CANADIAN NUCLEAR SOCIETY

# Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

DECEMBER 2017 DECEMBRE VOL. 38, NO.4


• Fire Safety and Emergency Preparedness • Meet the new CNS President • History: Archives of D orge C. Laurence

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# Oh Climate Change!

The United Nations Environmental Program has issued a new report that says, not surprisingly, that pledges and commitments made under the Paris Agreement (COP 21) to reduce Green House Gas emissions is way short of what is needed to prevent a 2°C rise in global temperature. The report was released at the COP 23 held in November 2017 in Bonn, Germany. Ironically, Germany has already phased out nuclear energy in favour of coal and it would appear that the United States will follow suit, albeit for much different reasons; in Germany the decision was ideological while in the US the reasons are more practical such as the bankruptcy of Westinghouse. Nevertheless, the US decision to withdraw from the Paris Agreement does not help.

But things are moving differently in Canada.

Canadians by and large are very concerned about the environment and are willing to take action to avert GHG emissions, although many Canadians are misguided as to what actions to take. Clearly a product of "fake news" many Canadians believe wind and solar will solve our energy problems, or they believe that electricity "happens" so it doesn't need to be generated.

Ontario tried the wind and solar experiment and it just doesn't work! And Canadians everywhere are taking notice.

The Ontario government, wisely, decided to phase out coal in favour of clean electricity. Mission accomplished, but it was costly. A far cry from Sir Adam Beck's vision of "Electricity at Cost", the provincial Liberals bungled the mission. Ontario consumers pay much more than they would be paying for electricity had the Liberals chosen to seek (and take) expert advice from professional engineers who plan our electricity system, the way the electricity system had been expertly planned prior to the political interference of breaking up the former Ontario Hydro.

Well that's water over the dam. And for sure it was not all for naught. Private investment from Bruce Power to bring idled nuclear units back to service was the very reason the government met its goal of a coal phase-out, while keeping our lights on!

As for wind and solar? It's just a costly nuisance for consumers AND managing the power grid. An overcapacity of gas plants have to run idle in readiness to manage the variability of intermittent wind and solar. Also, at times of surplus generation (windy sunny days) nuclear and hydro generators (which have the lowest cost) curtail production to accommodate costly wind and solar.

Perhaps it's the shock of skyrocketing electricity rates, or learning from a failed experiment, Ontario is now on track again to be a world leader in clean electricity generation through its commitment to refurbish the Bruce and Darlington reactors and OPG's study aimed at extending the life of the Pickering reactors. And Bruce Power will complete its Major Component Replacement project using, not tax-payer money, but private capital, and will provide reliable electricity at half the cost of wind, and less than one-seventh the cost of solar!

Despite the failure of the Paris Agreement, and despite the influence of "fake news", Ontario will lead the world in producing GHG-free electricity! Let's hope other jurisdictions take note and do the sensible thing, to "Live Better Electrically" using atoms, not misguided dreams.

# In This Issue

The 11th International Conference on CANDU Maintenance and Nuclear Components Conference (held October 1-4, 2017) has become one of the best attended events sponsored by the CNS because its focus is on the operating nuclear power plants, Ontario's major source of reliable, economic GHG-free electricity, and because of the major refurbishment projects underway to ensure the long-term supply of clean electricity. The high quality of discussions and presentations attracted many industry organizations. The technical papers were exceptional and space prevents any more than a few selections for the Bulletin.

Thanks to Mike Welland and his colleagues for providing a summary of the 2017 Materials Modelling and Simulation for Nuclear Fuels [MMSNF] workshop in Gatineau, Quebec. Although not sponsored by the CNS it has world recognition as a prestigious technical workshop on nuclear fuel.

For the first time the CNS sponsored a student job fair and more than 600 students attended. It is encouraging to see such a large turnout and shows a renewed interest among students aspiring to a career in the nuclear industry.

We received a very interesting and informed letter regarding Scott Luft's article on the "real" cost of electricity. The letter, and Scott Luft's response are published in this edition.

And last but not least Dr. Neil Alexander ponders "loneliness" in a world tilted against nuclear.

2017 has been a good year for the CNS and the nuclear industry, and it is appropriate during the holiday season to reflect on our accomplishments, and focus on having a safe and festive time as 2017 comes to a close. Happy New Year!

This December issue of the Bulletin marks the end of what has been an outstanding year for Canada's nuclear industry and for the Canadian Nuclear Society. From the large to the small, the year has been marked by a number of strong developments by both organizations.

Starting with the large, Ontario Power Generation's project to refurbish its Darlington nuclear power station is now just over one year into the project. At the time of writing, the project is 40 per cent complete and remains on time and on budget. As OPG President Jeffrey Lyash remarked earlier this year, "Project that end well tend to start well."

It's too soon to predict a successful outcome, but what can be stated is that with the project closing in on its half-way mark, the omens look good. And the Ontario Provincial government agrees with this. Nuclear power took a prominent role in the province's Long Term Energy Plan released this year. According to the government, nuclear power will remain the dominant source of electricity in Ontario past 2050, thanks to the refurbishment and continued operation of the Bruce and Darlington nuclear stations.

Even further, the province has expressed strong support for operation of the Pickering nuclear station to 2024. Operating Pickering beyond its scheduled closure date of 2018 will mean stability and lower cost for all Ontario electricity consumers. What is equally noteworthy is that some within OPG are starting to look at the technical feasibility of Pickering beyond 2024. The CNS commends highly such examination, as continued long term operation of Pickering would mean continued reliable and economic electricity supply for Canada's industrial and economic heartland.

Beyond Darlington, Bruce Power has also begun preparation for its reactor refurbishment in 2020 with its program for major component replacement. Already in anticipation of its Unit 3 outage in 2020, Bruce Power has committed hundreds of millions of dollars in preparatory work and contract commitments. As envisioned right now, the Bruce Power program will prolong the useful life of the station to 2064.

What is notable about this is that Bruce Power is funding all of its refurbishment projects out of the company's own resources. Bruce Power is not dependent upon government funding or grants but is doing it all as a private company out of its own financial strength and resources. And it's doing it based on a future electricity price locked at 6.7 cents/kWh.

So yes, private capital can undertake large multi-billion dollar nuclear projects with effective planning and preparation.

But there's also a new future which has emerged for nuclear power during 2017, and it's called the Small Modular Reactor (SMR). All of these represent new nuclear reactor technology, ranging in size from 5 MW to 200 MW. They envision a range of new methods of reactor systems such as molten salt or superheated water reactors. No less than seven applications have been made before the Canadian Nuclear Safety Commission (CNSC) this year for preliminary examination of these designs for their compatibility with CNSC safety performance requirements. One of these designs has received preliminary approval during November. It should be noted that some of these seven applications have come from outside Canada, demonstrating that Canada has a reputation for nuclear research development, and the industrial infrastructure to support nuclear development around the world.

Canadian Nuclear Laboratories (CNL) is already very active in the field of SMRs. Early this past summer it issued a request for expressions of interest. Before the end of fall, CNL reported that it had received over 80 responses from a variety of companies and institutions, some of which have indicated clear interest in working with CNL and possibly siting prototypes for new designs at Chalk River.

It's a remarkable contrast between Canada and most of the rest of the OECD nations. Much of the new reactor construction in the United States has for the time being floundered with the bankruptcy of Westinghouse. Germany has closed half of what was once one of the world's most successful nuclear fleets for rather turgid and shortsighted political motives. In France, its new government appears completely lost in its nuclear policy with its energy minister talking about shutdown for the sake of shutdown, with no rational economic reason that anyone can discern. All this is occurring in a nation which, more than any other, built a successful nuclear fleet to meet at least 80 per cent of the country's entire electricity demand. Meanwhile, Japan remains mired in post-Fukushima difficulties, though it has managed to restart a number of reactors this year.

