2.7 billion in gold and now the taxpayers are dealing with the toxic tailings, laced with arsenic trioxide, at a cost of about $1 billion. It is unlikely that the contaminated lands and waters will ever be restored to their previous pristine condition.

As seen in photos on the cover page of this Bulletin, Canada's far north is a cold, harsh and delicate environment. As noted in one of the SMR papers in this Bulletin, northern residents pay an enormous amount for electricity (and most other goods) which depends on diesel. These communities are too far away to connect to a common grid; it would be prohibitively expensive, not to mention line loss over very long transmission lines. The northern communities have no option but to generate electricity locally and diesel is very expensive. With recent events in the oil producing countries and soon to be enacted carbon taxes diesel prices will skyrocket. Furthermore, a typical 10 MWe diesel generator emits some 55,000 tonnes of CO_2 per year! And ironically, the far north is feeling a disproportionate effect of anthropogenic climate change.

Compared to diesel, a SMR would help both the environment and the wallets of northern citizens. As observed at the recent International Meeting on Small Reactors there is rapidly growing interest in SMR technology and several potential vendors are working out details to make them as safe and economic as possible. From the perspective of the scientifically savvy they just make good sense. It should be a no-brainer to replace northern diesel electric generators with SMR electric generators. As a side benefit, the SMR can also provide heat, a welcome resource in the true north strong and free.

From the perspective of risk-averse financiers, the risk is a tad slanted by licensing uncertainty, but this negative bias is diminishing as our regulator studies the various SMR designs, and no doubt they can be licensed, perhaps with just a few design tweaks to make the regulator (and financiers) more "comfortable". A good example is the SLOWPOKE small reactor, now routinely operating in Universities.

From the perspective of the First Nations, who call the far north home, well, the industry has a lot of work to do. According to their website, "The Dehcho Dene were put there 'by the Creator as keepers of our waters and lands.'" It is their "ancestral territories and waters [governed] according to their own laws and system of government since time immemorial." To be sure, these people have been burned before and will treat any "proposal" with a lot of scepticism.

Perception is a difficult road to navigate. When the road is slippery, one must avoid sudden turns! A lot of trust-building will need to be done, with lots of compassion.

In This Issue

The 4th International Meeting on Small Reactors is summarized by Colin Hunt. Although the topic was on small reactors the attendance was anything but small. It was a huge success with many vendors providing details of their products and regulators describing their reviews. No decision has been made to build one in Canada, but SMRs are being advocated to replace expensive diesel in areas that are too remote for the power grid, or where the existing grid is too small for a typical power reactor such as the CANDU. This edition of the Bulletin is dedicated to the topic of small reactors.

Gilles Sabourin continues to research Canadian women who worked in the Montreal Laboratory during WWII, and has provided Part II of the series (see History in this Bulletin). Part III will appear in a future edition.

Finally, Jeremy Whitlock provides possibly his last Endpoint; he has now moved on to a new position with the IAEA in Vienna.

Comments and letters are always welcome. Please enjoy a safe and happy holiday!

From The Publisher

A number of remarkable developments have occurred for Canada's nuclear industry during the fall of 2016. These include both domestic developments and prospects for expansion off-shore. These also include both developments in research and technology, and in the growth of Canadian technology in power generation.

Let's look at research and development first. This fall, Canadian Nuclear Laboratories (CNL) opened a large, new research centre. By itself, this represents what may be the largest investment of new capital in Canadian nuclear research in decades. The new centre replaces a large number of old smaller buildings, some of them dating back to the late 1940s and 1950s. It constitutes a commitment by the federal government going back approximately 10 years to renew and rebuild Canada's nuclear research infrastructure. This expansion of research investment clearly indicates that Canada's nuclear R&D sector will continue to have a strong capability for the foreseeable future.

R&D is where it all starts. With such an enduring infrastructure, customers of Canada's nuclear products and services can have confidence that there will be a strong technical base of support for its industry in the years to come. This applies to both domestic customers and to those overseas.

It also means that young Canadians interested in nuclear research and technology will continue to find strong opportunities within Canada. For them, the signal is loud and clear; new infrastructure means an enduring commitment for the future.

In naming the new facility the Harriet Brooks Building after Canada's first female nuclear physicist, the nuclear industry is openly advertising the fact that its work force in all areas has a strong and growing contingent of women. As a symbol, it shows that Canada's nuclear industry may be one of the most culturally and gender diverse high technology industries in the country. This development is welcome indeed, as any high technology industry needs creative talent wherever it may be found.

This investment in new R&D capability is starting to show concrete results. Looking at developments within Canada, in October, Ontario Power Generation (OPG) and the Ontario government expressed their faith in Canadian nuclear technology with the shutdown for refurbishment of Darlington Unit 2. The plan for Darlington is straight-forward; starting with Unit 2 and proceeding through units 3, 1, and 4, each of the reactors will undergo a 40-month, sequential outage. When complete in about 10 years, the plant will have full operational capability well past the mid-point of this century. Coupled with the forthcoming refurbishment of six reactors by Bruce Power, this means that nuclear generated electricity will supply the bulk of Ontario's electricity beyond the lifetimes of most of the province's current residents.

But there's much more that's happened in the power generation sector. SNC-Lavalin announced in November that it had been awarded a contract for preliminary work at the Atucha site in Argentina. Argentina like many nations around the world needs new supplies of electricity. With a new CANDU reactor at Atucha, Argentina's electricity future is one invented and developed in Canada.

In addition to Argentina, it is anticipated that Romania will commit to the construction of Cernavoda 3 and 4. When completed, nearly half of that country's electricity will be coming from CANDU reactors. This will constitute a very large change for a nation which emerged from the collapse of the Warsaw pact, impoverished and almost wholly dependent on fossil fuels for its electricity.

All of these developments have come about because of co-operation with companies in China. The Chinese have further expressed their confidence in Canadian nuclear expertise with their earlier agreement for a new CANDU project in China specifically to use advanced nuclear fuel cycles.

But it's not limited to just CANDU. Two applications have been made to the Canadian Nuclear Safety Commission (CNSC) for vendor design reviews for small modular reactors. One by Starcore and one by Terrestrial Energy, both are very different from traditional power generation technology. The first is a concept for high temperature, gas-cooled reactors, while the second is for a molten salt reactor. And more applications from more nuclear companies are anticipated.

There's a reason why this new nuclear development is coming to Canada. As the second nation in the world ever to demonstrate controlled nuclear fission, Canada has the experience, the research infrastructure and the manufacturing base to sustain a growing global demand for new nuclear technology. Plans and intentions are one thing, but what has been shown here is that governments and industry are investing large amounts of capital and expressing confidence in Canada's nuclear future.

It's a package deal, folks, and in nuclear, Canada has the total package.

C.G.H.

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~ Cover Photo ~

Canada's Arctic is a truly harsh environment almost wholly dependent upon diesel fuel for heat and power.

Photos courtesy Hatch

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Editor / Rédacteur
Ric Fluke Tel. (416) 592-4110
e-mail: richard.fluke@amecfw.com

Publisher
Colin Hunt Tel./Fax (613) 742-8476
e-mail: colin.hunt@rogers.com

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Huge Turnout for CNS Small Reactor Technical Meeting

by COLIN HUNT

Traditionally, the conference on small reactors held by the Canadian Nuclear Society (CNS) has been a relatively small gathering of reactor designers and interested members of industry and government.

Not this year. The 4th International Technical Meeting on Small Reactors held in Ottawa, November 2-4, 2016, was a large, bustling heavily attended conference with more than 160 participants. Conference delegates filled the rooms and corridors, and exhibit booths jammed just about all available space this year, demonstrating clearly that the topic of small reactors was of great interest to dozens of companies and organizations.

Stephen Bushby, General Conference Chair.

In opening the conference, General Conference Chair Stephen Bushby expressed gratification at the strong attendance and indicated that small reactors were indeed a future frontier of development for new nuclear technology. He noted three areas of attraction for small modular reactors (SMRs) for electricity production:

- lower capital costs;
- lower operating costs; and
- greater flexibility in siting.

"Canada is well positioned to lead in small modular reactor development for a host of reasons," Mr. Bushby said. Those reasons included an established nuclear manufacturing, design and development infrastructure, a past history of small reactor development, and a strong, reliable regulatory structure.

Speakers in the opening plenary session expanded on Mr. Bushby's overview. Robert Holmes, Chief Scientist at Canadian Nuclear Laboratories (CNL) observed that the concept of SMRs is very favourable to governments at this time, particularly in the United Kingdom and United States.

Dr. Holmes noted that SMRs may have a number of advantages not available to typical large power reactors. One such is the high proportion of work that can be done in factory assembly rather than on-site. This can allow a much higher degree of quality control in building an SMR compared to traditional on-site assembly for large power reactors.

He also noted that SMRs are not new, either in concept or in actual construction. Canada has a strong past history of such developments, noting in particular the development of the SLOWPOKE reactors in the 1960s and early 1970s in Canada.

Terry Jamieson, Vice President of the Canadian Nuclear Safety Commission (CNSC) outlined the steps that the CNSC has undertaken to prepare for the future licensing of design, construction and operation of SMRs. He noted that the CNSC process can allow for both traditional licensing applications and for combined construction and operating licences. He also indicated that CNSC is well prepared for a variety of different technologies for which licensing applications may be sought.

Mr. Jamieson stressed the importance of pre-licensing consultations between developers and regulators. Through such consultation, developers get a clear understanding of the regulatory requirements for new reactor technology, saving considerable time in ensuring that licence conditions will be clearly understood and unambiguous. Mr. Jamieson noted that Canada's regulatory structure is performance-based, not prescriptive-based. This places a greater burden on the developer to demonstrate the safety case of a new design but also allows greater flexibility to meet the regulator's requirements.

Subsequent speakers in the opening plenary touched on the interest of the federal government in the use of SMRs to reduce Canada's greenhouse gas emissions and of the Ontario government in a variety of applications for both grid and off-grid power generation in remote locations.

Speakers for the second plenary on Thursday, November 3 outlined critical reasons why SMRs are needed. Nuclear development history in the United States served as a strong example. The importance of government support in development was noted, as private capital does not in general step up to support innovative projects. This is particularly the case when uncertainty of project completion is high, as has been the case in the United States.

In the United States, of the large power reactors built according to the Congressional Budget Office, the average project cost overrun was 400 per cent. After Three Mile Island in 1979, the average construction time of large power reactors increased from five to 12 years. Finally, all 41 reactors ordered after 1973 were subsequently cancelled during or prior to the beginning of construction.

Thursday Morning Suppliers' Panel Plenary.

Dr. Robert Watson speaking at the conference dinner.

On a global basis, 50 per cent of all large power reactors were completed over budget and late in schedule.

Speakers on the second day suppliers panel noted a variety of ways that SMR developers can mitigate some of the problems of the past. Glenn Archinoff of Candesco stressed the importance of thinking about regulatory requirements and meeting with regulators early in the design process of a new SMR. Albert Lee of SNC-Lavalin noted that developers should not under estimate the potential difficulties of civil engineering. Benoit Parent of Cummins Eastern Canada observed that developers must have a clear idea of the security requirements of their technology. Mr. Parent stated that about one per cent of the total asset cost is usually related to providing security of a facility.

Beyond the plenary sessions, the conference featured a large number of parallel technical sessions. These sessions explored topics including siting in remote locations, reactor physics, research and neutron beam applications, passive safety features, staffing and fitness for service needs, safety analysis, and SMR economics.

The principal sponsors of the conference included:

- Sylvia Fedoruk Canadian Centre for Nuclear Innovation;
- Liburdi GAPCO;
- SNC-Lavalin Nuclear; and
- Kinectrics Inc.

The organizing committee of the conference included: Stephen Bushby, General Chair, Metin Yetisir and Steve Livinstone, Technical Program Chairs; and Dan Brady, NRCan; Paul Chan, RMC; Marcel de Vos, CNSC; Roger Humphries, Amec Foster Wheeler; Benjamin Rouben, CNS; Pavel Samuleev, RMC; Gina Strati,CNL; Bhaskar Sur, CNL; Daniel Banks, Canadian Neutron Beam Centre; and Bob O'Sullivan, CNS.

Looking into the 21st Century with New Reactors for Small Applications

by COLIN HUNT and BRIAN GIHM, Hatch Nuclear Technologies Lead

Canada's nuclear industry has a long history of innovation. Canada was the second nation in the world to demonstrate self-sustaining fission with the startup of the ZEEP (Zero Energy Experimental Pile) reactor on September 5, 1945. Canada has been one of the very few nations to develop a large power reactor for purposes of electricity generation, and Canada was among the first nations to explore the use of small nuclear reactors for niche applications such as district heating and distributed power generation.

It is in this niche application of nuclear technology where much of the new thinking is taking place with respect to new nuclear power systems. There has been in recent years a large number of new startup companies emerge, both in Canada and around the world. Many of these are technology venture companies engaged in the development of a wide variety of different Small Modular Reactor (SMR) types. The definition of an SMR is quite simple: any single unit modular reactor less than 300 MWe.

And they are starting to attract attention from much larger, well established engineering companies. One such entity is Hatch Ltd., whose industry knowledge in SMRs was highlighted this year with its production for the Ontario government of a study providing an overview of the technology, application prospects and development of SMRs.

The small size of SMRs is important for Hatch as it increases greatly the potential number of applications of nuclear power. At this time, Hatch sees two large potential applications:

1. Utility scale power generation:

Current nuclear power reactors come only as large units. In the case of CANDU, the heavy water-moderated CANDU 6 reactor has a capacity of approximately 700 MWe. Light

Colville Lake new hybrid power plant.

Recently, CNS Bulletin discussed with the Hatch. engineering team the importance of SMR technology to Canada and its potential applications and benefits.

How many SMR studies has Hatch undertaken?

Hatch has done 6 studies for external clients, 7 internal studies, 7 conference papers and various publications.

For the Ontario Ministry of Energy – How many SMR Proponents were initially looked at?

There were Ninety (90) SMR technologies in the initial list.

From the initial list how many were "Short Listed" and included in SMR Study?

The study focused on Nine (9) SMR technologies

What were the criteria for the "Short List" Candidates?

System size that fits the requirement for Remote Communities and Mining Operations, vendor credibility, active development and existing operating SMRs

What is the purpose of the SMR Evaluation Databank?

The cost factors that impact the economics of very small modular reactors (VSMRs) in remote areas are not as clearly known today. Hatch created the SMR evaluation databank and populated it with the initial values based on extensive research so that they can be used in SMR financial models. It is intended that these values are updated in the future as new information become available.

What would be the environmental benefit of utilizing SMRs?

A nuclear reactor is a very low GHG emitting power generation technology, even when its entire lifecycle emission is considered. As VSMRs are intended to replace diesel generators, significant amounts of GHG emissions can be potentially avoided. Other benefits include reduced risk of diesel spills and air quality improvements in areas where diesel generators are the primary source of power generation.

How much reduction in Green House Gases?

For every 10 MWe VSMR installed, it is equivalent to removing approximately 14,000 passenger cars from the road annually.

Fuel storage tanks, Clyde River, Nunavut.
Photo credit: Peter Ewins, WWF Canada

GahchoKue

water-moderated technologies are typically 1000 + MWe. The large reactor size poses a problem for accommodating in small grids. In the case of New Brunswick for example, the Point Lepreau reactor provides nearly 25 per cent of the province's generating capacity and well over 30 per cent of the province's electrical energy. When this single unit reactor goes out of service for maintenance, it requires large amounts of other generation to provide additional supply.

SMRs can overcome this difficulty. A conceptual power station for utility generation could involve a number of SMRs installed in a reactor generation complex. By using a number of small reactors rather than a single large reactor, maintenance and refueling outages can be managed without the large adjustments required by large power reactors.

Mary River Project Iron Ore

What would be the Socio-Economic impact to Ontario?

It really depends how much of VSMR manufacturing can be done in Ontario and their eventual market penetration. If 50% of the spending can be captured in Ontario, every 10 MWe of SMR installation will represent approximately 2,600 person-years of employment or about a half billion dollars.

What are the challenges facing SMR deployment?

Investment and regulatory uncertainties are associated with the first of a kind unit development. The potential customers of SMR want a product that can be readily deployed with minimal risks. However, the technology proponents need the customer commitment to justify the initial development cost.

Are there any "Ready for Deployment" SMR Technologies?

There are a few technologies that are more mature than others; for instance, integral pressurized water reactors. However, the technology can only be considered ready for deployment when the regulatory approval is obtained for implementation.

How long would it be before a SMR could be licensed in Canada?

In our report to Ontario Ministry of Energy, we indicated that 2030 would be the reference case to see the first SMR unit operating in Canada. However, there is a possibility that licensing may be quicker for some vendors with more developed technology and we could see the first unit operating in 2023.

How long would it take to erect a SMR?

Ideally, the plant could be modularized such that the pre-fabricated parts can be shipped to the site on trucks or barges and they can be assembled on site with mobile construction equipment in a few months.

How would the role of the nuclear operator for an SMR be addressed?

We do not see the role of the nuclear operator for an SMR to be different from those for large CANDU power stations. Regardless of the reactor size, qualified nuclear operators will be required

.How many staff would be needed to operate a SMR?