The only bright lights in Europe would seem to be Britain and Sweden. The United Kingdom is continuing forward with its three new nuclear projects at Hinkley Point C, Moorside and Wylfa. The Swedish government announced this year that it sees no alternative to a strong continued presence of nuclear power in its energy mix.

For all practical purposes, the 1980 phaseout policy

*continued on page 46*

## Contents



~ Cover Photos ~

Cobalt-60, used for cancer treatment, sterilization of medical equipment, food safety and numerous industrial processes, has been produced at Chalk River for decades. With the planned permanent closure of the NRU, a new agreement with Nordion, Cameco and Bruce Power will ensure a continued, reliable supply of this important radioisotope. The cover photo shows the "harvesting" of cobalt-60 at Bruce Power. (See news item in this issue.)

*Photo courtesy of Bruce Power.*


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# bulletin

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

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# CMNCC Shows the Strength and Endurance of Canada's Nuclear Industry

by COLIN HUNT

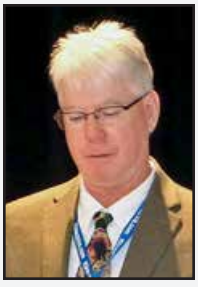
*Shane Ryder, Conference Honorary Chair*

The 11th International Conference on CANDU Maintenance and Nuclear Components Conference on October 1-4, 2017, is one of the premier technical conferences held by the Canadian Nuclear Society (CNS). This year's conference was hosted and chaired by Shane Ryder, Vice President, Fleet Operations and Maintenance, Ontario Power Generation (OPG). More than 270 industry professionals and students attended the four-day event in Toronto.

*Ramzi Jamal, CNSC*

The conference commenced with two strong panel sessions on Monday, October 2 devoted to long term asset management. In his opening remarks, the first session chair Ramzi Jamal, Executive Vice President, Canadian Nuclear Safety Commission (CNSC) noted the vital importance of maintenance to the successful operation of nuclear facilities. He commented on the strong improvement of maintenance practices and resulting improved safety performance of Canada's reactors. He urged the leaders of Canada's nuclear suppliers to become involved in CNSC licencing processes.

"Canada's nuclear industry represents the science and expertise and experience of the nation's nuclear power program," Mr. Jamal said.



*Kevin Pushee, INPO*

His opening remarks were followed by Kevin Pushee, Team Leader of the Institute of Nuclear Power Operations (INPO). He described the current situation in the United States as one of rising operating costs and declining electricity revenues. He observed that four or five nuclear power reactors principally in the north-east as being in danger of premature closure because of these developments, adding that INPO is working to counter that trend.

Mr. Pushee said that INPO has developed 12 industry teams specifically tasked with working to improve plant operational and maintenance efficiency. Over the past year, these teams have issued a large number of documents affecting all areas of plant maintenance and operations. They are published as efficiency bulletins about every 10 months. He indicated that it's expected that when implemented these bulletins will translate into real cost savings for the US nuclear fleet.

*Gary Newman, Bruce Power*

Mr. Pushee was followed by Gary Newman, Chief Engineer and Senior Vice President of Engineering, Bruce Power. Mr. Newman's remarks were directed to plant maintenance practices in preparation for Bruce Power's major component replacement program scheduled to start in 2020. As a result of this, Mr. Newman noted that Bruce Power is now taking longer planned outages on its units prior to 2020. These longer outages allow for the preparatory work to be done for the 2020 program commencement.

Mr. Newman noted that the component replacement program will commence with Unit 3, and that the cost estimates for the unit have now been finalized.

However, maintenance operations have continued to strengthen throughout the past several years. Mr. Newman stated that the forced loss rate of Bruce Power is now down to 1.2%, which is a remarkable achievement for the world's largest operating facility.

Jason Wright, Director of Engineering, Pickering NGS, OPG, followed Mr. Newman with an overview of Canada's oldest operating nuclear power station. From an operations and maintenance perspective, Mr. Wright noted that Pickering has had some of its best performance ever in the past year with a forced loss rate of just 3.5%. He said that the goal of plant staff is to reduce the forced loss rate further to 2.5% by the end of 2019.

The maintenance focus of Pickering now, according to Mr. Wright, is on new processes, plant culture and leadership. He illustrated some of the new technology introduced that is making maintenance more effective on the plant floor.

The turnaround of the performance of the six Pickering units has been remarkable. Mr. Wright stated that, a decade ago, the forced loss rate of Pickering NGS was 25%.

This improvement in performance and maintenance is of very real, immediate consequence. At this time, OPG expects to operate Pickering to 2024. It has applied for renewal of its operating licence for continued operation with the CNSC, and the application will be reviewed by the CNSC in 2018.

One of the strong highlights of the conference was the Utility Engagement Panel on Maintenance on Monday evening. This event, the first of its kind, was an open panel with John Slade, Chief Engineer, CNL, Ken Hamilton, Manager Plant Maintenance, OPG, Pierre Michaud, Manager Programs Engineering NB Power, and Jason Lehtovaara, Team Lead, Bruce Power. More than 200 filled the room for an open discussion on the current challenges and opportunities for Canadian nuclear companies and suppliers to assist utilities with improving maintenance performance at the nuclear stations in Canada. Edwin Chen, Amec Foster Wheeler, and Don Wilson, CANDU Owners Group (COG), did a very efficient job at moderating what was in effect one of the industry's largest workshops ever held on maintenance practices and technology.

*Glenn Thibeault, Ontario Minister of Energy*

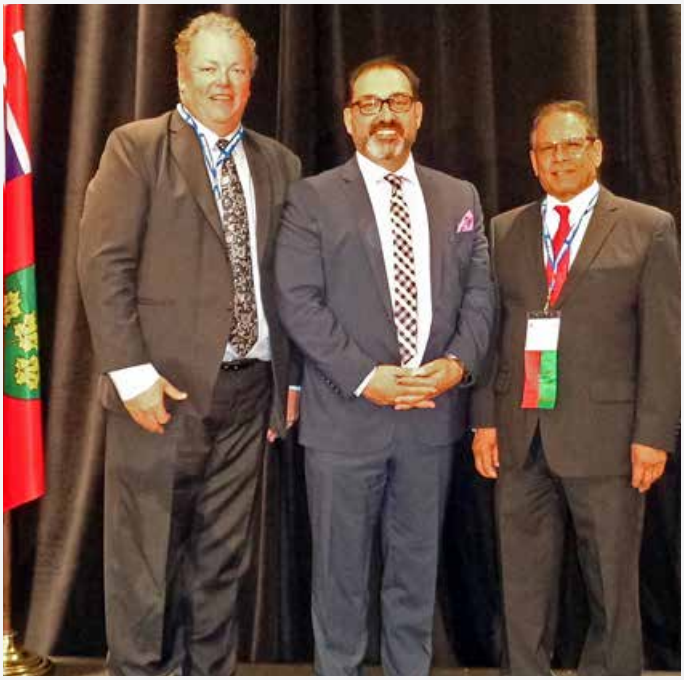
The principal highlight on Tuesday was the appearance of Ontario Energy Minister Glenn Thibeault. In his remarks, Mr. Thibeault noted the vital importance of nuclear power as the mainstay of Ontario's electricity supply and its essential contributions to the province's industrial infrastructure. Mr. Thibeault said that nuclear science and technology had been pioneered in Canada and that it remained a global leader. On current matters, Mr. Thibeault stressed the importance of nuclear power to the government's new Long Term Energy Plan and the need for continued operation of Pickering NGS. Mr. Thibeault made a point afterward of visiting and talking to all of the nuclear suppliers attending the conference.