The minimum staff complement is prescribed in the General Nuclear Safety and Control Regulations 12 (1) (a). In summary, the regulation says that there should be 'enough' people to ensure a safe operation of an SMR. 10 to 15 on-site staff could potentially operate a small

SMR facility, but there are vendors who aim to have no operator(s) on site.

At a remote off-grid site would a SMR be able to handle the cyclic load?

As most SMRs plan to use low enriched uranium as fuel, the reactors are not affected by fluctuations in neutron absorption related to xenon production. Also the small core size makes an SMR less susceptible to the effects of power oscillations. It is reasonable to assume that SMRs can handle the cycling load in remote off-grid locations. However, if the remote off-grid location is a mining site, then additional system such as micro-grid controller with energy storage will be necessary due to rapid load fluctuations and reactive power swings.

Explain what a Micro-Grid Controller is.

In a power grid, the electricity generation and consumption must be balanced to make sure that the AC frequency is correctly maintained. A micro-grid controller is a real-time monitoring and controlling system of power generation and dispatch. It is a critical system in a small grid that contains a variable power source such as a wind turbine or Energy Storage for fluctuating demands such as a hoist in a mine.

What would be the potential energy storage solutions?

It is anticipated that a mixture of fast acting and long term energy storage solutions will be required to complement an SMR in a remote power system. For instance, Hatch's flywheel technology (fast acting), Batteries and a hydrogen storage system (long term) all co-ordinated with a Hatch Micro-Grid Controller can be used to reduce the burden on an SMR.

Where are potential SMR deployment Sites?

The ideal SMR deployment sites are "Off Grid" locations such as Canadian Arctic industrial or residential locations where other technology options cannot provide economical base load power generation.

Is Hatch currently supporting SMR technologies?

Hatch has developed several application technologies that can support installation and integration of SMRs in remote off-grid locations. These include arctic engineering, logistics to deliver SMR modules to remote areas, Hatch's own micro-grid controller, energy storage technologies and mining power system design. We are looking for the right solution that could provide cost effective and safe power options to our mining clients in remote areas.

Mary River Project

Meadowbank Gold

In so doing, addition of new nuclear capacity can be more closely matched to growth in demand for electricity.

Furthermore, installing SMRs incrementally minimizes the capital cost of initial installation, spreading it out over time as new SMRs are added to a nuclear generating facility.

2. Off-grid power applications

As a large engineering company, Hatch has had decades of experience in installing complete power generation and distribution systems for isolated sites without access to an electrical grid. Most commonly, these have been mining sites that usually have unique requirements for both electricity and process heat.

Thus far, the principal method of producing power and

Tank farm

heat for isolated sites has been diesel generation. This in turn provokes an additional problem. Diesel fuel must be transported to the remote site in large quantities. And the transport problems can be severe. As a recent paper given at the 2016 CNS Annual Conference noted, transport of diesel fuel into Canadian Arctic communities can constitute as much as 75 per cent of the tonnage of goods shipped in. In the case of some particularly remote communities, much of this transport must be delivered by air.

This means that relying on diesel results in power supply that is both highly expensive and highly fragile with respect to transport vulnerabilities.

By contrast, SMRs would avoid many of these problems. Once installed, an SMR could provide power and heat as required by the site while operating for a number of years without requiring new fuel. Transport requirements would be reduced enormously, both in cost and quantity.

Hatch has had long experience with providing power solutions to clients operating in remote sites. And it's looking to SMRs as a method of addressing power generation challenges.

Jim Sarvinis of Hatch said that the company is technology neutral with respect to SMRs. Different sizes of reactors may be appropriate for different applications. Instead of developing in-house reactor technology, Hatch plans to work with partner companies that will develop and supply the reactors while Hatch maintains its focus on system installation and integrationSMR technology could be particularly attractive to Canada. A large number of communities in northern Canada are isolated and lacking in any power generation in the community other than local diesel generation. Canada has a very large mining infrastructure, much of it in remote locations. And Canada has a large number of electric generating utilities, varying greatly in their grid size and electricity demand.

For all of these, SMRs can play a key role in providing reliable and lower cost energy in areas of Canada most in need.

Some of the most important aspects of new nuclear technology are regulatory and licensing considerations. The Canadian Nuclear Safety Commission (CNSC) and its regulatory process are a competitive advantage for Canada. Its use of a risk-informed rather than prescriptive methodology better enables the Canadian regulator to deal with new, innovative technology while ensuring public, workplace and environmental safety. In so doing, the CNSC methods compel licence applicants to be highly qualified and thorough in their work to be approved.

Raglan

The Trusted Informant: Showing Empathy to Build Credibility

by E. LLOYD[1]

[Ed Note: The following paper was presented at the 4th International Technical Meeting on Small Reactors (ITMSR-4), Delta Ottawa City Centre Hotel, Ottawa, Ontario, Canada, 2016 November 2-4]

Abstract

We can provide information to the public, but what if no one is listening? Public mistrust of nuclear industry representatives stands as a barrier to successful communication of factual information on health, safety, and environmental impacts of small reactors. In this paper I demonstrate with reference to social science and marketing research how empathy can help to gain trust and dispel misinformation when communicating with potentialhost communitiesand the broader public.

Introduction

As the small reactor industry moves forward, a key element of deployment success will be finding suitable site locations for first-of-a-kind (FOAK) small reactors. The commercial success of these reactors pivots on whether they can achieve economies of scale with a proven design. Achieving that first build, followed by the rapid deployment of several additional units, will be the proving grounds for Canadian industry leaders seeking to establish themselves in national and international markets.

In a number of industries, social factors are becoming increasingly influential for site selection. Community support for a project can help fast-track environmental impact assessments and other regulatory hurdles, avoiding costly delays. For the best chance at success, long-term planning for small reactors must now lay groundworkfor successful partnerships with Canadian communities [1]. Although educated publics are more likely to support nuclear power [2], effective social outreach must go beyond education alone. Successfulcommunication of factual information is itself dependent on a foundationof trust and mutual understanding. Empathy can play a key role in building this trust.

1. How Mistrust Perpetuates Misinformation

As prerequisites for systematic evaluation, a person must possess both sufficient motivation to consider an issue as well as the background knowledgenecessary to process the information [3]. We want people, especially those living in potential host communities,to carefully consider all benefits and drawbacks using relevant and accurateinformation.

There are many excellent outreach initiatives in place to bring this informationabout nuclear to the public. But surveys of Canadians reveal widespread distrust of the nuclear industry: many do not view industry representatives as credible sources of information [4]. What happens when those who hear accurate information do not trust its source?

Mistrust presents a significant barrier to communication. This is because factual arguments alone cannot easily instil motivation and can only guarantee availability of information not acceptance of that information as accurate (Figure 1). Without first establishinga link of trust, capacity to dispel myths and convey helpful and accurate information to public audiences is limited.

Figure 1: Mistrust blocks the communication needed to inform thoughtful evaluation.

2. Two Paths to Trust

To trust another person is to believe with confidence that they will not act in violation of our interests. Research on business-consumer interactions has studied the critical role of trust for building relationships. For example, mathematical modeling has established trust as a key pathway for communication to eventually result in positive (i.e. cooperative) outcomes [5].

One way that trust can be established is from past experience. If I seethatsomeonerepeatedly meshed well with my best interests, I might be confident that this pat-

1 M. Sc. Marketing Student, University of Saskatchewan, Saskatchewan, Canada (185 - 25 Campus Drive Saskatoon SK S7N 5A7)

tern will continue. However, this route for gaining trust takes time, and first requires enough trust(or low enough initial risk) that people are willing to take a chance on a person or on an organization in the first place.

A second way to establish trust depends on our ability to understand and thus predict another

If I perceive that someone intimately understands my own point of view and more importantly has respect for my best interests, it is only natural for me to trust that they will act accordingly. The beginnings of this trust can form in an instant and are rooted in our social nature to connect with other human beings throughempathy.

3. Understanding and Feeling Empathy

Empathy involves dees understanding of another person's emotional state. It is the ability "to perceive the internal frame of reference of another with accuracy, and with the emotional components and meanings... as if one were the other person" [6, pp. 210-211]. Empathetic corporations possess a strategic advantage for understanding consumer needs, supporting relationships, and building trust [7, 8]. In fact, empathy is *most* important for consumer satisfaction when initial trust is very low [9].

Empathy's ability to connect people is grounded in shared emotionalexperience.Facts and emotion are sometimes seen as polar opposites [2], but it is important to note that emotions are a natural human response to (perceived) situations. Even if an emotion springs from a misinfo rmed assumption, the experience of feeling that emotion is still an entirely rational responsecause and effect for the human brain. Dismissing nuclear opponents as "emotional" instead of rational thinkers is an oversimplification that hurts the industry's long-term objectives. In actual fact, careful evaluation of an issue involves *stronger* emotions than when one is persuaded without much thought [7]!

Feeling empathy includes a cognitive component (understanding) as well as an emotional component (feeling with another person) [6]. It requires that we set aside our own perspectives and even our background knowledge for a temporary moment. As if trying on someone else's shoes, we step into and consider the assumptions, values, and knowledge held by the other person. *How would I feel if I were this person, knew only what they know; and thought the way they think?* Only then can we bridge the gap between our opposing perspectives and acknowledge the other person emotions as valid.

Bridging this gap has powerful benefits for the empathizer's social interactions. Empathy is necessary in order for diverse groups to identify common ground and form collective goals [10]. Furthermore, it lessens our innate tendency to feel prejudice against people with different viewpoints [11]. This makes empathy proactive: the ability to foresee, quickly apprehend, and relate to public concerns can facilitate a more measured and understanding response to negative, high-intensity public emotions.

4. Communicating and DemonstratingEmpathy

Empathy helps us to understand other perspectives, but the greatest benefits come when we demonstrate this in a way that is visible to others. It is not our self-perception, but rather *consumer* perceptions of our empathy that predict future relationship trust [8, 9, 12]. This is especially important to consider when responding in highly charged situations.

Communication behaviour generally falls along a spectrum of instrumental versus expressive [13]. Communication is instrumental when used to obtain a specific goal. The speaker often appears calm and may engage in constructivedebate or bargaining. Expressive communication,on the other hand, is done with the *singular* primary objective of **being heard and understood.** The speaker may sometimes express certain goals or make requests, but these are secondary. If the person does not **feel that they are being listened to**, absolutely no progress can be made. Attempts to reason or inform are ill-received because they hold little relevance to the true concern at hand.

Meeting this need to feel heard is best accomplished through active listening behaviours. These methods are effective even in crisis situations [13] and include conversational strategies like paraphrasing, asking for clarification, and offering to solve problems jointly. Furthermore, consumer perceptions of empathy are known to depend on the active listening skills of salespersons they encounter [12].

5. Conclusions

We have a responsibility to provide accurate information to the public. Empathetic communication cannot replace informational outreach, but the trust which empathy is shown to build can be an important pre-requisite to that information's acceptance. At a time when a fact-centric counterpoint might be ill-received and ignored by most, a visibly empathetic response could instead convey understanding and foster trust especially for onlookers to the conversation. In situations calling for empathy and a deep perspective, the best questions to ask are driven by curiosity to understand, not rhetoric to make a point or counter argument.

A consistently empathetic approach to public communication requires forethought and rehearsal. Active listening rarely comes as an instinctive response, especially in conflict-prone sitations where we ourselves care deeply about the issue at hand. When practiced, however, empathy can enable us to demonstrate greater understanding, mitigate heated situations, convey accurate information with wider success, and inspire greater trust in industry for the long-term.

6. Acknowledgements

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Safety Analysis Report for Molten Salt Reactors

by DR. HELMY RAGHEB[1], P.Eng.

[Ed Note: The following paper was presented at the 4th International Technical Meeting on Small Reactors (ITMSR-4), Delta Ottawa City Centre Hotel, Ottawa, Ontario, Canada, 2016 November 2-4]

Abstract

This paper provides a review of certain conceptual design features for the Molten Salt Reactor (MSR) and the relevant experience gained from the Molten Salt Reactor Experiment (MSRE) that operated in Oak Ridge National Laboratory (ORNL). The purpose of the review is to explore the challenges that may arise in applying the current international standard of Ref. [1] that provides guidance on the Safety Analysis Report (SAR), to the design features and postulated accidents of a newly built MSR. The review found that while the current IAEA standard is adequate to capture the safety issues arising fromthe MSR design, a number of features peculiar to the MSR need to be captured by the SAR and covered by the IAEA standard within the routine update process of the standard.

Introduction

A regulatory approval to build and operate a nuclear facility requires the applicant for a license to submit to the Regulatory authority a Safety Analysis Report (SAR). While the current international standard (Ref.1) that describe the contents of the SAR is now being updated to reflect the experience with the newly built Nuclear Power Plants (NPPs), a new generation of reactors has already appeared on the seen such as the MSR with different design concept, different types of safety barriers and new set of initiating events. This requires further research and development aimed at ensuring compliance international standards.

The design concept of the MSR has been used in this review as an example to explore the extent to which the current SAR requirements and guidelines of Ref. [1] can be applied effectively to its design safety features and to propose possible amendment to the current SAR standard. The essential MSR design features considered in this review are those demonstrated in the MSRE that operated in ORNL between 1965 and 1969. A number of reports that describe the MSRE program is listed here as References [2 to 6].

1. Issues involving safety analysis

Based on the analyses and results of the MSRE, the accidents scenarios identified [4] are consistent with the SAR categorization of events as Anticipated Operational Occurrences (AOOs), Design Basis Accidents (DBAs) and Severe Accidents. The guidance offered in the SAR appears, in general, to be adequate to cover issues arising from the MSR design. However, due the distribution of fuel and the radioactive fission products throughout the primary system, the drain tanks and the off-gas systems, some additional guidance may need to be introduced in the SAR to address the impact of the spread of radioactivity in the reactor system. The following are remarks on some aspects of the safety analysis.

1.1 Modeling of containment during seismicevent

In the MSRE, the sealed reactor and the drain-tank cells are the secondary containment for the fuel salt during operation. The lines and vessels through which the cell atmosphere is recirculated by the component coolant pump are in effect extensions of the reactor cell (Fig. 1). All service lines penetrating the secondary containment are equipped with closure devices. In the current safety analysis of the CANDU plants, and during seismic event, containment is assumed to either maintain its integrity or to allow some penetrations through the containment to fail, thus creating a path for limited release of fission products in the steam or spilled coolant to the environment. Such a release is expected to be below the single failure release limit due to the fact that fuel failure is not assumed in the DBAs. However, in the case of an MSR releases from the containment will now contain the fuel itself which will produce releases to the environment that could reach the dual failure release limits or beyond. Guidance in the SAR should, therefore, be provided to ensure adequate modeling of the MSR containment, unless it demonstrated that containment failure is incredible and falls within the severe accidentsdomain.

1.2 Interactions between multiple units

When one or more units are moth-balled and kept in safe-storage state (e.g. in preparation for future replacement or decommissioning), it is proposed that a description should be provided of any severed inter-

1 Safety Probe International, Ottawa, Ontario, Canada

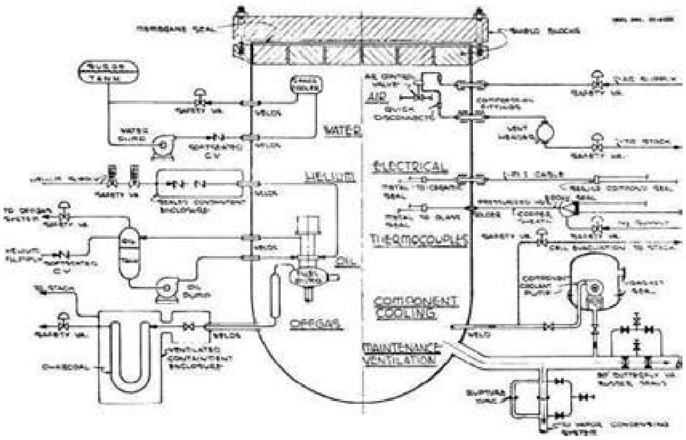

Fig. 1: MSRE Secondary Containment Showing Penetrations Seal. From Ref. [3].

connections or services provided by shared systems. In addition, results of analyses addressing the impact of severing the interconnections and shared services on other operating units should be provided.

1.3 Criticality in the draintanks

Fuel salt that contain uranium concentration appropriate for power operation of the reactor is thought to be highly unlikely to form a critical mass in a drain tank or in a storage tank under any conditions. However, if conditions exist to cause a large increase in uranium concentration, criticality could occur in a tank. A credible way for this to occur would be for the salt to freeze gradually, leave the UF4 in the remaining melt, and thereby concentrate the uranium into a fraction of the salt volume. ORNL calculations in Ref. [3] indicated that concentration by more than a factor of 4 would be necessary for criticality to occur in any such case. Studies also indicated that concentration of this magnitude is not impossible. Several factors could eliminate the possibility of large concentrations, such as the availability of power for the heaters to prevent freezing, dividing the fuel between two tanks and the inherent negative reactivity in the event of an increase in the reactivity. To address the risk of criticality in the drain tanks there is a need to include in the SAR Chapter 11 (Waste management) a call to present the safety analysis for the solid fuel waste, especially in the longer term, to assess the potential for criticality.This was the case with the ORNL MSRE, when in 1994 (25 years after the MSRE was shutdown 1969) an analysis was made using advanced computer codes to assess the likelihood of criticality of the solid fuel salt (Ref. [6])

2. Issues related todesign

2.1 Operating modes of the plant

Chapter 3 specifies the operating modes of the NPP to include all modes from startup, to normal operation, shutdown and refueling. In the MSR design a peculiar feature is the pre-operational mode which involves the flushing with salt of the reactor core followed by the transport and heating of fuel in the fuel addition system. Since in this mode certain accidents are postulated, a clear guidance is required in the SAR to include the "preoperational" phase as one of the operational modes. Defueling also is another mode that is used in the case of the MSR as means of shutting-down the reactor during certain transients.

2.2 Overhead heavy-load handling system

Chapter 9 of SAR requires the description of the overhead heavy-load handling system along with the associated safety requirements. But in the case of a MSR, the experience gained from the maintenance of the MSRE as reported in Ref. [2] found that, in addition to the use of heavy cranes, maintenance and repair of the MSRE involved handling substantial amounts of radioactivity in fuel sampling, off-gas sampling and other radioactive systems. To minimize the potential for radiation exposure or activity release that could affect the personnel operating the reactor, maintenance equipment designed to handle or replace failed components used long handled tools and jigs designed specifically for major components. These handling tools were operated directly through a portable maintenance shield. It is therefore recommended that Chapter 9 of the SAR include a description of any tools or jigs designed to handle components with substantial amount ofradioactivity.

2.3 Reactor coolant system valves and auxiliarysystems

Chaper 5 of Ref. [1] describes the SAR guidance on documenting the Reactor Coolant System (RCS) design for conventional LWRs and PWRs. With respect to the valves and connected systems, the SAR focusses on safety and relief valves as the major valves performing safety functions. However, in the MSR design, protection of the pressure boundary of the RCS requires the use of "freeze valves" which allow or stop the molten salt flow, for example, to the draining tank. Reference [5] describes tests performed on three types of freeze valve (see Fig.2) the 'Resistance heated" valve, the "Induction heat" valve and the "Calrod heated" valve. It is therefore suggested that freeze valve design description be included in this section of the SAR.

As well, in th MSR two essential systems are connected to the RCS; the off-gas system and the draining tank. These need to be added to "Reacor Auxiliary Systems" section of SAR Chapter 5.

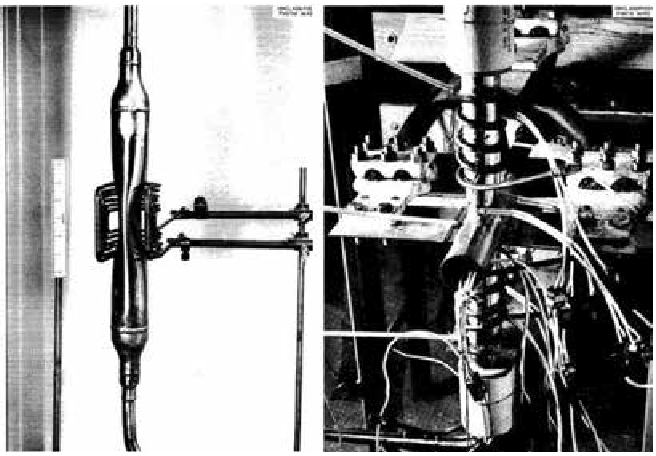

Figure 2. Induction-Heated Valve and Resistance-Heated Valve, from Ref. [5].

3. Modularization of reactor core/vessel assembly

Chapter 3 of the SAR requires additional supporting documents to describe the results of tests and analyses of manufacturers' material and other design qualification data. If an MSR is to utilize reactor core, vessel or containment modules that are manufactured and assembled off-site, compliance with this requirement will need further guidance since these modules may be viewed as integrated off-shelve products that may be subject mainly to manufacturing standards as opposed to being subject to the traditional commissioning tests that are performed on-site under the regulatory oversight.

4. Assuring system maintainability before power operation

Some of the advantages of the MSR concept are related directly to the liquid nature of the fuel and are due to the ease of moving the bulk of the fuel inside piping systems, removing reactor poisons, reprocessing to remove fission products and adding new fissionable material to make up for the bumup. However the same liquid property causes radioactivity to be distributed throughout the primary systems. Therefore special means are required for maintaining all equipment that comes into contact with or in the proximity of the fuel salt and the off-gas system.

The experience with maintenance of the radioactive portion of the MSRE [Ref. 2] indicated that maintenance plans that had been prepared before the operation required changes to reflect the experience with radioactive maintenance during operation. While basic methods and original planning served quite well, it was found that changes in tools, methods, reactor equipment, and administration of the maintenance operation made it necessary to prepare new fully detailed procedures for most shutdown work.

It was therefore recognized that the design of each component had to include provisions for maintenance, and the steps in the achievement of this goal included a design surveillance program. Thus those who had the maintenance responsibility had an opportunity to influence the system and component design in the early stages. Ref. [2] reported that this activity took varying degrees of participation from consultation and approval to detailed designs and layouts. Surveillance of the design was followed by a similar program during the construction, assembly, and installation stages. Accompanying the fieldwork of installing reactor components was a demonstration and practice program in which selected components were handled with remote-maintenance tools and methods. Many corrections were made during this period to improve the basic designs and to correct fabrication errors and maintenance techniques.

The lessons learned from the ORNL MSRE program was that surveillance of the design, construction assembly and installation stages were the logical methods of assuring the maintainability of the system before power operation. These methods had the further result of producing a nucleus of experienced personnel at the beginning of power operation at the **MSRE.** It is, therefore, recommended that the initial SAR submissions to the regulator, during the preoperational phases, include an assurance that the design of the plant is continuously reviewed with a view to ensure that final system assemblies are safely accessible and that components can be maintained with minimum exposure to radioactivity.

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Small Modular Reactors – Update on the CNSC's SMR Disussion Paper

by K. LEE[1]

[Ed Note: The following paper was presented at the 4th International Technical Meeting on Small Reactors (ITMSR-4), Delta Ottawa City Centre Hotel, Ottawa, Ontario, Canada, 2016 November 2-4]

Abstract

To keep current on technology trends and regulatory implications, many nuclear regulators, including the CNSC, have been reviewing the application of novel features in more traditional, and larger, **NPP** designs. SMRs, however, represent novel technologies that aim to achieve greater efficiencies and reduced operational costs. One of the key questions that nuclear regulators - including the CNSC - must address with vendors and other stakeholders is what are the regulatory and licensing implications presented by SMRs? If a proponent decides to deploy such technologies in Canada, what are some of the key regulatory issues that need to be resolved in advance to meet Canadian licensing requirements?

Over the past several years, many technology developers have expressed interest in the construction and operation of SMRs inCanada.Consequently, the CNSC has been looking into the nuclear regulatory and licensing implications challenges for SMR-related activities. The CNSC has met with technology developers and conducted outreach with the public and academic institutions at conferences such as this conference.

Based in part on these interactions, the CNSC was able to confirm that existing regulatory requirements for nuclear power plants remain valid and useful. It was also determined that the CNSC should examine the level of applicability of existing nuclear regulatory requirements and guidance to the innovative approaches of SMRs.

As a result of the CNSC's examination, a discussion paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challengeswas* published on May 31, 2016 and is open for comments until September 28, 2016. The discussion paper provides an overview of potential regulatory issues associated with SMRs and how they could be addressed. In summary, the paper explained:

- issues at a high level, along with a short description of specific items to be addressed in future work
- how the CNSC plans to address these issues using existing regulatory tools and processes
- the implications of the innovative approaches being considered by SMR proponents that need to be examined to a greater degree to confirm if additional supporting regulatory requirements or guidance are needed

Most small modular reactor **(SMR)** concepts, although based on technological work and operating experience from past and existing plants, employ a number of novel approaches simultaneously.

Novel approaches can affect the certainty of how the plant will perform under not only normal operation but also under accident conditions, in which predictability is paramount to safety.

In addition to addressing the technical challenges of designing an **SMR**, anSMR proponental so needs to ensure that the design meets the CNSC's regulatory requirements.

This section examines some key areas where novel approaches may present uncertainties, and where information from the public and interested stakeholders would help inform regulatory policy. The following list of topics was developed based on approximately five years ofinteraction with SMR vendors, utilities, government agencies and other interested stakeholders who have stated that these are important to the discussion. The topics are:

- technical information, including researchand development activities used to support a safety case
- licensing process for multiple module facilities on a single site
- licensing approach for a new demonstration reactor
- licensing process and environmental assessments for fleets of SMRs
- management system considerations
- licensees of activities involving SMRs
- safeguards verification
- deterministic and probabilistic safety analyses
- defence-in-depth and mitigation of accidents
- emergency planning zones
- transportable reactor concepts
- increased use of automation for plant operation and maintenance

1 Canadian Nuclear Safety Commission (CNSC), Ottawa, Ontario Canada

- human/machine interfaces in facility operation
- impact of new technologies on human performance
- financial guarantees for operational continuity
- site security provisions
- waste management and decommissioning
- subsurface civil structures important to safety

The discussion paper drew 435 comments from the following:

o Ontario Ministry of Energy
o SNC -Lavalin
o Terrestrial Energy
o Star Core Nuclear
o Moltex Energy
o Bruce Power
o Ontario Power Group
o Canadian Nuclear Laboratories
o Canadian Nuclear Association
o Candesco
o Hatch Consulting
o Amee FosterWheeler
o Mr. Lucas Forget

At a very high level, stakeholders commented that " *. . .the discussion paper was found to be well written and thus allowed industry to provide effective input during the review. The major themes of the consolidated comments are:*

1. Industry supports the application of a graded approach to all elements in the discussion paper.
2. There is no need for significant changes to the regulatoryf ramework.
3. *The licensing process should be streamlined to take into account production of repeat* ***SMR*** units.
4. *There are no insurmountable roadblocks to licensing* ***SMR*** *units in Canada under the existing regulatory framework.*"

CNSC staff acknowledges and recognizes that additional discussions at the working level are necessary to further reinforce how application of the graded approach is possible in the development of a safety casefor SMR projects. This comment was not unexpected given the variety of technological concepts being developed and the conditions under which they would be constructed and operated.

CNSC recognizes that many of the novel approaches and design concepts being proposed for SMRs (as well as larger reactors) have the potential to enhance safety in the construction and operation of nuclear facilities. However, an applicant for a licence must demonstrate to the Commission that the safety claims of approaches/design concepts are sufficiently proven via relevant and credible:

- operatingexperience
- combinations of technical and R&D investigation necessary to support the scientific claims. Because each SMR concept is different, these demonstrations need to be performed and considered on a case by case basis.

The range of SMR designs and energies managed vary considerably. However the hazards presented by all of them are consistent with Class lA nuclear facilities which address requirements for all reactor facilities. There is no clear evidence at this point in time that SMRs represent a separate class from the facilities currently regulated under Class 1 Facilities Regulations.

CNSC remains open to discussing industry proposals on alternative approaches to licensing that continue to respect the principles laid out in REGDOC 3.5.1 Licensing Process for Nuclear Power Plants and Mines and Mills.The current EA and licensing process can already be applied to projects that will consider "expandable facilities". For example, the EA can be completed for a project that considers a maximum number of units for the site even if installation of some units will be deferred to match capacity growth projections. Licenses can be developed to encompass ongoing construction, commissioning and operation within the same facility to reflect expansion until all modules have been added. However, once the maximum capacity considered in the EA has been reached, further module additions would then trigger a new EA for the further expansion.

CNSC staff is considering future workshops on the application of the graded approach by applicants. Included in these discussions will be topics such as:

- Reinforcement of Defence in Depth principles
- The role of regulatory guidance in articulating grading in particular areas without compromising safety
- The role of supporting information in demonstrating that safety and control measures being proposed are adequate to meet requirements
- Application of conservative approaches where significant uncertainties exist in safety analysis
- An overview of the CNSC's Conduct of Technical Assessment Process in the technical assessment process of the CNSC

The presentation made at the CNS conference will highlight the feedback received from various stakeholders on DIS-16-04 and outline how the CNSC will use the feedback received to bring greater clarity to its regulatory framework for SMRs.

Melting Permafrost and Site Conditions for Small Modular Reactor Installations in Remote Northern Canada Communities

by D. G. MALCOLM[1]

[Ed Note: The following paper was presented at the 4th International Technical Meeting on Small Reactors (ITMSR-4), Delta Ottawa City Centre Hotel, Ottawa, Ontario, Canada, 2016 November 2-4]

Abstract

The paper describes the permafrost conditions of northern Canada, conditions that occur in nearly all of the remote communities or prospective mine sites that might become locations for Small Modular Reactor (SMR) power plants. It discusses four new standards that the Standards Council of Canada has prepared under the Northern Infrastructure Standardization Initiative, plus a fifth standard that is presently in the public consultation phase. These standards will no doubt be taken into account for the development of any prospective SMR project.

1. Extent of Permafrost Conditions in Canada

The purpose of the paper is to discuss the pervasive presence of permafrost conditions in Arctic and Sub-Arctic landscapes in Northern Canada, and the impacts of these permafrost conditions on the design, construction, and operation of Small Modular Reactor (SMR) power plant facilities. The permafrost areas cover the entire Boreal Region of Canada as well as the Arctic tundra, and contain virtually all of the remote communities that would likely be used as sites for SMRs. An interactive permafrost map of Canada can be viewed at http://ftp2.cits.rncan.gc.ca/pub/geott/atlas/archives/english/5thedition/environment/land/mcr4177.jpg (accessed July 15, 2016). Please be aware that this map, produced and printed in 1995 by Natural Resources Canada is now out of date, in the sense that the boundaries of the continuous and discontinuous permafrost are moving north at an alarming rate, sometimes at tens of kilometers per decade because of climate warming and melting permafrost [2][2]. When this map was produced temperatures would drop down into the minus forties Celsius from December through February and stay there for weeks at a time, considering Inuvik, Northwest Territories as an example. Contrast that to the past two winters 2014 and 2015 in Inuvik when the coldest temperature recorded by the author was -33°C and temperatures seldom reached down to the low -20s.

These climate warming trends point to permafrost engineering as being a very important discipline for SMR manufacturers, designers, construction contractors, and operators to consider. All sectors of the SMR industry must take discontinuous pennafrost into consideration when remote communities are considered as possible power plant sites. What was continuous permafrost in 1995 is now likely to be discontinuous permafrost, especially anywhere near rivers, lakes or river deltas. Careful geotechnical analysis of each specific site is required. Even when the planned reactor site is expected to be on bedrock, care must be taken since the expected bedrock may be fractured at its boundaries and surrounded by unstable permafrost. The extreme picture may be a rock island in a sea of permafrost.

2. The Northern Infrastructure Standardization Initiative

Conventional engineering design and construction for nuclear reactor installations and other power plant buildings will have to take appropriate design practices for foundations in permafrost into account. If the on-site permafrost cannot be removed prior to foundation construction, the only option may be to keep the soil surrounding the small reactor installation (which is a continuous heat source) perpetually frozen to ensure lasting foundation stability. This is a common practice for buildings in the Northwest Territories for example, using underground passive refrigeration (e.g., thermosyphon applications) or active refrigeration systems.

1 Malcolm and Associates, Inuvik, Northwest Territories, Canada

2 This paper, cited as reference [1], was written for the Northern Climate Exchange at Yukon College in 2002 and is not available through any popular database . Copies in pdf format can be obtained from the author at david.malcolm@mcri.ca.

Permafrost is defined as soil and sediment that remains at or below 0°C for at least two consecutive years. If permafrost exists it will lie below the active layer of soil and sediment that melts and freezes with the seasons, usually from 1 to 2 metres in depth. In the warming Arctic much of the permafrost near the earth's surface may be warm permafrost, i.e., permafrost that is warmer than -1°C. It has been stated in an interesting review of the characteristics of permafrost that about 25% of the earth's exposed surface and approximately 80% of Alaska are underlain by permafrost [2].

The Standards Council of Canada (SCC) has recognized through consultation with engineers and architects practicing in the North that new infrastructure design, construction and operations maintenance, as well as existing infrastructure renovation, must take the warming and melting of permafrost into account. To this end the SCC developed the Northern Infrastructure Standardization Initiative (NISI) which is described at https://www.scc.ca/en/stakeholder participation/roadmaps-and-standardization-solutions/northern-lnfrastructure-standardization initiative (accessed July 15, 2016). The author of the present paper is accredited as a trainer through the Canadian Standards Association (CSA) to deliver training workshops on the first four standards developed under the NISI banner. The NISI Standards can be purchased at minimal cost from the CSA shop at shop.csa.ca.

2.1 CAN/CSA-S500-14: Thermosyphon Foundations for Buildings in Permafrost Regions

A thermosyphon is a closed two phase natural convection system that absorbs heat from the ground and discharges it into the atmosphere. The gas/liquid medium is carbon dioxide that functions in a closed pressure vessel, configured as an underground piping layout, under a pressure varying from about 300 to 700 psi. The purpose of the thermosyphon is to freeze the ground under the piping layout during the winter so that it remains frozen and stable during the entire spring and summer seasons. The thermosyphon ceases to operate in the warmer months of the year. A good discussion of thermosyphon foundations has been prepared for the Government of the Northwest Territories by Holubec [3].