One of the most interesting technical panels was on Wednesday, the closing day of the conference. The panel, consisting of Steve Ostrowski, Bruce Power, Andrew Allport, NB Power, and Peter McLean, Kinectrics, discussed the issue of equipment obsolescence. Given the years when they were built, Canada's nuclear plants now contain equipment for which the original manufacturer no longer exists. As Mr. Ostrowski pointed out, there are not approximately 430,000 obsolete components installed in the various stations. A group has been formed, the Nuclear Utility Obsolescence Group, to inventory all of these components and where replacements can be found. Peter McLean noted the various steps that can be taken if replacements are not available such as reverse engineering.

This conference was strongly supported by the industry this year. The Host Sponsor was Ontario Power Generation (OPG). Additional sponsors included Amec Foster Wheeler, Bruce Power, BWXT, Canadian Nuclear Laboratories (CNL), the Canadian Nuclear Safety Commission (CNSC), ES Fox, Kinectrics-Candesco, North American Young Generation in Nuclear, NB Power, PWC, SNC-Lavalin, Westinghouse Electric Canada, Women in Nuclear Canada.

The exhibitors included Amag, Areva, ASI Group, Black & McDonald, BWXT, Canadian Nuclear Laboratories (CNL), Canadian Nuclear Partners, Farris, Kinectrics-Candesco, Lakeside, Laveer Engineering, Liburdi, Lisega, McMaster University, Organization of Canadian Nuclear Industries (OCNI), Pall Corporation, PermaFix Canada, Promation Nuclear, Rolls-Royce, SWI, Tyne Engineering, Unified Engineering, Unitech Services Group, and Westinghouse Electric Canada.

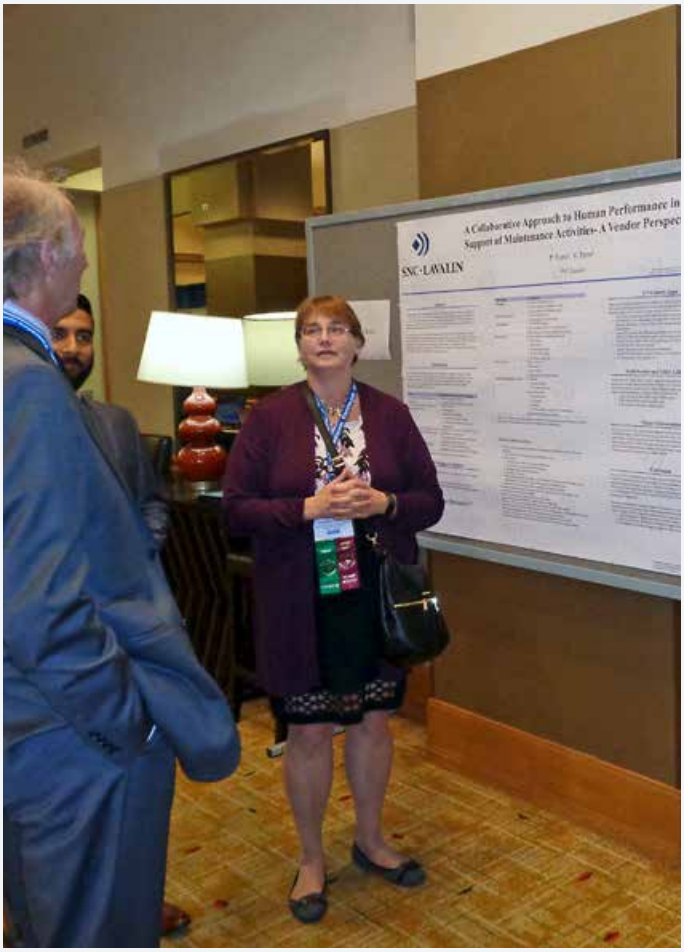
## Meeting the Minister

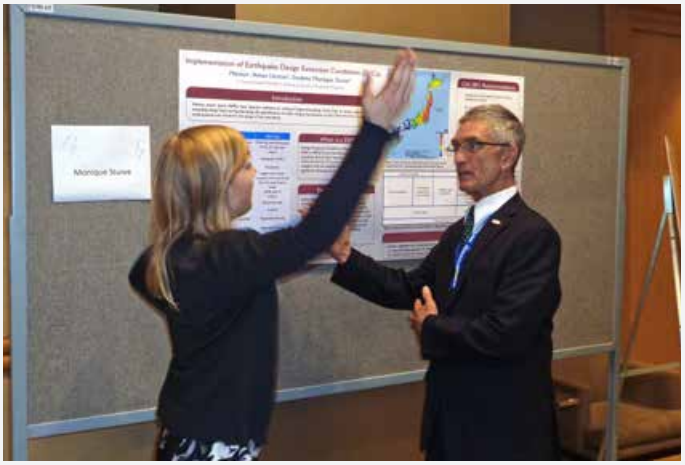



*Shane Ryder, Glen Thibeault, Aman Usmani*


*Aman Usmani, Conference General Chair*

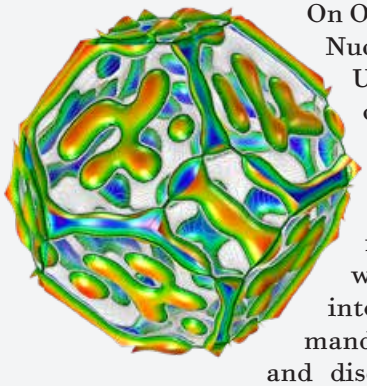
## Student Poster Competition



# Canada Hosts the 2017 Materials Modelling and Simulation for Nuclear Fuels Workshop

by MIKE WELLAND, ANDREW PRUDIL, and MARKUS PIRO



On October 3rd and 4th, Canadian Nuclear Laboratories and the University of Ontario Institute of Technology hosted the 2017 Materials Modelling and Simulation for Nuclear Fuels [MMSNF] workshop in Gatineau, Quebec. The workshop is a prestigious international meeting with the mandate to stimulate research and discussions on modelling and simulation of nuclear fuels, and to facilitate the development of improved fuels, and the evaluation of fuel performance codes.

Since 2003, the workshop has been held annually rotating between countries in Europe, Asia, and the USA. This was the first time this international workshop has been held in Canada and had a total of 65 participants from Canada, France, USA, England, Korea, Japan, Russia, Sweden, and Switzerland. Canadian government, industrial, and academic institutions also participated with representatives from the Canadian Nuclear Safety Commission, Canadian Nuclear Laboratories, the National Research Council of Canada, and TRIUMF as well as several Canadian universities.

The single track was divided into sessions of 1 hour and 20 minutes devoted to a particular topic. Each session had three 20 minute presentations with all questions being held until the final 20 minute discussion period. The three presenters were then asked back to the front of the room to engage in a panel discussion, using the questions to catalyse the conversation. This resulted in a high degree of exchange between presenters and the audience where differing approaches could be presented and discussed frankly. Conversations often continued in smaller groups during the ensuing breaks.

The oral track was complimented by a poster session coinciding with a sponsored wine and cheese reception. Participants were able to take their drink and food and visit posters to engage in focussed discussion on the material. There was also a student poster competition which was judged by the workshop session chairs who selected three winners: Jacob Siemons, Amani Cheniour, and Eric Tenuta.

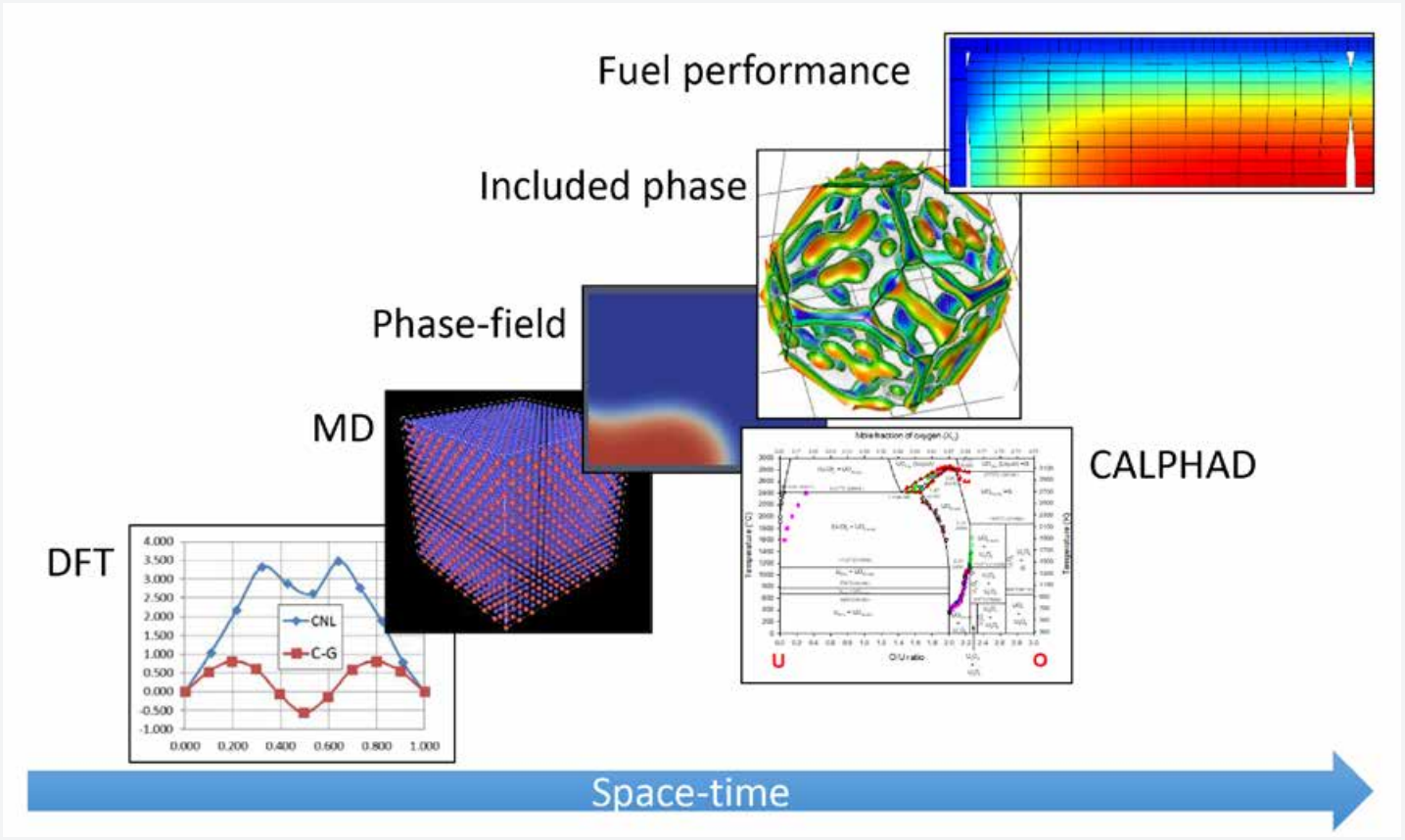
The topics of the sessions followed a multiscale paradigm with a progression of space and time scales. Discussion began at the scale of electronic structure with techniques such as density function theory for small systems of atoms and their electron clouds. This progressed to, and often informs the atomic scale where molecular dynamics considers larger groups of atoms and can capture kinetic and thermodynamic properties. Increasing in the number of atoms, classical thermodynamics and the CALPHAD (Computer Coupling of Phase Diagrams and Thermochemistry) approach incorporates thermodynamic information such as phase and reaction equilibria. This information can be integrated into mesoscale simulations where interfacial phenomena are captured within such

*Group photo of the participants of the 2017 Materials Modelling and Simulation for Nuclear Fuels workshop*

*Workshop organisers along with student poster competition winners. Left to right: Mike Welland, Mike Tonks (accepting on behalf of his student Amani Cheniour), Jacob Siemons, Eric Tenuta, Andrew Prudil, Markus Piro.*

techniques as phase-field, and the included phase model. Finally, all these components factor into fuel performance codes which integrate lower length-scale studies into a mechanistically informed multi-physics model which can predict the behaviour of current and advanced nuclear fuel designs.

The success of this event was enabled by the workshop participants, and our sponsors: Canadian Nuclear Laboratories, the University of Ontario Institute of Technology, and Ontario Power Generation. Next year's MMSNF will be incorporated into the 2018 NuMat (Nuclear Materials) conference in Seattle, Washington.




*Schematic of the multiscale modelling approach showing the progression of spatiotemporal phenomena and some applicable models.*

# CNS Job Fair Draws Hundreds of Students

by COLIN HUNT
NAZEE KHERADMANDSHAD, Photographer

More than 600 students registered to attend the first ever Canadian Nuclear Society (CNS) Student Job Fair, Saturday October 21 at the campus of UOIT/ Durham College in Oshawa. The students came out on a Saturday to meet with nearly 50 Ontario companies and institutions to learn about career opportunities in the Canadian nuclear industry.

Not limited to the immediate region, students came to the Job Fair from colleges across Ontario from as far away as London. The day-long event occupied the main gymnasium at the campus, and it was filled with booths from most of Ontario's principal nuclear institutions. More than 70 members from the nuclear industry were on hand to discuss specific career opportunities with the students. The Job Fair included a number of break-out sessions for seminars on various nuclear topics during the day.

The Job Fair was more than an opportunity to meet prospective employers. Ian Martin Ltd., UOIT and Durham College also provided career counselling.

The CNS provided a free lunch for students attending the conference. But so large was the discussions at the booths that the lunch room was thinly attended for most of the day.

The day-long event was organized by former CNS President Jacques Plourde and supported by 24 volunteers from local branches of the CNS. The principal organizations arranging the event were the CNS, the University of Ontario Institute of Technology (UOIT), Durham College, and the Organization of Canadian Nuclear Industries (OCNI).

The main sponsors of the event were Bruce Power, Ontario Power Generation (OPG), Promation Nuclear, ANRIC, and Canadian Nuclear Laboratories (CNL).

The break-out session seminars were held by the CNS, North American Young Generation, Women in Nuclear, OPG and CNL.

*Jacques Plourde (right) principal organizer.*

*Marina Oeyangen, OCNI.*


*A rare quiet moment at the OPG booth.*


*Setting up.*


*Action at the CNS Booth.*

*Early morning registration.*

*Career Counselling.*


*Student registration.*

# Scenes from the Floor



## To: Scott Luft
## From: John Riley
## Subject: Article in CNS September 2017 Bulletin

I read your article entitled "Real Costs of Electricity in Ontario" and the included data with considerable interest. This sort of information should be summarized and distributed to the general public, in a way in which they can understand it. Including it only in the CNA Bulletin is interesting, but preaching to the converted.

Using the data contained in your article and data from the IESO, for the year 2015, I derived capacity factors and production costs shown for Nuclear, Gas/Oil, hydroelectric, wind and solar power generation. My detailed calculations are attached in case these are of interest.

### Capacity Factors

In the process of trying to derive capacity factors for the various types of generation using the TWh power generation numbers for 2015 from the table in your article and installed capacity data from the IESO quarterly reports for 2015, I produced Table A below. With the possible exception of nuclear, the results are hard to believe. The only reasons that I can think of for the numbers is that the production figures for wind and solar have been inflated, perhaps at the expense of hydroelectric or gas. Do you have any suggestions as to how I can obtain backup for the wind and solar numbers?