As quoted from the NISI website to introduce the CAN/CSA-S500-14 Standard: "Heated structures built on permafrost without mitigative systems, such as thermosyphons, can degrade the permafrost and thereby destabilize a structure's foundation. This standard helps to ensure the ongoing stability of thermosyphon-supported foundations of new buildings constructed on permafrost in Canada's North." Although the standard is meant for new foundation design and construction, it may also prove useful for renovating and protecting existing foundations.

2.2 CAN/CSA-S501-14: Moderating the Effects of Permafrost Degradation on Existing Building Foundations

Many northern buildings were designed without consideration for climate change, or did not take known permafrost temperature and degradation into account. Melting permafrost destabilizes structures. The standard outlines steps to assess permafrost loss, to maintain the existing permafrost, and to mitigate permafrost loss beneath and adjacent to existing buildings.

In the Introduction to the Standard, four steps are stated as a progression to moderate the effects of permafrost degradation. They are summarized as follows:

a) Pre-emptive and proactive measures to maintain permafrost beneath and adjacent to existing buildings or structures;
b) Assessment of structures impacted by changing permafrost conditions;
c) Mitigating permafrost degradation and its effects on existing buildings and structures;
d) Undertaking long-term maintenance and monitoring.

2.3 CAN/CSA-S502-14: Managing Changing Snow Load Risks for Buildings in Canada's North

Climate change has brought increased precipitation in winter in some parts of the North. Snow depth on the level may be greater now than when existing buildings were installed. Also, inadequate design and maintenance practices may increase snow load risks on roofs of northern buildings. There have been cases of roof collapse due to snow load in the North.

The Standard should be used to develop and establish practices that reduce snow overload risks over the life of the building. These practices must include pre-season planning for snow removal and maintenance. This will reduce risks of roof collapse, and will increase the building lifespan.

2.4 CAN/CSA-S503-15: Community Drainage System Planning, Design, and Maintenance in Northern Communities

Visits to remote communities throughout the North reveal many drainage problems. These may be due to a lack of drainage system planning, design and implementation. Or they may be due to poor maintenance practices in the face of melting permafrost and the resulting heaving and slumping along roadways and on building sites.

The purpose of the Standard is to increase community capacity to develop and impement effective drainage plans. It also provides guidance for rehabilitation and maintenance of drainage systems in northern communities.

2.5 CAN/BNQ 2501-500 Geotechnical Site Investigations for Building Foundations in Permafrost (under development)

This Standard is in the draft stages of development, and is primarily aimed at geotechnical design consultants. However, it will also be useful to designers, contractors, regulators, and owners of buildings. It defines a consistent methodology for performing geotechnical site investigations with a view to assist foundation design. The Standard considers distinctive permafrost characteristics, seasonal and expected annual climate conditions up to the end of service life of the building foundations, and other conditions that may affect building foundations.

3. Conclusion

The five Standards introduced in this brief paper provide the required information, along with conventional nuclear power plant engineering design practice, for SMR project developers and designers to include most or all aspects of permafrost behavior in their design, construction, and operations planning and implementation.

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Design Challenges with Licensing SMRs - A Perspective from a Nuclear Industry Service Provider

by A.G. LEE[1]

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ABSTRACT

Small modular reactors (SMRs) employ some novel features to achieve their design objectives. This paper presents a perspective from a nuclear industry service provider on a design approach to systematically associate the design of the systems, structures and components for SMRs to known codes and standards to ensure the necessary quality is achieved to support the safety case. The design approach utilizes the lessons learned from designing evolutionary Generation III nuclear power plants and the experience gained from a pre-licensing vendor design review of the Enhanced CANDU 6® reactor by the Canadian Nuclear Safety Commission.

Introduction

Most small modular reactor (SMR) concepts rely on a number of factors to achieve their design objectives and a lower initial capital investment:

- Very high percentage of the plant can be built in a factory controlled setting,
- SMRs could be installed module by module to improve on the level of construction quality, and
- Increased use of passive safety features and passive safety systems which lead to less redundancy in the plant design.

To achieve their design objectives, some novel features are employed in the SMRs. From a licensability perspective, a novel feature would be a major system, structure or component (SSC) that has not been previously licensed for a nuclear facility. However, the novel feature may be based on technological work and operating experience from past and existing nuclear facilities. Hence, from a design perspective, the novel

1 SNC-Lavalin, Mississauga, Ontario, Canada

feature may be considered to have a degree of provenness. The challenge from a licensability perspective is to demonstrate that the novel features will perform their safety functions with high reliability under normal operating conditions and postulated accident conditions.

Demonstrating high reliability for novel features in the designs of SMRs relies on using a design process that systematically associates the design of the SSCs to known codes and standards to ensure the necessary quality is achieved to support the safety case. During the implementation of the design process, credible information is needed to quantify operating and safety margins under normal operating conditions and postulated accident conditions, and to show the reliability of passive safety features under normal operating conditions and accident conditions.

Based on SNC-Lavalin's experience with design processes that were subjected to a pre-licensing review by the Canadian Nuclear Safety Commission (CNSC) for the Enhanced CANDU 6® 1 (EC6®) design, this paper outlines an approach to ensure that novel features in a SMR are:

- Designed with the appropriate stringency commensurate with their level of safety importance,
- Supported by appropriate research and development to demonstrate the claims for safety performance,
- Specified to be manufactured using processes based on verifiable quality standards, and
- Specified to be operated and maintained to ensure fitness for service.

This is just one example of the experience and expertise that SNC-Lavalin is well positioned to provide for a variety of reactor designs to ensure international regulatory requirements are met.

1. Graded Approach to Design

Within a regulatory framework that is based on risk-informed regulation, a graded approach can be used to establish design measures, safety analyses and provisions for conduct of operations commensurate with the level of risk posed by the reactor facility. The activities to support the design and licensing of existing and Generation III nuclear power plants have made extensive use of a graded approach. This experience can be readily applied to the designs of SMRs.

At the design stage, the graded approach starts with establishing the safety importance of SSCs, so that engineering design rules to be applied in a graded manner. SSCs that must perform their safety functions with very high reliability during anticipated operational occurrences (AOOs) and design basis accidents (DBAs) require the highest quality and the most stringent demonstration of the claims for safety performance. SSCs that perform their safety functions during design extension conditions (DECs) can have less conservative safety margins.

2. Establishing Safety Importance of Structures, Systems and Components

Establishing the appropriate quality to apply to the design of SSCs for an SMR is dependent on having a systematic process for ensuring that the fundamental safety functions are available in normal operation and during and following anticipated operational occurrences and design basis accidents. SNC-Lavalin's safety classification process is readily adapted for SMRs, because the safety classification process determines the safety importance, based on:

- Fundamental safety functions to be performed during normal and accident conditions:
  - o Controlling reactivity,
  - o Removing heat from the reactor core and from spent fuel, when stored on site,
  - o Confining radioactive material,
  - o Controlling operational discharges and limiting accidental releases,
  - o Providing radiation shielding, and
  - o Monitoring safety critical parameters to guide operator actions,
- Consequences of failure to perform the safety functions,
- Probability that the SSC will be called upon to perform the safety function, and
- The time following a postulated initiating event at which the SSC will be called upon, and the expected duration of that operation.

SNC-Lavalin successfully established the following safety classification process for the EC6 reactor which was shown to meet the expectations of the CNSC:

1. Identify a list of postulated initiating events that includes AOOs, DBAs and DECs.
2. Rank in descending level of safety importance:
   - i) SSCs that are required to achieve a controlled state during DBAs,
   - ii) SSCs that are required to prevent uncontrolled radioactive releases during DBAs,
   - iii) SSCs that are required to support operation of SSCs in the highest and second highest levels of safety importance, control plant behavior during AOOs or during normal operation ,
   - iv) The remaining SSCs that perform a fundamental safety function.
3. Identify SSCs as not important to safety when they do not fall into the rankings in item 2.

3. Establishing Safety Requirements for Structures, Systems and Components

The next step is to identify the applicable set of safety requirements for each SSC.

- **Robustness requirements:** The ability of SSCs to perform their safety functions when credited in the safety case determines the extent to which SSCs need to be seismically qualified, environmentally qualified, and protected against other common cause failures.

The use of physical barriers and separation can also be used to address robustness requirements. SNC-Lavalin's experience in implementing these types of features can provide insights into optimizing the plant and equipment layouts for SMRs.

- **Reliability requirements:** Reliability requirements include identifying design features for SSCs such that:
  - o The failure rates are consistent with the safety analysis.
  - o The single failure criterion is satisfied.
  - o The likelihood of a DBA is very low.
  - o The likelihood of failure to perform the safety functions due to common cause failures is very low.
  - o Their failure could be 'practically eliminated'2•

SNC-Lavalin's experience in addressing reliability requirements can provide insights into making trade-offs among the design features to address reliability requirements for SMRs. These insights can help to take advantage of the novel features to reduce the need for redundant systems or components.

- **Capability requirements:** The capabilities for the SSCs to perform their safety functions, as required are stated in terms of performance requirements. For example, a capability requirement for a reactor vessel could be stated as "The reactor vessel shall retain its structural integrity for all accidents where the reactor can be shut down and the fuel cooled."

Once the safety requirements are established, the appropriate quality standards need to be selected to ensure that the SSCs will be designed, manufactured, constructed, installed, commissioned, operated, tested, inspected and maintained in accordance with the safety case. SNC-Lavalin's experience with selecting codes and standards to establish the correspondence between the safety class of the SSC and the associated engineering design and manufacturing rules supported the conclusion from the CNSC pre-licensing vendor design review that there are no fundamental barriers to licensing the EC6 design in Canada.

Both deterministic and probabilistic safety analyses are performed to verify that the SSCs important to safety can perform their safety functions when demanded.

4. Summary

This paper has discussed the use of SNC-Lavalin's experience with design processes and approaches for the EC6 reactor that were subjected to a pre-licensing review by the CNSC to outline an approach that would ensure that novel features in a SMR meet regulatory requirements. Regulatory confidence in the claims of high reliability for novel features in the designs of SMRs can be supported by a design process that systematically associates the design of the SSCs to known codes and standards. The design process also enables the supporting research and development to be systematically planned, obtained and evaluated to underpin the performance of the novel features. In this respect, SNC Lavalin's capabilities and extensive experience for a variety of reactor designs allows it to provide valuable support to SMR designers.

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2 The IAEA defines practically eliminated as "The possibility of certain conditions occurring is considered to have been 'practically eliminated' if it is physically impossible for the conditions to occur, or if the conditions can be considered with a high level of confidence to be extremely unlikely to arise.

CNSC Publishes industry comments on SMR Regulations

Discussion Paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*

CNSC requested comments on DIS-16-04 by 28 September 2016. Industry comments have been published at http://nuclearsafety.gc.ca/eng/acts-and-regulations/consultation/history/dis-16-04.cfm.

Women of the Montreal Laboratory – II

by GILLES SABOURIN

Since the article 'The scientist women of the Montreal Laboratory' was published in the December 2015 edition of the Bulletin, describing 8 Canadian women who worked in Montreal during WWII, more information came to light on other women working in different capacity in the Tube Alloys project. Here is a follow-up to the article of December 2015.

Percentage of women working in Montreal

I have been able to obtain the list of staff working at different periods in the Montreal Laboratory from the beginning of 1943 to the middle of 1944. As was the case in other industries related to the war effort, a considerable number of women worked in the Montreal Laboratory. Here is a brief list of numbers of women versus total numbers of workers in the Montreal Lab:

- April 1, 1943: 20 women on a total of 88 workers (23%);
- January 25, 1944: 40 women on a total of 124 workers (30%);
- May 25, 1944: 38 women on a total of 132 workers (29%).

At the peak of the work in Montreal in the middle of 1945, there were more than 300 people working. I have not yet been able to obtain the list of staff for this period, but the percentage should have been similar. If we assume 25% of the workers being women, that would mean that more than 75 women worked in the Montreal Laboratory. This percentage would be comparable to the number of women working in Britain for Tube Alloys in 1945, which was 23%.

Below are details about further women that worked in different capacity in Montreal for the Tube Alloys project in the period 1942-1946.

Women in technical positions:

Gladys Alma Thompson Chackett (1918-)

The following biography is largely based on information provided by Alma Chackett and her daughter Daphne MacDonagh.

Gladys Alma Thompson was born on 26 September 1918, only child of John Alexander Thompson and his wife Gladys Evelyn, née Thatcher. She was born in Smethwick, near Birmingham, where her father was working as a gas engineer, but the family moved to the Wirral some three years later when her father's job moved to Liverpool.

Alma studied Chemistry at the University of Birmingham, England, graduating in 1940. While at university she met her future husband Kenneth Frederick Chackett who was also an undergraduate there. In the 40's, Birmingham university had one of the most advanced atomic research group in the

Corrections to December 2015 Bulletin Article "The Scientist Women of the Montreal Laboratory"

The author has found new information regarding two of the scientist women cited in the article:

Muriel Wales was born in Belfast, Ireland, as Muriel Kennett in 1913. In 1914, her mother, Alice Girvan, moved to Vancouver where she soon remarried to George Fredrick Wales. From that time, Muriel was known by the last name Wales.

After she left Chalk River in 1949, she returned to Vancouver and, although she had a Ph.D. in mathematics, she worked as a shipping clerk until 1970 for the Canadian Blue Star Line, where her stepfather was working. The Blue Star Line was a British passenger and cargo shipping company that was in operation from 1911 to 1998.

After her retirement, Muriel Wales lived in Vancouver in the house where she grew up, until her death in 2009, at the age of 96.

Ethel Kerr Steljes (no 21 in the group photo) was born in Montreal in 1924 to Dr. Robert and Ethel Kerr. She graduated with a B.Sc. in chemistry from McGill University. Ethel Steljes said to her children that while working in a laboratory at AECL she was bitten by a rat and had to wear a fur coat in a cold room! She worked until her first child, Ian Robert, was born in 1949. She was involved in several volunteer activities in Deep River, such as the Meals on Wheels. She died in 2010, one week before her 86th birthday.

Gilles Sabourin

gilles.sabourin17@gmail.com

Sources:

- "Muriel Wales" in the Atlas of Irish Mathematics & Mathematicians (http://www.cardcolm.org/Atlas.html) consulted September 26, 2016.
- Personal communication from Celia Steljes, January 2016.

world. It is while they were at Birmingham that Otto Frisch and Rudolf Peierls wrote the famous 'Frisch-Peierls memorandum' in 1940, calculating that the critical mass of uranium-235 necessary for a bomb to be approximately 1 kg (it is higher than this, but Frisch and Peierls were using imprecise data).

After graduation Alma's first job was with Northern Aluminium. She and her colleagues were responsible for testing the composition of alloys used to manufacture parts for the Lancaster bombers, the Spitfire and the Hurricane. They worked very long hours as British firms poured every resource they had into building aircraft in preparation for the Battle of Britain. Having the correct composition for the metal parts was crucial for the survival of warplanes. Later she went to work at the gas works at Walsall. Here she was responsible for testing the composition of coal gas and its byproducts.

In the summer of 1944 Ken Chackett completed his Ph. D at Birmingham University, on techniques for separating rare gases. He was recruited by Professor Fritz Paneth for the Tube Alloys project in Montreal, Canada. Ken and Alma were married on July 10, 1944 and barely three weeks later Ken left for Canada on the Queen Mary, sailing from Greenock to New York. Alma had been told that she could not be employed by the government on the same project, but hoped that she would be allowed to join him a while later as his wife, but there was no certainty about anything. However one day she received a letter asking her to present herself at Canada House in London, where she was interviewed, vetted and subjected to medical examination. During the interview a buzz-bomb fell nearby and everyone dived under their desks for shelter.

Shortly afterwards, another letter directed her to pack her bags and go to a particular platform at New Street Station in Birmingham, where she was to join a train labelled W17. At the station her bags were labelled W17 and she was told to board the train. She did not know where the train was headed, but it pulled out from Birmingham towards the north, so she hoped it would be Liverpool. However at Crewe the train headed further north, and eventually finished up at Glasgow. She sailed from Greenock on the Aquitania, bound for St. John and Halifax. With her were Hilda Amphlett (wife of Colin), Joyce Musgrave (wife of Ken) and Nancy Cook (wife of Gerry). On arrival in Montreal, she was immediately hired by the Canadian National Research Council.

Alma Chackett's name can be found in the list of staff of the Montreal Laboratory in May 1945, as 'locally engaged staff', with a yearly salary of 1680 $CAN. Her husband was hired by the Montreal Laboratory in August 1944, as a junior scientific officer, with a yearly salary of 330 £ (as part of the British contingent of Tube Alloys), which is equivalent at the time to 1460 $CAN. She was thus paid more than her husband, a very unusual situation in the 1940's.

Alma and Ken Chackett in their Montreal apartment, 1945.

Ken and Alma had nothing with them other than their clothes. They were not allowed to take more than £10 out of Britain, but when they arrived at Montreal they found accommodation at a rooming-house and their living expenses were subsidized by the authorities. Later they moved to a pleasant apartment on Avenue Decelles, Outremont, together with their friends Frank and Sheila Morgan, the Musgraves and the Amphletts.