My methodology was to: a) Sum Installed **Generation Capacity (Grid-Connected)** and **Contracted embedded Generation Capacity** data for each quarter and multiply the result by the hours for quarter; b) Sum the quarter results to give the maximum available for the year 2015; c) Take the TWh output for 2015 from the table in your article; d) Divide the c) result by the b) result and multiply by 100 to get a capacity factor percentage.

### Production Costs

All the data that I used was obtained from the tables in your article. The results are shown in Table B. It will be noted that the cost of wind power production is more than twice that of nuclear and more than seven times that of solar. However, these costs do not take into account expensive gas turbine idling when the wind doesn't blow or the sun doesn't shine and hydroelectric water spillage when the wind blows or the sun does shine.

**TABLE A**

| | A | B | | |
|---|---|---|---|---|
| **Generating Facility Type** | **Sum of installed Capacity X hours for each Quarter divided by 106 to get maximum available TWh** | **Production in TWh from Table in Article** | **Column B X 100 divided by Column A to get Capacity Factor (%)** | **Comments** |
| Nuclear | 113.69 | 92.3 | 81 | Believable, but nothing to boast about. |
| Gas/Oil | 88.59 | 15.5 | 17.5 | Very low, but if true, perhaps a lot of idling waiting for the wind to stop blowing or the sun to stop shining. |
| Hydroelectric | 76.33 | 37.20 | 49 | Very low, but if true, perhaps a lot of water spilling waiting for the wind to stop blowing or the sun to stop shining. |

**TABLE A**

| | A | B | | |
|---|---|---|---|---|
| **Generating Facility Type** | **Sum of installed Capacity X hours for each Quarter divided by 106 to get maximum available TWh** | **Production in TWh from Table in Article** | **Column B X 100 divided by Column A to get Capacity Factor (%)** | **Comments** |
| Wind | 28.20 | 10.2 | 36 | Unbelievably high. Is the production figure inflated? |
| Solar | 4.76 | 3.0 | 20 | May be feasible, but very likely high. Is the production figure inflated? |

**TABLE B**

| Generation Facility Type | Installed Capacity MW | Cost of Production in $Million from Table in the Article | Production in TWh from Table in Article | Cost of Production in $Million vs Power Production | Comments |
|---|---|---|---|---|---|
| Nuclear | 12978 | 5864 | 92.3 | 63.53 | |
| Hydroelectric | 8701 | 2159 | 37.2 | 58.04 | |
| Gas/Oil | 10151 | 2183 | 15.5 | 140.84 | More than twice Nuclear |
| Wind | 3392 | 1346 | 10.2 | 131.96 | |
| Solar | 2076 | 1386 | 3.0 | 462.00 | More than seven times nuclear |

## To: John Riley
## From: Scott Luft

Your letter brings up some important points regarding capacity factors and, subsequently, the credibility of the data. This response will address 2015 specifically, while noting comments can be applicable to other years.

There are some surprises in annual capacity factors by generation type. You write you can only think of errors in "production figures", but I'll show the errors are more likely in the denominators (reported capacity).

The 2015 capacity figure is, as you state, "Believable, but nothing to boast about." The figure is more believable knowing there were 2 vacuum building outages in 2015: Bruce B in the spring and Darlington in the Fall. Less impactful, the Independent Electricity System Operator (IESO) reported 897 gigawatt-hours (GWh) of "nuclear reductions" due to Surplus Baseload Generation (SBG).

SBG is the reason the capacity factor of hydro-electric generation may surprise on the downside. Ontario Power Generation (OPG) reported they, "lost 3.2 TWh of hydroelectric generation due to SBG conditions." Accounting for this foregone supply the capacity factor is 4.2% higher than your calculations and I don't perceive a 52% capacity factor as unusual for Ontario hdyro-electric generation.

Analysis of wind's capacity factor can be impacted by confusing reporting on capacity. The figures in the quarterly "Ontario Energy Report" are, I've realized in replying to you, lower than the figures in the quarterly "Progress Report on Contracted Electricity Supply." As far as I know both are produced by the IESO so I can't account for the variation. The IESO does now share an Active Generation Contract List, and analysis of that site level data shows the "Progress Report on Contracted Electricity Supply" report is

much more accurate. By 2015 3,483 megawatts (MW) of contracted supply from wind had entered commercial operation, and by the end of the year the number had climbed to 4,259 MW. The average was 3,788 MW, which given generation of 10.2 TWh means the capacity factor 30.7%. Although some may think that high for wind, it no longer is. The IESO reported 733.5 GWh of wind "dispatched down" in 2015: accounting for that the capacity factor rises towards 33%.

People are often surprised by the capacity factor of Ontario solar too, but I think this is due to misunderstanding what capacity is contracted/reported. The figures for the two quarterly reports noted above differ, and the analysis is complicated by microFIT contracts omitted from either set of reporting. Accounting for that the capacity factor is a still higher than most would anticipate 18.9%. I suspect his is due primarily to not understanding the contract allows for an overbuild of solar panels behind a connection point – meaning a 10 MW contract would have an ability to deliver 10 MW onto the grid (AC), but is likely to have 11.5 MW of solar panels (DC) behind the connection point. While not every site is overbuilt, the largest sites (Samsung's Grand Renewable and Kingston) have 40% overbuilds. If the average overbuild is 15% the 18.9% capacity factor of solar sites indicates a 16% capacity factor of solar panels.

To summarize, I agree with your methodology, but would discourage the use of the Ontario Energy Report for capacity information, and I'd emphasize curtailment and solar overbuilds are both factors that need to be considered in order to see trends over time and comparisons between systems.

## POWER GENERATION COST CALCULATIONS FOR ONTARIO IN 2015

**Notes:**

1. The information in the tables was obtained by a Canadian Nuclear Society author from Ihe IESO (Independent Electricity System Operator) through a freedom of information request. The (IESO) is a statutory corporation responsible for operating the electricity market and directing the operation of the bulk electrical system in the province of Ontario.
2. In the table: Cpty MW is the installed MW capacity of the generation source; Cst is the cost for the year 2015 shown in millions of dollars. It presumably includes the capitalized cost for the year plus operating and maintenance costs for the year; Prd is the generation output for the year 2015 in TWh; Cst vs Prd is the cost in millions of dollars per TWh of generation for the year 2015.
3. It will noticed that most favourable ratios of cost to production by some margin, are hydroelectric followed by nuclear. The wind cost to production ratio is more than twice that of nuclear and solar is more than seven times that of nuclear. However, this understates the differences due to expensive gas turbine idling when the wind doesn't blow or the sun doesn't shine and hydroelectric water spillage when the wind blows or the sun shines.

**Data for the year 2015**

| Generation Source | Cpty MW | Cst | Prd | Cst vs Prd | % cost |
|---|---|---|---|---|---|
| Nuclear | 12978 | 5864 | 92.3 | 63.53 | 45.97 |
| Hydroelectric | 8701 | 2159 | 37.2 | 58.04 | 16.93 |
| Gas/Oil | 10151 | 2183 | 15.5 | 140.84 | 17.11 |
| Wind | 3392 | 1346 | 10.2 | 131.96 | 10.55 |
| Solar | 2076 | 1386 | 3.0 | 462.00 | 10.87 |
| Bioenergy | | 194 | 0.6 | 323.33 | 1.52 |
| Coal | | 0.1 | | | |
| Other | | 60 | 1.4 | 42.86 | .47 |
| Imports | | 169 | 5.8 | 29.14 | 1.32 |
| Exports (Revenue) | | -606 | -23.0 | 26.35 | -4.75 |
| | | 12755. | 143.0 | | 100.00 |

## CAPACITY FACTOR CALCUATIONS FOR ONTARIO IN 2015

**Notes:**

1. "Installed MW Capacity" data is from IESO Quarterly reports for 2015.
2. "TWh from Table" data is for 2015 in the TWh table in the article entitled "Real Costs of Electricity in Ontario" in the CNA Bulletin for September 2017

| **Wind 2015** | **Q1** | **Q2** | **Q3** | **Q4** | **Totals** |
|---|---|---|---|---|---|
| Installed MW Capacity (Grid-Connected) (A) | 2925 | 3209 | 3234 | 3504 | |
| Installed MW Capacity (Contracted) (B) | 425 | 425 | 484 | 488 | |
| Installed MW Capacity Total A+B (C) | 3350 | 3634 | 3718 | 3992 | |
| Quarter hours (D) | 2160 | 2184 | 2208 | 2208 | |
| Maximum production TWh CXD/1,000,000 (E) | 6.32 | 7.01 | 7.14 | 7.74 | 28.20 |
| TWh for 2015 from Table (F) | | | | | 10.20 |
| Capacity factor % (FX 100)/E | | | | | **36.17** |

| **Solar 2015** | **Q1** | **Q2** | **Q3** | **Q4** | **Totals** |
|---|---|---|---|---|---|
| Installed MW Capacity (Grid-Connected) (A) | 40 | 140 | 140 | 240 | |
| Installed MW Capacity (Contracted) (B) | 1634 | 1684 | 1766 | 1836 | |
| Installed MW Capacity Total A+B (C) | 1674 | 1824 | 1906 | 2076 | |
| Quarter hours (D) | 2160 | 2184 | 2208 | 2208 | |
| Maximum production TWh CXD/1,000,000 (E) | 3.616 | 3.058 | 3.091 | 5.299 | 15.064 |
| TWh for 2015 from Table (F) | | | | | 3.00 |
| Capacity factor % (FX 100)/E | | | | | **19.92** |

| **Hydroelectric 2015** | **Q1** | **Q2** | **Q3** | **Q4** | **Totals** |
|---|---|---|---|---|---|
| Installed MW Capacity (Grid-Connected) (A) | 8462 | 8462 | 8462 | 8432 | |
| Installed MW Capacity (Contracted) (B) | 248 | 253 | 264 | 269 | |
| Installed MW Capacity Total A+B (C) | 8710 | 8715 | 8726 | 8701 | |
| Quarter hours (D) | 2160 | 2184 | 2208 | 2208 | |
| Maximum production TWh CXD/1,000,000 (E) | 18.81 | 19.03 | 19.27 | 19.21 | 76.326 |
| TWh for 2015 from Table (F) | | | | | 37.20 |
| Capacity factor % (FX 100)/E | | | | | **48.74** |

| **Gas 2015** | **Q1** | **Q2** | **Q3** | **Q4** | **Totals** |
|---|---|---|---|---|---|
| Installed MW Capacity (Grid-Connected) (A) | 9920 | 9920 | 9934 | 9942 | |
| Installed MW Capacity (Contracted) (B) | 108 | 208 | 209 | 209 | |
| Installed MW Capacity Total A+B (C) | 10028 | 10128 | 10143 | 10151 | |
| Quarter hours (D) | 2160 | 2184 | 2208 | 2208 | |
| Maximum production TWh CXD/1,000,000 (E) | 21.66 | 22.12 | 22.40 | 22.41 | 88.59 |
| TWh for 2015 from Table (F) | | | | | 15.50 |
| Capacity factor % (FX 100)/E | | | | | **17.50** |

| **Nuclear 2015** | **Q1** | **Q2** | **Q3** | **Q4** | **Totals** |
|---|---|---|---|---|---|
| Installed MW Capacity (Grid-Connected) (A) | 12978 | 12978 | 12978 | 12978 | |
| Installed MW Capacity (Contracted) (B) | 0 | 0 | 0 | 0 | |
| Installed MW Capacity Total A+B (C) | 12978 | 12978 | 12978 | 12978 | |
| Quarter hours (D) | 2160 | 2184 | 2208 | 2208 | |
| Maximum production TWh CXD/1,000,000 (E) | 28.03 | 28.34 | 28.66 | 28.66 | 113.69 |
| TWh for 2015 from Table (F) | | | | | 92.3 |
| Capacity factor % (FX 100)/E | | | | | **81.19** |

# Maintenance Optimization – Predictive vs. Preventive Maintenance

by Holger Damies[1], Thomas Seitz[1], André Zander[1], Dr. Gerit Gloth[1], Peter Brückner[1]

*[Ed. Note: The following paper was presented at the 11th International Conference on CANDU® Maintenance and Nuclear Components, October 1-4, 2017, Toronto, Ontario, Canada]*

## Abstract

The Long Term Operation Policy for nuclear plants poses new technical challenges on the power industry, since the plants need to be operated reliably for 50 and more years. It is therefore necessary to deal with the degradation behavior of equipment and its predictability in order to reduce maintenance costs and ensure high safety and high availability at the same time.

For this reason an effective maintenance strategy needs to be applied for the surveillance of possible aging effects and preventive measures need to be implemented to ensure the necessary technical basis for maintaining safety margins throughout the plant. Beside overall plant safety there is a special focus on reliable component operation what increases the demand for predictive maintenance solutions based on continuous surveillance and efficient monitoring.

## 1. Plant Life-Cycle Management Approach

AREVA has developed methodologies and solutions to manage the life cycle of plant components and to optimize maintenance and inspection programs always under the aspect of high plant safety, availability, reliability and maintenance costs while meeting strategic objectives (see Figure 1).

In case of passive mechanical components the maintenance and surveillance programs shall be based on a reliable condition based degradation assessment. The concept is based on a condition based degradation assessment methodology by applying dedicated corrosion and degradation codes in combination with inspection feedback trending.

Maintenance needs for active components (like valves, pumps, etc.) can be assessed based on industry experience regarding symptoms and root causes of system malfunctions. The active components concepts and solutions provide the technological basis for predictive/prognostics capabilities by Figure 1. Maintenance Concept providing a range of reliability performance indicators for basis for predictive/prognostic capabilities by providing a range of reliability performance indicators for key power plant components.

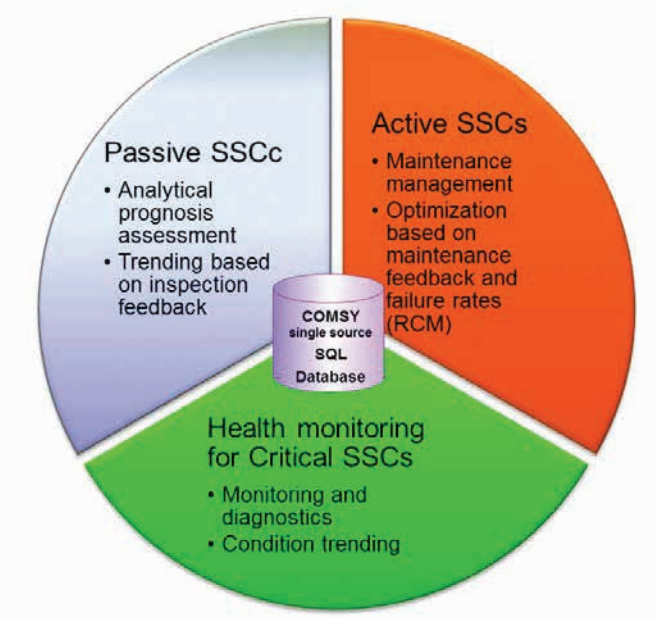



**Figure 1.** Maintenance Concept

The concept for key components, due to safety or availability requirements is based on application of monitoring and diagnosis solutions like AREVA's MonISAvER (Monitoring Solutions for Improvements in Safety, Availability, Economics and Reliability) product family.