The chemists working on the Tube Alloys project were divided into small groups, each investigating the properties of different fission products of Uranium. Alma was studying bromine and iodine under the direction of Dr Jules Guéron, while Ken worked on the rare gases neon, argon and xenon. Alma recalls that the scientists rarely mixed socially outside their own groups. Naturally they were not encouraged to talk about their work; besides, scientific research never fits into regular hours, so people took their breaks as and when they could. At the time the Montreal campus was new and mostly unoccupied, so there were no on-site facilities such as canteens or cafés, and the workers used to take brief meal breaks in town.

The adjacent wing of the building was, however, occupied by a priests' seminary. Alma recalls watching from her laboratory window during the winter months, when the seminarians would come spilling out of their classes in their long black cassocks, slipping and sliding on the ice. They frequently fell over, and as they wore purple socks the effect was quite comical.

Shared house at Beaurepaire, on Montreal Island.

Although Ken and Alma worked hard, their time in Canada was a welcome respite from the dangers and privations of wartime Britain. Alma recalls a weekend break in the Laurentian Mountains, staying in a log cabin with a group of friends, messing about in boats and enjoying the beautiful fall scenery. She remembers a shared house at Beaurepaire (now merged with Beaconsfield) on the St.Lawrence River that was available for recreational use by the project staff.

They also visited cousins in Toronto, and went to

Niagara Falls during the Christmas holiday. All in all it was a happy time, tempered of course with concern for the fate of their loved ones in Britain. Much of their leisure time was taken up with assembling food parcels to send to their relatives, which were very gratefully received back home.

Starting in 1945, Alma and Ken Chackett would form a wife-and-husband scientific team for at least the next 25 years. They are co-authors of two reports from the Montreal Laboratory:

CI-122: 'Report on the analysis of commercial electrolytic oxygen for traces of nitrogen', K.F. Chackett and G.A. Chackett, 1946. And,

CI-124: 'Methods of estimating fission iodine in irradiated uranium metal without using carrier', G.A. Chackett and K.F. Chackett, 1946.

The CI reports were internal reports or memos of the Chemical Division. We can note that Alma is the first author of the second report, indicating that she did most of the work documented in CI-124.

By the summer 1946 it was all over. Ken and Alma returned home on the Eria, a Danish boat, in late August. Ken didn't want to take a job at Harwell, and as Prof. Paneth was going to Durham University, Ken joined him there, along with Graham Martin and Ken Musgrave. His research interest was in studying rare gases, especially helium, in meteorites. When a sizeable meteorite fell at Beddgellert in north Wales, Ken was sent to get it and fetch it back to the university on the train.

Ken and Alma lodged with the Musgraves for a time until the job of Observer at the Durham Observatory became vacant, and Alma applied for it and was appointed. This job came complete with residence at Observatory Cottage. Her duties at the Observatory included taking meteorological and seismological measurements. Strangely, they had to wait until January 1947 for the furniture they acquired in Canada to be shipped back to them. Alma and Ken's daughters were born at Observatory Cottage, Lesley in 1947 and Daphne in 1949.

The family moved to Birmingham in early 1952 when Ken obtained an appointment at Birmingham University to continue his studies of rare gases using the Nuffield Cyclotron. He also supervised Ph.D. students and taught a radiochemistry course at M. Sc. level. Alma joined him as a research assistant, initially unpaid, and the team did seminal work on the determination of half-lives of radioactive isotopes. The team were involved in the race to create Element 101 but eventually had to concede to an American team (of which was part Bernard Harvey, another chemist who worked in the Montreal Lab), and then dropped out of the race to produce the higher transuranics because of limitations of their accelerator. Alma and Ken Chackett are however credited with discovering (or perhaps more precisely creating) a new isotope of Thallium, Tl-193, using the Nuffield cyclotron in 1959.

The Nuffield Laboratory was host to the first cyclotron of the Birmingham physics department. It operated from 1948 to 1999. Alma Chackett worked as a researcher in the physics department using the cyclotron until 1980. Alma's main role was to process the results of bombardments, separating out the various products, for example Na-22, which were sold to other research institutions. During these years, she co-authored with her husband and several other researchers, 12 papers that were published in the Journal of Inorganic and Nuclear Chemistry, in the International Journal of Applied Radiation and Isotopes, and in the Proceedings of the Physical Society (London).

Alma Chackett is also thanked in a number of papers, as in 'Mono-energetic positions in Bi-205' by C.F. Perdrisat and collaborators of the Federal Institute of Technology of Zurich, Switzerland, in 1962: 'We are greatly indebted to Mrs. G.A. Chackett for the irradiations facilities at the Birmingham University Cyclotron.'

Both Ken and Alma retired in 1980. They moved to a country house in Herefordshire and devoted themselves to creating a beautiful ornamental garden which was a great source of joy and adventure for their growing family. In 2008, as Ken's health was deteriorating, they moved to Swansea to live close to their younger daughter. Ken died in 2013 after a long illness, just a year short of their 70th wedding anniversary.

At the age of 98, Alma is still active and in good health apart from failing eyesight. She lives independently, cooking her own meals, tending her garden, researching the family history and reading avidly with the aid of a tablet computer. She is frequently visited by her two children, two grandchildren, four great-grandchildren and one great-great-grandchild.

Considering the time she was born and her gender, her professional life in physics and her publication record is exceptional.

The photograph below was graciously provided by Alma Chackett. It is a most remarkable photo, being only the second known group photo of personnel of the Montreal Laboratory, and the only one where we see women. It was taken in front of the main building of Montreal University, in the summer of 1945 and is showing the Chemical Division. On the 42 persons in the photo, a third are women. Approximately half of the people have been identified. The help of readers to identify further persons in the photo would be much appreciated.

The ladies identified by numbers 9, 12 and 16, were, according to Alma Chackett, French Canadian secretaries. Because this photo was taken more than 70 years ago, the identification of some people is not 100% certain.

1	Kenneth (Ken) Musgrave
2	Bertrand Goldschmidt
3	Albert English
4	Alma Chackett
5	Geoffrey Wilkinson (future Nobel laureate in Chemistry)
6	Kenneth (Ken) Chackett
7	Henry Heal?
8	William (Bill) Grummitt
9	Unknown
10	Jack Sutton
11	Unknown
12	Unknown
13	Frank Morgan
14	Alan Vroom
15	Friedrich (Fritz) Paneth (director of the Chemical Division)
16	Prof Paneth's personal secretary
17	Leslie Cook
18	Graham Martin
19	Leo Yaffe
20	Allan Lloyd Thompson
21	Ethel Kerr
22	Jules Guéron
23	Samuel Epstein
24	Patricia Gorie
25	Gerda Leicester
26	Robert Betts
27	Maurice Lister
28	Ruth Golfman

Elsie Beatrice Mabel Murrell Martin (1914-2008)

Elsie Murrell during her Cambridge days

Elsie Beatrice Mabel Murrell was born in 1914 in London and was raised in Cambridge. She graduated with first-class honours in Physics from Cambridge University. She joined the Cavendish Laboratory as a researcher at the end of the 1930's.

In 1939, she co-authored two papers with C.L. Smith on disintegration of different isotopes bombarded with protons and deuterons. She was part of a small group of people at the forefront of the atomic research just before the Second World War.

She was hired by the Tube Alloys project probably in 1942, when the Cavendish Laboratory was, to all purposes, requested to work on the atomic war researches. She worked mainly in a team with Egon Bretscher (1901-1973) and Anthony Philip French (1920-). Bretscher is famous for having proposed in 1940 (with Norman Feather) that Plutonium-239 could be produced by a neutron capture in Uranium-238, and that it would be fissile. Anthony French and Egon Bretscher were seconded to Los Alamos in 1944.

Bretscher, French and Murrell published an important report in January 1944, summarizing their research: 'Determination of U-235 and U-238 fission cross-sections'.

In 1943, Elsie Murrell married a co-worker from the Cavendish Laboratory, Graham Robert Martin (1920-1989), who was six years younger than her. Graham Martin was also working with Bretscher. He co-authored papers with him on a standard neutron radium-beryllium source, and on isolation and spontaneous fission of Uranium-234.

In August 1944, Elsie and Graham Martin moved to Montreal. Graham worked in the Chemical Division of the Laboratory, while Elsie stayed home with her young son who was one year old, Peter. Although she did not participate in the Montreal Laboratory per se, the work she did in Cambridge for Tube Alloys was very important for the Montreal work. Their second son, David, was born shortly after the end of the war.

After the war, Elsie Martin was offered a post of researcher in the Physics Department at the University of Durham, where Graham was hired as a lecturer in radiochemistry, at the same time the Chacketts were there.

In 1964, they moved to the new campus of the University of Kent at Canterbury, southeast of London. Graham was appointed as the inaugural professor of Chemistry, where he worked until his retirement in 1981. He became Dean and eventually Pro Vice-Chancellor (whatever it means) of the University.

Elsie Martin was hired as a researcher in radiochemistry at the University of Kent at Canterbury. According to her obituary, she was most happy in the laboratory or in her garden, did not like house work and had no taste for formal occasions which were part of her spouse's life as Dean or Pro Vice-Chancellor.

Elsie Graham in 1971

She became a Radiation Protection Officer and joined AURPO (the Association of University Radiation Protection Officer), serving on committees, writing monographs and becoming an Honorary Life Member of the association. Aged 68 years old, in 1982, she published a 120-page monograph titled 'Adventitious X-Rays from High Voltage Equipment'.

Late in life, she gave a long interview on her scientific career and the challenges facing a woman physicist in the 30's in Cambridge and during her whole life. She felt that she had not made an outstanding contribution to research in physics and that it was partly due to the fact that she was a woman. She was often pressured to choose between her domestic and scientific lives. She had a strong support from her husband to pursue her research in physics, but resented the fact that the opportunities for men and women were not equal. She kept a keen interest in science her whole life and continued to stay informed of the latest developments in physics.

Graham Martin died in 1989 at the age of 69. Elsie survived him for 19 years, passing away in 2008, aged 94.

Gertrude Blanch (1897-1996)

Gertrude Blanch did not work in the Montreal Laboratory, but is a co-author of the first Montreal Theoretical Report (MT-1: The functions of En(x), April 1943) with George Placzek. The functions En(x) appears frequently in diffusion theory. G. Blanch wrote an Appendix for x+n >> 1. She thus deserves a place in this paper.

Gertrude Blanch was born Gittel Kaimovitz in Kolno, Poland. Her parents immigrated to the United States when she was 10 years old. She graduated from Brooklyn's eastern District High School in 1914. She wanted to continue to college but had not enough money to do so. She worked for 14 years as a clerk in New York saving money. She enrolled in New York University (NYU) where she graduated with a major in mathematics and a minor in physics in 1932.

That same year she changed her name to Gertrude Blanch. She then went on to study for a Ph.D. in mathematics at Cornell University, a degree that she obtained in 1935 in algebraic geometry. Her dissertation ‘Properties of the Veneroni Transformation in S4’ was published in the American Journal of Mathematics in 1936. She was not able to find a job as a mathematician, finding only a substitute position as a professor at Hunter College, a women’s public university, for one year. In 1937, she was able to find a position with a company manufacturing cameras in New York.

While working there, she took an evening course on relativity at Brooklyn’s College given by the physicist Arnold Lowan, in order not to lose her knowledge in mathematics. Shortly thereafter, Lowan was hired as the administrative director of the Mathematical Tables Project and invited Blanch to become the mathematical leader.

The Mathematical Tables Project was one of the largest computing organizations in existence before the invention of the electronic computer. It employed up to 450 people to compute by hand tables for higher mathematical functions. It was started under Franklin D. Roosevelt administration by the Works Progress Administration, a New Deal public agency that was setup to carry out public works project hiring unemployed people.

In 1942, the project became part of the wartime Office of Scientific Research and Development. During the war, the Mathematical Tables Project created ballistic calculations for the Army, navigation tables for the Navy and provided fundamental calculations for the Manhattan (and Tube Alloys) project. The Montreal Laboratory had also its own computer section, employing mostly young women who had a high school or college degree in mathematics or science. The Mathematical Tables Project continued to operate until 1948.

After the war, Gertrude Blanch was offered the position of assistant director of the Institute for Numerical Analysis in Los Angeles. In 1954, she was appointed senior mathematician at Wright-Patterson Air Force base in Dayton, Ohio, where she worked until her retirement in 1967. During the 1950s, her career was hampered by FBI’s suspicions that she was a secret communist. There was no evidence of this. It is hard to believe it, but the fact that she was a single woman with no children was used as a suspicion against her. She fought against this and she demanded and won a hearing to clear her name.

After her retirement, she stayed as a consultant to the Air Force through the Ohio State University. In 1970, she moved back to California where she resided until her death in 1996, at the age of 99 years old. She published over 30 papers, mostly on numerical analysis.

Acknowledgements

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Gilles Sabourin
gilles.sabourin17@gmail.com

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- “Gertrude Blanch” page on Wikipedia (https://en.wikipedia.org/wiki/Gertrude_Blanch) consulted September 26, 2016.
- “Gertrude Blanch papers” on the website of the archives of the University of Minnesota (http://archives.lib.umn.edu/repositories/3/resources/278) consulted September 26, 2016.
- “Computer Oral History Collection, Dr. Gertrude Blanch, May 16, 1973” on the website of the National Museum of American History (http://amhistory.si.edu/archives/AC0196.pdf) consulted September 26, 2016.

2017 Canadian Nuclear Achievement Awards
Call for Nominations

We are announcing the Call for Nominations for the 2017 Canadian Nuclear Achievement Awards, jointly sponsored by the Canadian Nuclear Society (CNS) and the Canadian Nuclear Association (CNA). These Awards represent an opportunity to recognize individuals who have made significant contributions, technical and non-technical, to various aspects of nuclear science and technology in Canada.

Nominations may be submitted for any of the following Awards:

- W. B. Lewis Medal
- Ian McRae Award
- Harold A. Smith Outstanding Contribution Award
- Innovative Achievement Award
- John S. Hewitt Team Achievement Award
- Education and Communication Award
- George C. Laurence Award for Nuclear Safety
- Fellow of the Canadian Nuclear Society
- R. E. Jervis Award

The deadline to submit nominations is **January 14, 2017.** The Awards will be officially presented during the CNS Annual Conference held June 4 – 7, 2017 in Niagara Falls, Ontario, Canada.

For detailed information on the nomination package, Awards criteria, and how to submit the nomination please visit: http://cns-snc.ca/cns/awards.

If you have any questions, please contact Ruxandra Dranga, Chair – CNS/CNA Honours and Awards Committee by email at awards@cns-snc.ca, or by phone at (613) 717 – 2338.

GENERAL news

(Compiled by Colin Hunt from open sources)

SNC Lavalin Awarded Contract for Atucha 2

SNC-Lavalin announced that it has been awarded a pre-project contract from Argentina's Nucleoeléctrica Argentina SA (NA-SA) for the CANDU nuclear new build project at the Atucha site in the district of Zàrate, about 100 kilometres from Buenos Aires. If this project materializes, it would be the first CANDU new build since Cernavoda Unit 2 came on line in 2007.

The six-month contract will allow SNC-Lavalin to engage with suppliers for long-lead equipment, conduct preliminary design work, deliver safety analysis, offer licensing support and provide technical assistance from Canada.

"We are very excited about this contract," said Preston Swafford, Chief Nuclear Officer & Executive Vice-President, Nuclear, SNC-Lavalin. "It is a clear signal of recognition of SNC-Lavalin in the global nuclear market and recognizes international support for CANDU technology."

New Laboratory Complex Opens in Chalk River

Canada's premier nuclear research facility received a major boost October 19, 2016, with the opening of a brand new $113 million laboratory complex.

The Harriet Brooks Building, named after Canada's first female nuclear physicist, is an important part of an ongoing effort to revitalize the entire site, as old buildings are demolished to make way for new ones, as the owner Atomic Energy of Canada Ltd. (AECL) and the private sector operator of the site Canadian Nuclear Laboratories (CNL) prepare for the future of the nuclear industry.

The Honourable Jim Carr, Canada's Minister of Natural Resources, who helped open the complex with a ribbon cutting ceremony, said this new lab will not only signal the revitalization of the Chalk River site, but will help, with other investments, to ensure it remains at the forefront of nuclear research, innovation and technology in Canada. He said this facility is equally important to the government and its own ambitions to battle climate change.

"We are at a pivotal time ," Carr said, "when the world is making a historic transition to a lower-carbon future; when climate change is one of the great challenges of our generation; and when investing in clean technology and innovation is today's new imperative.

"The recent announcement of our government to invest $800 million in the revitalization of the laboratories at the Chalk River site will be key to advancing science and technology initiatives in Canada's world-class nuclear industry," he said.

Darlington Plant Refurbishment Begins

The first of four reactors at the Darlington nuclear power plant, Unit 2, went offline on Saturday October 15 at 3 a.m., beginning a major refurbishment project that is expected to last a decade and cost almost $13 billion.

Darlington provides 20% of the province's energy needs. Work on Unit 2 will last until 2020, at which time Unit 3 will begin its refurbishment outage, also expected to last 40 months.

The $12.8 billion refurbishment program at the Darlington Nuclear Generating Station in Ontario, Canada, will create as many as 11,800 jobs and contribute nearly $89.9 billion in economic benefits through the life of the power plant, according to the Conference Board of Canada.

Ontario Power Generation began the 10-year refurbishment program on Saturday, after announcing the benefits the massive overhaul will have on the local and national economy of Canada.

According to the province's Energy Minister Glenn Thibeault, the project will create up to 11,800 jobs annually "while contributing nearly $15 billion to Ontario's economy," the Energy Business review reported, notiong the refurbishment will end with the expectation that power from the station will cost between $72 and $81 per Mwh.

The project involves replacement or repair of many critical plant components. The Darlington plant in Clarington, Ontario, consists of four CANDU nuclear reactors with a total net capacity of 2,512 MWe. With all units operating, the plant supplies the province with 20 percent of its electricity, serving an estimated two million customers.

The Conference Board's study included the economic benefits of the overhaul and of at least 30 years of operations after the overhaul is complete.

Design Review to Begin for New Canadian HTGR

Canadian reactor designer StarCore Nuclear has applied to the Canadian Nuclear Safety Commission (CNSC) to begin the vendor design review process for its Generation IV high temperature gas reactor (HTGR).

Montréal-based StarCore, founded in 2008, is focused on developing small modular reactors (SMRs) to provide power and potable water to remote communities in Canada. Its standard HTGR unit would produce

StarCore design.

20 MWe (36 MWth), expandable to 100 MWe, from a unit small enough to be delivered by truck. The helium-cooled reactor uses Triso fuel - spherical particles of uranium fuel coated by carbon which effectively gives each tiny particle its own primary containment system - manufactured by BWXT Technologies. Each reactor would require refuelling at five-yearly intervals.

StarCore describes its reactor as "inherently safe", with a steep negative thermal coefficient which eliminates the possibility of a core meltdown. The use of helium - which does not become radioactive - as a coolant means that any loss of coolant would be "inconsequential", the company says. The reactors would be embedded 50 metres underground in concrete silos sealed with ten-tonne caps.

Engineers Enclose Remains of Chernobyl Unit 4

The process of sliding the arched structure into place to shield the damaged unit 4 of the Chernobyl nuclear power plant in Ukraine has been completed, the European Bank for Reconstruction and Development (EBRD) has announced.

The London-based EBRD said a ceremony in Chernobyl November 29 marked the successful conclusion of the sliding operation, which it described as a key milestone before finalisation of the international program to transform Chernobyl into an environmentally safe and secure state by November 2017.

The arch, called the New Safe Confinement, is the largest moveable land-based structure ever built, with a span of 257m, a length of 162m, a height of 108m and a total weight of 36,000 tonnes equipped. It will make the accident site safe and with a lifetime of 100 years will allow for the eventual dismantling of the ageing makeshift shelter from 1986 and the management of the radioactive waste.

New Schedule Agreed for Iter Fusion Project

An updated schedule for the Iter fusion project has been approved by the Iter Council, which represents the countries taking part in the project. Under the new schedule, first plasma is now slated for 2025 and the start of deuterium-tritium operation is set for 2035.

A two-day meeting of the Iter Council at the Iter headquarters at Saint-Paul-lez-Durance in France unanimously approved the project's baseline - its overall schedule and cost. The project is to build the world's biggest tokamak fusion reactor at Cadarache in southern France. It should be large enough and hot enough to reach 'ignition' and maintain a stable heat-generating plasma for minutes.

The Council concluded that project construction and manufacturing have sustained a rapid pace for the past 18 months, "providing tangible evidence of full adherence to commitments". The successful completion of all 19 project milestones for 2016, on time and on budget, is "a positive indicator of the collective capacity of the Iter Organization and the Domestic Agencies to continue to deliver on the updated schedule", it said.

Swiss Voters Reject Rapid Nuclear Phase-Out

The proposal to force older nuclear power plants to close in Switzerland has been rejected in a referendum. The five reactors that provide over one-third of electricity can continue to operate according to their economic lives.

Nuclear power is Switzerland's second largest source of electricity, providing about 35% of electricity in 2015 and complementing 52% hydro to give the country one of the cleanest and most secure electricity systems in the world.

In 2010 there were active plans to replace the five current reactors based on a supportive referendum and confirma-

Muhleberg nuclear power plant in Switerland.

tion by regulators that the sites were suitable. This program was scrapped by a National Council vote in June 2011, just four months after the accident at Fukushima Daiichi, and Switzerland was put on a path to lose nuclear power when existing reactors retired in the 2030s and 2040s.

On November 27, Switzerland went to the polls on a further proposal that would have accelerated the retirements by forcing reactors to close at the age of 45. Because they are already over this age, Beznau 1 and 2 as well as Muehleberg would have closed in 2017. Gösgen would have followed in 2024, and Leibstadt in 2029.

A majority - 54.2% - of people voted ‘No’ to the rapid phase out, recording a clear victory by winning both the popular vote and by taking majorities in the most cantons. The participation rate in the referendum was some 45% of voters.

Michael Chatlani (left) receives OCNI Exporters Award from Ron Oberth,President of OCNI.

British University Unveils ‘Diamond’ Nuclear-Powered Battery

The University of Bristol, in England, has developed new technology that uses nuclear waste to generate electricity in a nuclear-powered battery. A team of physicists and chemists from the university has grown a man-made diamond that, when placed in a radioactive field, is able to generate a small electrical current. The developers say the innovation could solve some of the problems of nuclear waste, clean electricity generation and battery life.

In a statement, the university said that, unlike the majority of electricity-generation technologies, which use energy to move a magnet through a coil of wire to generate a current, the man-made diamond is able to produce a charge simply by being placed in close proximity to a radioactive source.

The team demonstrated a prototype diamond battery using nickel-63 as the radiation source. However, they are now working to significantly improve efficiency by utilizing carbon-14, a radioactive isotope of carbon, which is generated in graphite blocks used to moderate the reaction in British nuclear power plants.

Radioactive carbon-14 is concentrated at the surface of these blocks, making it possible to process it to remove the majority of the radioactive material. The extracted carbon-14 is then incorporated into a diamond to produce a nuclear-powered battery.

The UK currently holds almost 95,000 tonnes of graphite blocks, the university noted, and by extracting carbon-14 from them, their radioactivity decreases, reducing the cost and challenge of safely storing this nuclear waste.

Carbon-14 was chosen as a source material because it emits a short-range radiation, which is quickly absorbed by any solid material. “This would make it dangerous to ingest or touch with your naked skin, but safely held within diamond, no short-range radiation can escape. In fact, diamond is the hardest substance known to man, there is literally nothing we could use that could offer more protection,” Fox said.

Despite their low-power, relative to current battery technologies, the life-time of these diamond batteries could revolutionize the powering of devices over long timescales. Using carbon-14 the battery would take 5730 years to reach 50% power.

37th Annual Conference of the Canadian Nuclear Society
and
41st Annual CNS/CNA Student Conference

Our Nuclear Future: Renewal and Responsibility
Notre avenir nucléaire: Renouvellement et responsabilité

2017 June 4 - 7

Sheraton on the Falls Hotel, Niagara Falls, Ontario, Canada

Call for Papers

Nuclear science and technology currently provides clean and safe energy, and benefits the health and security of the global community. Building on this strong foundation, nuclear science and technology will become of even greater importance well into the 21st century. Further advancement of the current state of the art would enhance public confidence and acceptance of nuclear science and technology.

The Canadian Nuclear Society (CNS) will host its 37th Annual Conference at the Sheraton on the Falls Hotel in Niagara Falls, Ontario, Canada, 2017 June 4 - 7. This conference provides a forum for exchanging views, ideas and information relating to the application and advancement of nuclear science and technology, and for discussing energy-related issues in general. Technical topics of interest are listed on the following page. The CNS 37th Annual Conference will feature:

- Plenary sessions with invited speakers to address broad industrial, commercial and research-related developments in nuclear science and technology.
- Technical sessions with subject-matter experts from utilities, suppliers, the regulator, academia, federal laboratories and agencies to present the latest advancements in nuclear science and technology.
- Exhibits with industrial leaders showcasing their latest nuclear products and technology.
- Social events (such as reception, lunches, coffee breaks and conference banquet) to facilitate in-depth discussions on common interests.

To facilitate interaction between experts and the future generation of nuclear scientists, engineers, and specialists, the 41st Annual CNS/CNA Student Conference will be held in parallel at the same venue. The Student Conference will feature a poster session, at which university students will showcase their latest research findings and advancements. A Call for Students' Extended Abstracts will be issued separately.

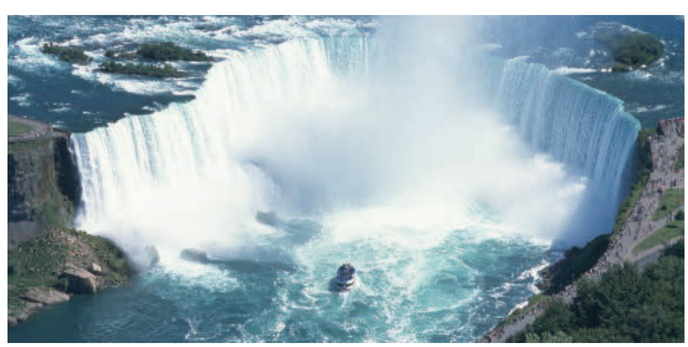
Important Dates:

Abstract submission (**extended**): **2016 December 23**
Draft paper submission: **2017 January 14**
Full paper submission: **2017 April 7**

Submission Guidelines:

- The abstract should be <150 words in length (technical topics of interest are listed on the following page).
- The full paper should present facts that are new and significant or represent a state-of-the-art review, and should include sufficient information for a clear presentation of the topic. The required format of submission is electronic (Word or pdf).
- Templates for abstract and full paper are available from the Conference website http://www.cns2017conference.org.
- Submission should be made via: http://www.softconf.com/h/CNS2017Technical
- Notes: At least one of the authors must register for the Conference by the "early" registration date (2017 April 16) for the paper to be included in the Conference Proceedings.

General Enquiry: Benjamin Rouben
e-mail: annualconference@cns-snc.ca
Tel: 416-977-7620



CNS news

News from Branches

1. WESTERN BRANCH – Matthew Dalzell

General

The Branch has had a largely quiet summer period, with activity increasing with the start of term and Nuclear Science Week.

Branch Activities

The Branch was well represented at the CNS Annual Conference and Student Conference, with branch members delivering plenary presentations, papers and some outstanding student posters. Work is continuing to build on the 'chapter' concept for the Western Branch, with small meetings and events in communities within the branch's area.

Outreach Activities

Jason Donev presented on nuclear power at an adults only night at the Telus Spark Science Centre on August 18th. The science night had 138 people, but only 32 attended the nuclear talk directly. After his talk, Jason spent a while trying to dispel radiation fear propagated by other groups at the event.

Branch members are getting ready to support Nuclear Science Week activities throughout Western Canada under the coordination of Jason Donev, including:

- A Nuclear Science Night at the Rothney Observatory in Calgary, October 15th
- TRIUMF sponsored talk in Vancouver
- nuclearFACTS science pubs featuring Nicholas Priest talking about "So Just How Dangerous is Low Dose Radiation?" at the Tox on Tap science pub in Saskatoon October 18th, and at the University of Regina Faculty Science's pub in Regina on October 19th

Duane Pendergast arranged for a presentation on September 22 from **Cosmos Voutsinos** to the Southern Alberta Council on Public Affairs. His talk titled; "Alberta's Power Grid: Where will Electricity Come from in the Future?" called for a broad scope study by engineers, environmental experts and economists of Alberta's proposal to phase out coal power by 2030.

The Energy Collegium contributed to the Alberta Association of Municipalities Directors Committee meeting by teleconference on September 26. The talk focused on costs of the Alberta Government plan to phase out coal power and replace it with renewables and natural gas power. Clive Schaupmeyer made the presentation entitled; "Alberta's Future Electrical Supply". CNS members, and Laurence Hoye, Duane Pendergast and Shaun Ward participated.

David Malcolm has been working with the Government of the Northwest Territories (GNWT), the CNSC, NAPEG, and the LeadCold SMR technology company to help organize a "small reactors for the Arctic" conference (http://www.leadcold.com/mra2016.html) to be held in Yellowknife November 29 -30.

2. BRUCE BRANCH – John Krane

The Bruce Branch participated in the Bluewater District Regional Science and Technology Fair held on April 1st and April 8th in Owen Sound Ontario.

Several members of the Bruce Branch were able to participate, judge and award prizes. Special recognition goes to Bill Moriarty (Bruce Branch Treasurer) who was able to participate on both days.

Two CNS prizes of $50 each were awarded and the Junior and Senior science fair recipients will be moving on to participate at the national science fair in Fredericton NB in May.

Good coverage, including a photo was published in the Owen Sound Sun Times newspaper, which I have attached for your interest (**Posted separately in CNS Council Reports**).

3. SHERIDAN PARK BRANCH – Rajendra Jain

1. A tour to McMaster Nuclear Reactor (MNR), McMaster Manufacturing Research Institute (MMRI) and McMaster Accelerator Lab (MAL) was organized on June 08, 2016.
2. A presentation by Shami Dua (Former Director, Quality Assurance, AECL Mississauga ; Former Director, Management System & Quality Assurance, Emirates Nuclear Energy Corporation (ENEC), Abu Dhabi) was organized on June 28, 2016. The title of the presentation was "Integrated Management System & Quality Assurance for Nuclear Industry - Global Movement & Trends for Regulatory Bodies & NPP"

3. The branch executive meeting was held on Aug 09, 2016 to discuss branch activities.
4. A presentation by Rob Whalen (Senior Vice-President Engineering, Intellectual Property & Technology SNC Lavalin Nuclear) was organized on August 16, 2016. The title of the presentation was "SNC Lavalin Nuclear / Candu Energy's Nuclear Capabilities and Future Prospects".
5. The branch volunteers attended CNS booth on Sept 28, 2016 at OCI Suppliers Day to promote CNS.

4. GOLDEN HORSESHOE BRANCH – Jason Sharpe

The GHS branch is planning a "Nuclear Workers Seminar Series" aimed at showcasing real nuclear jobs to undergraduates and graduate students interested in entering the nuclear industry. The presenters that are recruited will ideally cover the whole spectrum of jobs available in the industry. The series is scheduled to begin Nov. 15th.

Three new branch positions were created to increase student involvement with the CNS and to raise the CNS's profile. The three positions include:

- Events Officer, responsible for organizing branch events such as seminars, tours, guest speakers, etc. (Mario Ponce Tovar),
- Communications Officer, responsible for creating promotional material and outreach, including getting more people in the golden horseshoe area more involved with CNS activities (Mitchell Lemieux), and,
- Student Liaison Officer, responsible for specifically getting more students involved with the CNS and the GHS branch. In addition, this officer will collaborate with other student societies in efforts to raise CNS's profile (Michael Jobity).
- The students created a Facebook page to be able to share ideas for events, keep a record of possible speakers, chat about nuclear related news, and network with each other.

On Oct 6, 2016 the GHS branch held a seminar featuring Dr. Rian Prinsloo and Dr. Francois van Heerden. They came to McMaster from South Africa to collaborate with the McMaster Nuclear Reactor Group. Their presentation was titled: "The OSCAR System as a Research Platform and Industrial Support Tool for Research Reactor Core Analysis". The presentation is available upon request.

5. DURHAM REGIONAL BRANCH – Jacques Plourde

Activities have been underway to launch the new CNS Branch that will serve OPG in Durham Region. We are seeking Council's approval to officially create the Branch.

The executive meeting has met 3 times already to expedite preparations for a strong revival of what used to be the Darlington and Pickering Branches combined.

Outcomes of the discussions were as follows:

- The Branch has a strong founding Executive, many with CNS current or past experience, all OPG or ex-OPG. The Executive is already looking at its succession plan with an objective to engage more OPG employees in our Branch Executive and move our ex-OPG members to an advisor role.
- The Branch Executive is fully engaged in the CNS-OPG Face-to-Face initiative led by Paul Thompson, and wishes to use this very important meeting to secure OPG support for the local Branch.
- Assuming that the above meeting happens in October, the Branch is planning to set the start of its 2016-17 program a month later, in late November or early December. By then, the Darlington refurbishment program will have had a chance to settle into a groove and OPG staff will likely be more attentive.
- The Branch plans to launch with 4 repeat sessions, held in the form of Lunch & Learn information sessions, possibly adding a keynote speaker if OPG will allow us a full hour. Target locations:

1. Darlington
2. Darlington Energy Centre
3. Pickering
4. 889 Brock

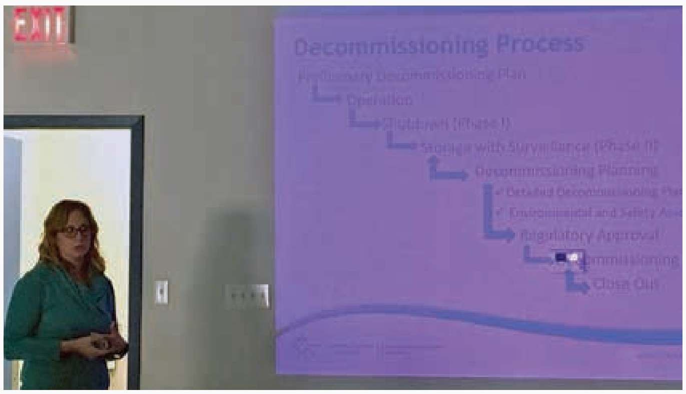
- These initial sessions will be followed by a larger, more elaborate, late afternoon event in a central location, aimed at attracting local membership.