## 2. Predictive Maintenance

The objective of maintenance activities is to keep the intended system or component functionalities and properties and prevent loss of performance or even breakdown.

To avoid an unpredicted breakdown of equipment, preventive maintenance programs were established in the past as time-based maintenance. By having reference average values or expected life statistics of similar items it is possible to set intervals (e.g. fixed time periods or operation cycles) for overhaul or repair of a component before breakdown.

This strategy makes no use of the wearing capacity, but uses historic experience from manufacturers,

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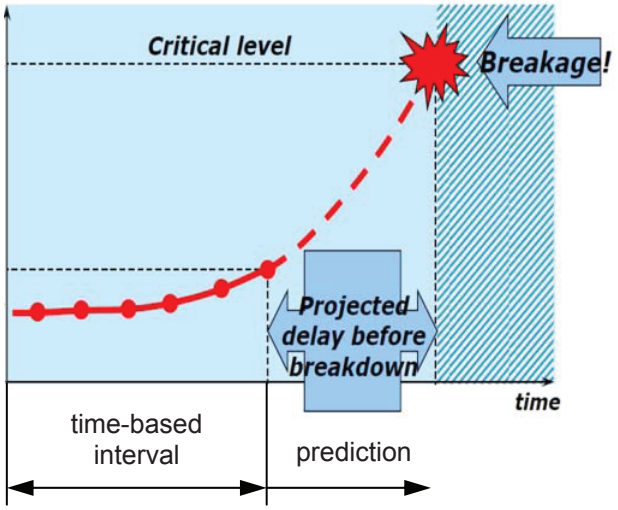



**Figure 2**. Maintenance time before breakdown

operators and service providers, requirements and recommendations instead. It avoids costs for unpredicted repair and usually minimizes loss of production or even the risk of a nuclear incident through a high ability of planning the maintenance event.

However as it is not considering actual condition, in some cases the wearing capacity is used up before the scheduled overhaul or repair takes place. These cases lead to component breakdown or loss of performance what requires immediate trouble shooting.

On the other hand there are maintenance activities done according fixed schedule even if it would not be required by present component condition (e.g. low wear linked to degradation and aging effects). So maintenance is done "if needed or not".

Therefore optimized maintenance programs are focused on executing maintenance tasks at the right time before breakdown. This strategy is based on actual status determination by periodic or continuous condition monitoring to predict future trend of equipment's condition.

The main objective of predictive maintenance is to execute the activities at most cost-effective point in time before equipment loses performance (Figure 2).

Therefore dedicated nondestructive condition monitoring solutions are required related to equipment specific degradation mechanisms.

Combining predictive maintenance with traditional preventive measures Reliability Centered Maintenance (RCM) is the approach to achieve lowest asset Net Present Costs (NPC) for a given level of performance and risk.

Predictive or condition-based maintenance is linked to data-driven decision making so data is the key for future maintenance. This means that beside monitoring and diagnostic tools for various types of equipment also efficient integral data management and analytics solutions are mandatory.

## 3. New "Condition Monitoring Platform" Dirom4i

High operational and maintenance costs pose a significant threat to the economic effectiveness and efficiency of a nuclear power plant. The implementation of predictive or condition-based maintenance is focused on doing maintenance at the right time to reduce the maintenance scope and costs.

AREVA's new condition monitoring platform DIROM4i for rotating machinery like pumps, motors, compressors or turbines but also valves and drives increases the availability and reliability of assets or the entire plant while simultaneously significantly reducing the expenditures.

It enables data-driven decisions for optimization of maintenance plan and tasks. It combines various monitoring and diagnosis tasks (e.g. process-, vibration- and electrical- signatures) into a single system which autonomously follows a deterministic and adaptive monitoring concept with local, event triggered data storage and server based deep diagnosis algorithms.

The system is modular to offer complete scale-ability to integrate as much asset data as the customer application requires. It can be easily adapted and extended to system clusters on plant or even fleet level.

The methodology applied for the assessment of active components which are not online monitored is based on the Reliability Centered Maintenance (RCM) approach, with the objective to optimize the resources

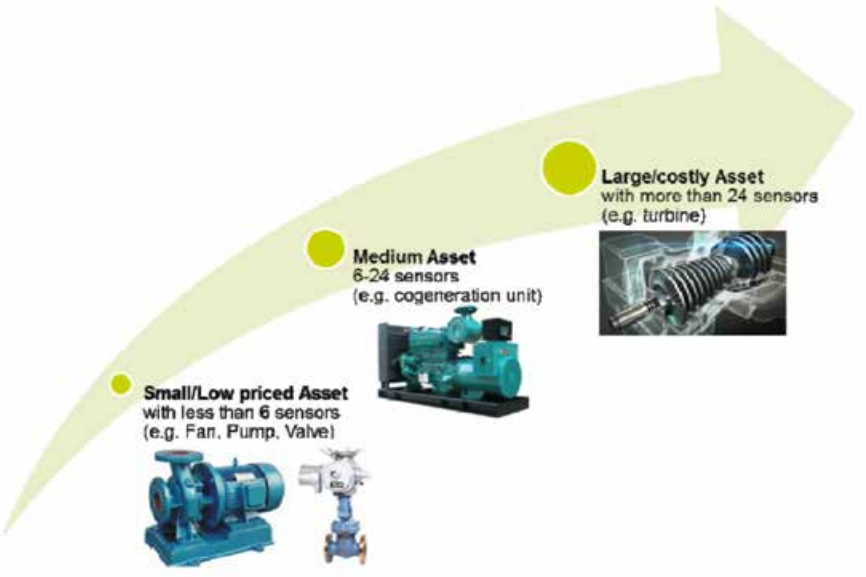



**Figure 3**. Scalability and Flexibility to customize the platform

available for maintenance in a power plant. It provides the technological basis for predictive/prognostics capabilities by providing a range of reliability performance indicators for huge range of power plant components.

This respective software platform with integrated monitoring tools is designed to manage aging issues and life cycle management activities with the objective to optimize maintenance programs. The data are securely stored in a single source database. Computerized monitoring and lifetime surveillance makes it possible to efficiently keep a lifetime consumption record as a basis for maintenance and repair strategies.

The system autonomously follows a deterministic and adaptive monitoring concept with local, event triggered data storage and server based deep diagnosis algorithms. Programming and re- configuration of the local system-intelligence (FPGA) can be provided remotely, if desired.

DIROM4i covers a number of safety- or availability-relevant assets. The system is modular to offer complete scale-ability to integrate as much asset data as the customer application requires.

The individual properties are checked for deviation from normal operating patterns using a Failure Mode Effect Analysis (FMEA), data analysis trending and Predictive Analytics.