6. CHALK RIVER BRANCH – Andrew Morreale

Algonquin College CNS Awards (2016): In **June**, Samy El Jaby from the CNS Chalk River branch was on hand to present the CNS award to two students (Joeseph Vu and Kaylia Doering) graduating from the Radiation Safety program at Algonquin College.

CNS CRB member Samy El-Jaby presents the CNS Award to Joeseph Vu and Kaylia Doering, graduating students of the Radiation Safety Program at Algonquin College.

Dr. Onder presents on Accident Tolerant Fuels at JL Gray in Deep River, August 2016.



Meggan Vickerd discusses the In-Situ Decomissioning Process being employed at the NPD reactor (Chalk River, September 2016).

Deep River Summerfest (2016): In **July**, the Chalk River Branch borrowed a "Go-To Telescope" from the Royal Astronomical Society of Canada / Ottawa-Centre Ted Bean Telescope Library to provide a low-cost science activity at the Deep River 2016 Summerfest. The 205 mm telescope was set up during the daytime on Saturday July 31st adjacent to other activities in an open field. Adults and children were treated to a view of the waning crescent of the moon.

CNS Chalk River Branch Star Party (2016): In **August**, the branch again made used of the "Go-To Telescope and held a "Star Party" in Deep River on August 10th from 21:30 to 22:30. The sky cleared sufficiently to allow the group that attended to view the First-Quarter Moon, Mars, and Saturn along with several bright stars.

Seminar on Accident Tolerant Fuels (2016): In **August**, the Chalk River Branch hosted a talk by Dr. Nihan Onder from CNL on accident tolerant fuel research. The presentation provided an in-depth review of international activities in this field and was well attended by CNS members and the community.

CNS/WIN Joint Seminar on Decommissioning (2016): In **September**, the CNS-Chalk River Branch partnered with the Chalk River Branch of Women in Nuclear (WIN) for the 8th annual CNS/WIN Joint Seminar. A talk on the In-situ Decommissioning plan for the Nuclear Power Demonstration (NPD) reactor in Rolphton, ON, was presented by Meggan Vickerd of CNL. This talk discussed CNL decommissioning efforts at their prototype reactor facilities (NPD, Douglas Point and Gentilly-1) and was very well attended by more than 35 members of the local community.

Upcoming events for the CNS Chalk River Branch (CRB) include talks by Chris Hatton from the Nuclear Waste Management Organization (NWMO) on geologic repositories, and by Samy El Jaby from CNL on Radiation Biology, and the CNS-CRB Annual General Meeting (AGM).

7. NEW BRUNSWICK (NB) BRANCH– Derek Mullin

The NB Branch executive is:

Chair:	Derek Mullin
Past Chair:	Mark McIntyre
Secretary:	Rick Sancton
Treasurer:	Elif Can Usalp
Member-at-Large:	Paul D. Thompson
Member-at-Large:	Vacant

Executive Meetings

An executive meeting was held on September 12, 2016, to discuss roles and responsibilities; branch finances; budget proposals for the next operating year; upcoming events; how we can engage in educational outreach initiatives to various institutions (university level and high school level); and, to collaborate with other engineering organizations and local service groups to promote the objectives of the Canadian Nuclear Society. This would include delivery of NB branch lecture series not only locally but also beyond the Saint John region.

Outreach Initiatives

The NB Branch has thus far reached out to the Association of Profession Engineers and Geologists of New Brunswick (APEGNB) who have expressed great interest in collaborating to promote the objectives of both organizations and increase awareness. Meeting will be held soon with the APEGNB to determine specific areas of collaboration that will benefit both organizations. The NB branch is also reaching out to other groups such as the New Brunswick Section of the Institute of Electrical and Electronics Engineers (IEEE).

If you are a member in good standing and have any interest in playing a more active role in the NB Branch activities in promoting the nuclear industry through outreach and education, or with providing assistance with planning and carrying out branch activities, please contact the Chair, Derek Mullin, at dmullin@nbpower.com.

Engineering Benchmark Team and CNS NB Branch Executive (Mr. Valentin Nae, fourth from the left)

Social Mixer Prior to Valentin Nae's Lecture

Branch Events

On June 8, 2016, Mr. Robert Whalen, Senior Vice-President, Engineering SNC-Lavalin, delivered a presentation entitled "Nuclear Capabilities and Future Prospects". Mr. Whalen discussed his experience in the US leading Engineering teams to improve plant performance and in doing so provided the audience with valuable insights into the differences and similarities in the US and Canadian capabilities and practices. Mr. Whalen also outlined the status of current and future project prospects. The presentation was well attended by about 20 CNS members and guests, generating lots of questions and discussion.

On September 21, 2016, Mr. Valentin Nae, Performance Engineering Manager, Societatea Nationala NUCLEARELECTRICA S.A (SNN) in Romania, delivered a lecture regarding Cernavoda Nuclear Power Plant's journey to excellence. Mr. Nae discussed the history of the region; significant milestones for Cernavoda; performance results for both Units 1 and 2; contributing factors that have led to their success; and, challenges that the plant continues to face as they strive towards further improvement and ongoing excellence. The interesting and informative lecture was well attended by about 25 CNS members and guests. This included an international engineering benchmarking team comprised of Mr. Nae and representatives from Korea and China (see Photo 1). Other interested individuals from outside the nuclear field also attended as a result of our outreach and collaboration initiatives. A pre-event social mixer was held and was a great success (see Photo 2).

CNS Membership Note

It is time to renew your CNS membership for 20157 Please log in to your personal CNS profile: You can access your account at any time by logging in to https://cns-snc.ca/accounts/cns_member_renew (or via the Membership page of the CNS website, www.cns-snc.ca). You can then very easily and quickly renew your membership.

Take advantage of a good discount with earlybird renewal fees! After December 31, your renewal fee will jump by 19-20%! Time goes fast; I encourage you to take a short minute to renew now!

And please remember to keep your CNS profile current when there are changes in your information.

Best regards,
Ben Rouben, Chair, Membership Committee

Note d'adhésion à la SNC

Il est temps de renouveler votre adhésion à la SNC pour 2015. Accédez à votre compte personnel en visitant https://cns-snc.ca/accounts/cns_member_renew ou bien à partir de la page des adhésions au site de la SNC (www.cns-snc.ca). De là vous pourrez renouveler votre adhésion très facilement et rapidement.

Vous profiterez d'un très bon escompte en renouvelant maintenant ! Après le 31 décembre, il y aura un saut de 19-20% dans les frais de renouvellement. Le temps passe vite; je vous encourage donc à prendre une toute petite minute pour renouveler tout de suite !

Et veuillez bien vous rappeler de mettre vos données à jour chaque fois qu'il y a un changement.

Bien cordialement,
Ben Rouben, président du comité d'adhésion

37th Annual CNS Conference
41st CNS/CNA Student Conference

"Our Nuclear Future: Renewal and Responsibility"

Niagara Falls, Ontario, June 4-7, 2017
Sheraton on the Falls Hotel

Call for Student Papers

In June, 2017, the Canadian Nuclear Society (CNS) will be hosting the 41st Annual CNS/CNA Student Conference and the 37th Annual CNS Conference in Niagara Falls, Ontario, Canada. Together, these conferences aim to promote meaningful connections within the community of nuclear science and technology through the exchange of views, ideas and information.

As students, you represent the future generation of this industry, and your active participation is strongly desired and encouraged. The central theme of this year's conference is: "Our Nuclear Future – Renewal and Responsibility", and it is important that students be given the opportunity to be an active part of this conversation. As such, we are soliciting papers from students in both undergraduate and graduate levels on all topics related to this theme and, in particular, on topics related to the application and advancement of nuclear science and technology.

The highlight of the student conference is the poster session, during which students are given the opportunity to discuss their work face-to-face with conference attendees. Your poster is meant to be a visual aid during these conversations, in which you present the most significant information and results published in your paper. Remember that the range of technical expertise of the poster session attendees will vary greatly, and it is important for you to understand your audience and to converse at an appropriate level. This is a highly technical industry whose future rests heavily on the ability of its representatives to communicate clearly with the public. With this in mind, one student from each submission category (Undergraduate, Master's and Ph.D.) will be presented with an award during the conference Honors and Awards Luncheon, recognizing both the technical aspects of the work as well as their ability to present the topic in a clear, concise and compelling manner.

In addition to this, during the conference students will have the opportunity to meet and converse with leaders from both industry and academia and to participate in the full range of conference activities:

- In-depth technical sessions given by experts in a broad range of current research topics
- Plenary sessions given by distinguished speakers
- Exhibits with industrial leaders showcasing their latest nuclear products and technology
- Social events to facilitate building strong relationships within the community (this includes a conference reception, daily lunches and coffee breaks, and a banquet evening)

37th Annual CNS Conference
41st CNS/CNA Student Conference

"Our Nuclear Future: Renewal and Responsibility"

Niagara Falls, Ontario, June 4-7, 2017
Sheraton on the Falls Hotel

Potential Technical Topics

- Reactor Safety and Licensing
- Reactor and Radiation Physics
- Thermalhydraulics
- Advanced Reactors and Fuel Cycles
- Fusion Science and Technology
- Process Systems and Chemistry
- Instrumentation and Control
- Materials Issues for Existing and New Reactors
- Uranium, Prospecting, Purification and Utilization
- Safety Culture, Worker Protection, Health Physics, and Quality Assurance
- Radiation Protection
- Plant/System Reliability, Maintainability, Operability and Safety
- Plant Life Extension, Refurbishment and Aging
- Operating Experience and Maintenance
- Environment and Spent Fuel Management
- Medical Physics, Isotope Production and Applications
- Oil Sands and Desalination Applications
- Effective Communication with respect to all Nuclear-Related Topics
- Other topics are acceptable, provided they relate to the theme of the conference

Guidelines for Submission

- Student papers should present facts that are new and significant, or represent an in-depth review
- They should include enough information for a clear presentation of the topic
- Each paper should be no more than 5 pages in length and should strictly adhere to the format of the template provided on the conference website:
  http://cns2017conference.org/
- Several important features of this template include:
  - Proper referencing of all related published information
  - Inclusion of the name(s), affiliation(s), and contact information of the author(s) and their supervisor(s) below the title of the paper
  - Inclusion of a short summary (50-100 words) at the beginning of the paper
  - MS Word "Normal" margin size
- Full paper submissions (in MS Word format, please) can be made through the electronic submission system:
  https://www.softconf.com/h/CNS2017Students

To help with planning, authors are kindly asked to log in to the submission site and input the title and main author of their planned paper even before making the final paper submission.

Contact information

Student Conference Committee

John Luxat (Chair): luxatj@mcmaster.ca
Andrew Ali: andrew.ali@amecfw.ca
Kendall Boniface: bonifak@mcmaster.ca

General

CNS Office: 416-977-7620

Executive Chair of the CNS Conference

Daniel Gammage

Important Dates

Submission Deadline: **February 17, 2017**
Notification of Acceptance: **March 31, 2017**
Submission of Revised Paper: **April 28, 2017**

Delivering Clean Energy through CANDU® Life Extension

11th International Conference on CANDU® Maintenance & Nuclear Components
2017 October 1-4
Toronto Marriott Downtown Eaton Centre Hotel
Toronto, ON, Canada

Conference Sponsor & Organizer: Canadian Nuclear Society – Nuclear Operations and Maintenance Division
Please see website: www.cmncc2017.org for updates and detail or contact the CNS Office by calling 416-977-7620 or by email at: cns-snc@on.aibn.com.

CMNCC-2017 CONFERENCE

The CANDU® Maintenance and Nuclear Component Conference (CMNCC-2017) will be held on October 1-4, 2017 at the Marriott Eaton Centre Downtown Toronto. The three-day program, built around a theme of "Delivering Clean Energy through CANDU® Maintenance and Life Extension", will comprise six plenary sessions and six parallel technical programs. The Sunday (October 1) program will include the popular CANDU® Configuration Overview Course, in addition to the Opening Reception. The CANDU® Configuration Overview Course focuses on CANDU® Plant and Reactor Orientation, Systems and Reactor Regulation, and Plant Operations, Degradation and Maintainability. CMNCC-2017 will also include the student program that includes a poster session based on technical paper submissions, similar to that in CANDU® Maintenance Conference (CMC)-2014 and International Nuclear Components Conference (INCC)-2015.

SPONSORSHIP OPPORTUNITIES and TRADE SHOW BOOTHS

A variety of items and levels of sponsorship are available. Consider booking a Trade Show booth space to showcase your company's products and services to the Conference participants. CMNCC-2017 provides an excellent opportunity to network and renew or establish new industry contacts that will lead to increased business opportunities. The complete Sponsorship and Trade Show Information package will be on the website: www.cmncc2017.org

IMPORTANT DATES

- Due Date for Abstract Submission: 1 June 2017
- Notification of Abstract Acceptance: 30 June 2017
- Paper submission due date: 20 August 2017
- Early-bird Registration deadline: 31 July 2017
- Hotel Room Block cut-off date: August 30, 2017
- The CANDU® Course: October 1, 2017
- The Conference: October 1-4, 20

CONFERENCE REGISTRATION

Conference Registration is to be completed online through the website: www.cmncc2017.org.

37th Annual Conference of the
Canadian Nuclear Society and 41st Annual CNS/CNA Student Conference

Our Nuclear Future: Renewal and Responsibility

Notre avenir nucléaire: Renouvellement et responsabilité

2017 June 4 - 7

Sheraton on the Falls Hotel, Niagara Falls, Ontario, Canada

CALL FOR PAPERS – TECHNICAL TOPICS

Deploying New Reactors and Building to Time	Establishing new build program; International collaborations; Risk-informed safety regulation; Policy; Regulation and risk assessment; Probabilistic & deterministic risk analysis; Addressing life extension and licensing renewal; Design and construction; Economics and financing; New - site licensing; New developments and designs; Gen-III+ designs/ Gen IV and SMR concepts/ advanced systems and components; Passive safety
New Technology and Applications in Nuclear Research and Development	Advanced reactor physics, radiation physics and health physics; Thermalhydraulics; Fusion; Hydrogen production; Modern fuel cycles; Used fuel recycling, reusing and reprocessing; Adopting new materials; Efficiency enhancements; Gen IV and SMR concepts; Space and mining applications; New nuclear codes and standards
Operation and Aging Management	Refurbishment and life extension; Economics; Maintenance; Reliability; Quality Assurance / Inspection; Risk assessment; Outage reduction; Fuel and equipment performance; New developments; Reliability enhancement; Power uprating; Obsolescence; Component replacement; Supply chain; OPEX
Facilitating Energy Policy and Global Consensus	Policy development; Energy mix; Sustainability; Climate change; Public acceptance; Education; Communications; International and regional cooperation; Safeguards; Proliferation-resistant fuels
Enhancing Safety and Security	Perspectives after Fukushima; Extreme events; Severe accidents; Accident management; Emergency planning; Plant security; Human performance; Safety culture; Stress testing; Shielding analysis; Criticality Safety Analysis; Risk assessment; Probabilistic analysis; Regulatory perspective; Nuclear security and non-proliferation
Environmental Protection and Waste Management	Designing for environmental protection; Assessment of environmental effects; Decommissioning and environmental remediation; Waste stream management and reduction; Progress in repository development; Interim used fuel storage strategies; Waste treatment, packaging and transportation
Fuel Cycles	Uranium and thorium mining, milling, refining, conversion and enrichment; Uranium and Thorium fuel manufacturing; Fault tolerant fuel design; Open and closed fuel cycle
Addressing Public Concerns about Radiation Impacts	Experience from Fukushima; Social impacts; Educating & partnering with public; Opinion surveys; Radiation protection; Linear-no-threshold issues; Radiation health effects; Lessons learned; Outreach
Facing Competitors and Reducing Cost	Design and construction; Manufacturing and modularity; Economics and financing; Supply chain assurance; Outage management; Market and competitive challenges
Acquiring Medical and Biological Benefits	Medical and biological systems; Treatments and protocols; New isotope manufacture; Novel accelerators and target development; Supply assurance; Handling waste streams; Economics; International trends; Advanced reactor physics; Isotope production and use; Agricultural applications

CNS' Education and Communication Committee (ECC) is looking for volunteers!

Are you:

- Passionate about nuclear technology?
- Comfortable listening to others expressing concerns with nuclear?
- Comfortable talking to others about nuclear?
- Comfortable talking to young persons?
- Willing to travel locally and occasionally further?
- Willing to take training?
- Accepting of peoples of different cultures and backgrounds?
- Able to discuss things nuclear in lay-persons' terms?

Join the CNS ECC team and participate in our educational and outreach activities. A broad, basic knowledge of the nuclear industry would be an asset, but it is not essential.

Volunteers who are CNS members are required for:

- Outreach to schools
- Mentors for school outreach activities
- Geiger support groups for teachers
- Nuclear for Everyone lecturers (facilitators)
- Nuclear 101 lecturers (facilitators)
- Outreach to First Nations' and Aboriginal peoples

If interested, please send your name and contact coordinates to the CNS Office, attn.: Ruxandra Dranga and John Roberts, at cns-snc@on.aibn.com (cc. ecc@cns-snc.ca), with one page supporting your volunteer preference(s) and your anticipated availability over five years.

Training will be offered starting in 2017 and is expected to continue for several years. If required, travel expenses may be reimbursed for successful volunteers, according to the CNS Travel Policy.

Canadian Nuclear Society
Société Nucléaire Canadienne
4th Floor, 700 University Ave, Toronto, ON M5G 1X6
Tel: (416) 977-7620 E-mail/Courriel: cns-snc@on.aibn.com

Scholarships in Nuclear Science and Engineering at Canadian Universities

The Canadian Nuclear Society (CNS) is pleased to offer scholarships to promote Nuclear Science and Engineering to students at Canadian universities.

Two scholarships are offered in 2017: One graduate school entrance scholarship of $5,000 and two undergraduate summer research scholarships of $3,000 each.

Graduate School Entrance Scholarship: $5,000

This entrance scholarship is designed to encourage undergraduate students to enter a graduate program related to Nuclear Science and Engineering at a Canadian university.

Eligibility

You must be currently enrolled in a full-time undergraduate program at a Canadian University and be a member of the CNS.

The duration of the graduate program must be at least two years and is expected to lead to a Master's or a PhD degree.

Undergraduate Student Research Scholarship: $3,000

This scholarship is designed to encourage undergraduate students to participate in research in Nuclear Science and Engineering during the summer months.

Eligibility

You must be enrolled in a full-time undergraduate program at a Canadian University for at least two years and be a member of the CNS.

The scholarship is to be matched by $2,000 from the student's supervisor for a total of $5,000.

The recipients of the scholarships will be selected on the basis of their academic standing and other information to be supplied with the application.

The Scholarship Committee of the Canadian Nuclear Society will collect and review the submissions, and make the award decisions.

Details of the scholarships and the procedure for application can be found on the CNS website at

www.cns-snc.ca/Scholarships

The deadline for submission of the application is **March 1, 2017**.

Canadian Nuclear Society
Société Nucléaire Canadienne
4th Floor, 700 University Ave, Toronto, ON M5G 1X6
Tel: (416) 977-7620 E-mail/Courriel: cns-snc@on.aibn.com

Bourses en science et génie nucléaire dans les universités canadiennes

La Société Nucléaire Canadienne est heureuse d'offrir des bourses afin d'encourager les étudiants dans les universités canadiennes à étudier la science et le génie nucléaire.

Deux bourses sont offertes en 2017: une bourse de 5,000$ à l'entrée aux études supérieures, et deux bourses de recherche d'été (de 3,000$ chaque) pour étudiants poursuivant la licence.

Bourse d'entrée aux études supérieures : 5,000$

Le but de cette bourse est d'encourager les étudiants à s'inscrire aux études supérieures en science et génie nucléaire dans une université canadienne.

Éligibilité

L'étudiant(e) doit être présentement inscrit(e) plein-temps à un programme poursuivant la licence dans une université canadienne, et doit être membre de la SNC.

L'échéancier du programme en études supérieures doit couvrir une période minimale de deux ans, et devrait mener à une maîtrise ou à un doctorat.

Bourse de recherche pour étudiants poursuivant la licence : 3,000$

Le but de cette bourse est d'encourager les étudiants poursuivant la licence à participer en recherche en science et génie nucléaire pendant l'été.

Éligibilité

L'étudiant(e) doit être inscrit(e) plein-temps à un programme d'au moins 2 ans poursuivant la licence dans une université canadienne, et doit être membre de la SNC.

Cette bourse doit être complémentée par un montant de 2,000$ de la part du directeur de la recherche, pour un total de 5,000$.

Les gagnant(e)s des bourses seront sélectionné(e)s à partir de la qualité de leur dossier académique, ainsi que d'autres données à être fournies en même temps que la demande de bourse.

Le Comité des bourses de la Société Nucléaire Canadienne recevra et étudiera les candidatures, et attribuera les bourses.

Les détails des bourses et les procédures de demande sont disponibles sur le site web de la SNC à

www.cns-snc.ca/bourses

La date limite pour la soumission de demande de bourse est le **1er mars 2017**.

2015-2016 CNS Council • Conseil de la SNC

Executive / *Exécutif*

President / ***Président***	Peter Ozemoyah	289-288-0490 x249
e-mail	pozemoyah@tyne-engineering.com	
Past President / ***Président sortant***	Paul Thompson	506-659-6234
e-mail	pthompson@nbpower.com	
1st Vice-President / ***1ier Vice-Président***	Daniel Gammage	519-621-2130 x2166
	dgammage44@gmail.com	
2nd Vice-President / ***2ième Vice-Président***	John Luxat	905-525-9140 x24670
e-mail	luxatj@mcmaster.ca	
Treasurer / ***Trésorier***	Mohamed Younis	416-592-6516
e-mail	mohamed.younis@amecfw.com	
Secretary / ***Secrétaire***	Colin G. Hunt	613-742-8476
e-mail	colin.hunt@rogers.com	
Financial Administrator / ***Administrateur financier***	Ken L. Smith	905-828-8216
e-mail	unecan@rogers.com	
Executive Director / ***Directeur exécutif***	Ben Rouben	416-663-3252
e-mail	roubenb@alum.mit.edu	
Communications Director / ***Directeur des communications***	Jeremy Whitlock	613-584-3311 x44265
e-mail	jeremy.whitlock@cnl.ca	

Members-at-Large / *Membres sans portefeuille*

Andrew Ali	905-240-2445
Parva Alavi	905-599-9534
Farzad Ardeshiri	905-858-3468
John Barrett, CNA barrettj@cna.ca	613-237-4262
Frederick C. Boyd	613-823-2272
Chris Ciaravino	416-697-4170
Rudy Cronk	905-949-2755 x 214
Ruxandra Dranga	613-584-3311 x 46856
Peter Easton	613-863-1027
Mohinder Grover	416-499-5591
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Dorin Nichita	905-721-8668
Nicholas Preston	289-200-9718
John G. Roberts	519-396-8843
Wei Shen	613-996-0192
Michael Smith	647-687-7112
Nick Sion	416-487-2740
Keith Stratton	506-343-4060
Ronald Thomas	613-236-3297
Kamal Verma	905-823-9040 x 35947
Pauline Watson	905-338-3032
Stephen Yu	905-823-9040 x 32179

CNS Committees / *Comités de la SNC*

Program / Programme
Keith Stratton .... 506-343-4060 kstratton@bellaliant.net

WiN Interface / Interface avec WiN
Pauline Watson .... 905-338-3032 watson@engspol.com

Branch Affairs / Chapitres locaux
Ron Thomas .... 613-236-3297 rthomas@storm.ca

Education and Communications / Éducation et communications
Ruxandra Dranga .... 613-584-3311 x46856 ruxandra.dranga@cnl.ca

Membership / Adhésion
Ben Rouben .... 416-663-3252 roubenb@alum.mit.edu

Finance / Finances
Mohamed Younis .... 416-592-6516 mohamed.younis@amecfw.com

Bulletin
Colin Hunt .... 613-613-742-8476 colin.hunt@rogers.com

Past Presidents / Anciens présidents
Paul Thompson .... 506-659-6234 pthompson@nbpower.com

Honours and Awards / Prix et honneurs
Ruxandra Dranga .... 613-584-3311 x46856 ruxandra.dranga@cnl.ca

International Liaison Committee / Liaisons internationales
Kris Mohan .... 905-332-8067 mohank@sympatico.ca
Fred Boyd .... 613-592-2256 fboyd@sympatico.ca

Internet / Internet
Andrew Prudil .... 613-483-0346 andrew.prudil@gmail.com

Inter-society Relations / Relations inter-sociétés
Peter Ozemoyah .... 289-288-0490 x249 pozemoyah@tyne-engineering.com

Strategic Planning
Jacques Plourde .... 905-441-2776 jap-performance@rogers.com

Young Generation / Jeune génération
John Roberts .... 519-396-8843 alchemy@tnt21.com

Scholarship / Bourses
Mohamed Younis .... 613-592-2256 mohamed.younis@amecfw.com
.... 416-592-6516

Technical Divisions / *Divisions techniques*

- Nuclear Science & Engineering / Science et génie nucléaires
  Elisabeth Varin 514-953-9790 varine@gmail.com
- Fuel Technologies / Technologies du combustible
  To 2014 October 7:
  From 2014 October 8:
  Paul Chan 613-541-6000 x6145 paul.chan@rmc.ca
- Design and Materials / Conception et matériaux
  Daniel Gammage 519-621-2130 x2166 dgammage@babcock.com
- Environment & Waste Management / Environnement et gestion des déchets
  Parva Alavi 905-599-9534 parvaalavi@gmail.com
- Nuclear Operations & Maintenance/ Exploitation nucléaire et entretien de centrale
  Aman Usmani 416-217-2167 aman.usmani@amec.com
  Polad Zahedi 905-839-6746 x4029 polad.zahedi@opg.com
- Medical Applications and Radiation Protection/Applications médicales et protection contre les rayonnements
  Nick Sion 416-487-2740 sionn@sympatico.ca
- Fusion Science and Technology / Scjence et technologie de la fusion
  Blair Bromley 613-584-3311 x43676 blair.bromley@cnl.ca

CNA Liaison / *Agent de liaison avec l'ANC*
John Barrett 613-237-4262 barrettj@cna.ca

CNS Bulletin Publisher / Éditeur du Bulletin SNC
Colin Hunt 613-220-7607 colin.hunt@rogers.com

CNS Bulletin Editor / Rédacteur du Bulletin SNC
Ric Fluke 416-592-4110 rfluke@sympatico.ca

CNS Office Manager / Bureau de la SNC
Bob O'Sullivan 416-977-7620 cns-snc@on.aibn.com

Branches / Chapitres locaux

Bruce	John Krane	519-361-4286 jck@bmts.com
Chalk River	Andrew Morreale	613-584-8811 x 42543 morreaac@mcmaster.ca
Durham Region	Jacques Plourde	905-441-2776 jap-performance@rogers.com
Golden Horseshoe	Jason Sharpe	905-975-5122 jason.r.sharpe@gmail.com
Manitoba	Jason Martino	204-753-2311 x62229 martinoj@cnl.ca
New Brunswick	Derek Mullin	506-650-3374 dmullin@nbpower.com
Ottawa	Ken Kirkhope	ken.kirkhope@cnsc-ccsn.gc.ca
Québec	Michel Saint-Denis	514-875-3452 michelstdenis@videotron.qc.ca
Sheridan Park	Raj Jain	raj.jain@candu.com
Toronto	Andrew Ali	andrew.ali@amecfw.com
UOIT	Cristina Mazza	905-728-6285 mariachristina.mazza@gmail.com
Western	Jason Donev	403-210-6343 jmdonev@ucalgary.ca

CNS WEB Page - Site internet de la SNC
For information on CNS activities and other links – Pour toutes informations sur les activités de la SNC

http://www.cns-snc.ca

Calendar

2017

May — **CANDU Maintenance and Nuclear Component Conference (CMNCC-2017)**
Toronto, Ontario
cns-snc@on.aibn.com

June 4-7 — **37th CNS Annual Conference & 41st CNS/CNA Student Conference**
Niagara Falls, ON
cns-snc@on.aibn.com

July 31-Aug. 4 — **13th International Topical Meeting on Nuclear Applications of Accelerators (AccAPP17)**
Quebec City, QC
cns-snc@on.aibn.com

Sept. 24-27 — **2nd International Meeting on Fire Safety and Emergency Preparedness for the Nuclear Industry (FSEP 2017)**
Toronto, ON
cns-snc@on.aibn.com

The IAEA is pleased to announce the publication of:

Nuclear Power and Sustainable Development

Transforming the energy system is at the core of the dedicated sustainable development goal on energy within the new United Nations development agenda. This publication explores the possible contribution of nuclear energy to addressing the issues of sustainable development through a large selection of indicators. It reviews the characteristics of nuclear power in comparison with alternative sources of electricity supply, according to economic, social and environmental pillars of sustainability. The findings summarized in this publication will help the reader to consider, or reconsider, the contribution that can be made by the development and operation of nuclear power plants in contributing to more sustainable energy systems.

STI/PUB/1754, 116 pp.; 31 figs.; 2016; ISBN: 978-92-0-107016-6, English, 45.00 Euro

Electronic version can be found:

http://www-pub.iaea.org/books/IAEABooks/11084/Nuclear-Power-and-Sustainable-Development

Energy, Electricity and Nuclear Power Estimates for the Period up to 2050

Reference Data Series No. 1

The 36th edition of the annual Reference Data Series No.1 contains estimates of energy, electricity and nuclear power trends up to the year 2050, using a variety of sources, such as the IAEA's Power Reactor Information System and data prepared by the United Nations.

IAEA-RDS-1/36, 53 pp.; 10 figs.; 2016; ISBN: 978-92-0-106816-3, English, 18.00 Euro

Electronic version can be found:

http://www-pub.iaea.org/books/IAEABooks/11120/Energy-Electricity-and-Nuclear-Power-Estimates-for-the-Period-up-to-2050

Snow Makes the Future Brighter

by JEREMY WHITLOCK

Yip hey, yip ho,
Keep them neutrons a-go,
Keep them rollin' and twistin',
And send that flux high...

Why Nuclear, you seem in good spirits today. Do come in.

I feel good Doc. It's a new day.

A new day! How wonderful. You were a little down in the dumps, the last time we spoke.

Well Doc, here's the thing: when you're in a toilet, you've got two choices right? Go down with the flush, or climb out of there.

Lovely! And here you are.

Yip hey, yip ho,
Out the header below,
Where the Ottawa River flows by.

...and in a singing mood I see. So you don't feel the world is going insane?

Oh it's going insane Doc. But you know – in crazy times, we humans sometimes do our best work. I was born during a huge war right? – a few brilliant lost souls, from all over the world, were thrown together at one of the darkest moments in history, and they came up with me. Me! The worst violence, and the best opportunity – all at the same time.

That's... that's remarkable Nuclear, I hadn't thought of it that way. And so you're okay with losing the NRU?

No that's still deplorable Doc. But is the lid closed on the toilet?

I'm not sure I...

No it's not! And who keeps the lid up?

My wife says I do.

People Doc! People. We have the best folks in the world working in this business, working on the best technology. And we have people out there Doc, in Canada, the ones who paid for this industry – and we're going to get better at communicating to them, and working with them to grow this country. Especially the people who were here before we were.

Ah, now forgive me for saying this Nuclear, but that's something of a tall order, isn't it. How do you –

Here, check this out.

Wait... what just happened? Where are we? It's cold. Where did this snow come from?

It's 80,000 years in the future Doc. We're standing on a two-kilometre-thick glacier where your office used to be.

How did you do that?

Never mind – now do you know what's below us? Two kilometers down there, under crazy pressure, everything that we knew is being mulched up and spread around – all the garbage, the engineered land-fill sites, the double-hulled toxic storage bins, the cars, houses, TVs, washing machines... Centuries of human detritus milled into geological strata for the next civilization to decontaminate when this ice melts.

I thought Global Warming...?

Focus, Doc! And do you know what future civilizations will NOT have to worry about? The one toxic waste product NOT being ground up down there and turned into a drumlin? The nuclear waste. Why? Because we put it below ground in stable rock that resists multiple ice ages, by design – the one byproduct of human progress that we cared enough to do that for. And that's just the stuff we didn't get rid of first in fast reactors. THAT'S what the people need to know Doc. It's not a million years or nuclear waste that we have to worry about – it's tens of millennia and it's washing machines. That's a great story.

Whoa. And now we're back in my office. How...?

I'm going to go away for a while and rest Doc. Remember - talk to the people!

But Nuclear, wait, you haven't said anything about Communications being the least-funded or cared-about part of the industry – how can that be if it's the most important?

Millie Kay, Millie Kay,
Dance for me,
You're hardly worth a dollar,
But I'll give you three.

I see – exit stage left singing bawdy reactor physics ditties. Okay, ta-ta and Merry Christmas! Hey how did this snow get on my floor?

Editor's Note:

This concludes Endpoint by Dr. Jeremy Whitlock. He and his family have left us to take up a post with the International Atomic Energy Agency (IAEA) in Vienna. We at the CNS Bulletin thank him for his years of contributions to the Bulletin.

CANADIAN NUCLEAR LABORATORIES
CANADA'S PREMIER NUCLEAR SCIENCE ORGANIZATION






Canadian Nuclear Laboratories is a leader in nuclear science and technology offering unique capabilities and solutions through its expertise in metallurgy, analytical chemistry, biology, physics, and engineering. CNL provides comprehensive nuclear services and capabilities across the entire nuclear life cycle. Offering industry-driven solutions in Energy, Health, Environment, Safety and Security, we deliver innovative problem solving to keep industry competitive.

Depending on your requirements, we may work with or through trusted nuclear suppliers to deliver the best solution to you. In these cases, we will consult with and advise you on the most appropriate path forward.

For more information, please contact us at ***commercial@cnl.ca*** or visit us at ***cnl.ca/commercial***.

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