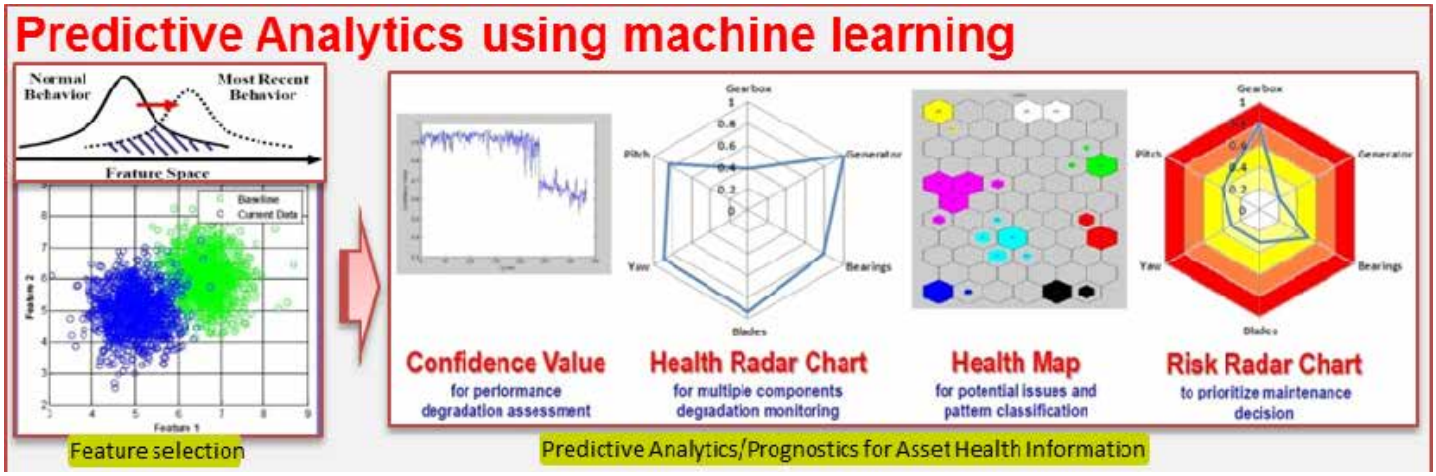
Deviations from the rule based diagnostics are reported in a dashboard including automated ticket generation.

## 4. Remote Diagnostic Service

The bigger the available database the more the diagnostic intelligence is increased. This may be accomplished by historical data records. Combined data from several plants leads to even better diagnostic results. Consequent asset monitoring of one plant or even a fleet generates massive amounts of data. Analysis can be difficult because of the complexity and amounts of data or missing expertise.

The "Remote Diagnostic Service" solution manages large amounts of data easily and provides timely expert analysis.

This is achieved by the combination of big data analytics used for recognition of patterns in unstructured



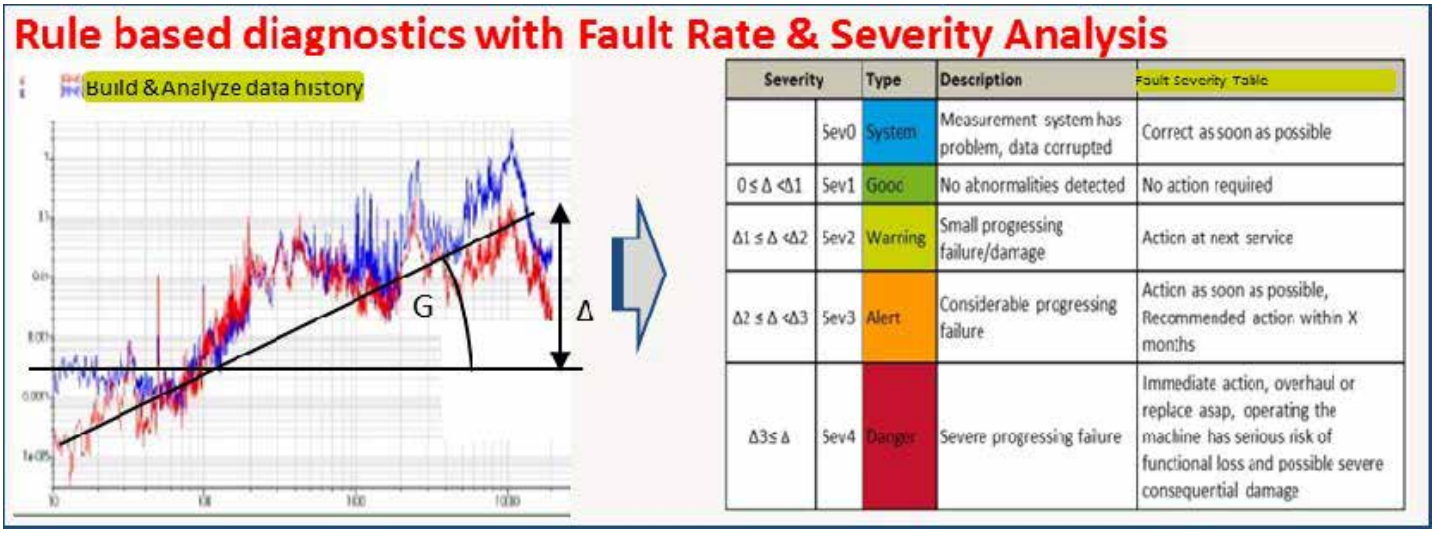




**Figure 4.** Data Analysis – Trending by historian and failure prediction

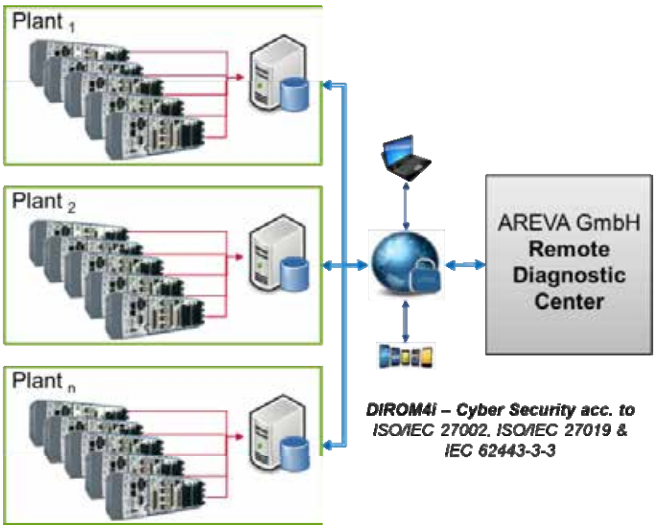



**Figure 5.** Clustering, remote connection and configuration using the Internet of Things

data with wide diagnostic expert know-how and Failure Mode Effect Analyses resulting in structured data and less data transfer.

The data is pre-filtered locally so only diagnostic relevant data is transferred to a web-based Asset-Management-System.

This system is made possible by the modern network called "Industrial Internet-of-Things". Safeguarding sensitive systems-control in a NPP like the refueling machine using appropriate Cyber Security is mandatory. Security has been proven by external independent assessors and by authorities. The Internet-of-Things platform conforms to ISO/IEC27002, ISO/IEC27019 and IEC62443-3-3.

Main features are intelligently optimized asset performance and maintenance efforts, extremely low level of false alarms and minimum data transfer.

## 5. Innovative Valve Monitoring and Service Solutions

Valves and their actuators are a significant and important part of a plants maintenance program. Applied in nearly all plant systems with specific safety-related or availability-related functions the proper design-based valve operation is a key factor for overall plant performance. Therefore valves are a significant part of a plant maintenance program and a considerable equipment group for predictive maintenance.

Due to the importance of proper valve function already in the past specific testing or diagnostic activities had been introduced into maintenance programs. The conventional approach is recurrent at-the-valve testing during outages mainly linked to preventive maintenance tasks exemplarily to verify correct actuator limit switch setting and validate torque / force values related to given margins.

With regard to implementation of predictive maintenance a periodic or continuous condition monitoring is required to get a sufficient amount of data for predictive analytics. For valves that are equipped with an actuator like motor operated valves (MOV), air operated valves (AOV) or solenoid valves (SOV) there are several specific parameters (mechanical and electrical) that can be used for diagnosis and assessment. So these groups of valves are suitable for implementing monitoring solutions.

Beside degradation mechanisms and related parameters there are also engineering and design aspects relevant for setting optimum maintenance strategies.

Taking into account the different aspects and criteria ensuring the specified function of valves and actuators, an integral approach was established, see Figure 6.

This concept is linking all relevant disciplines in

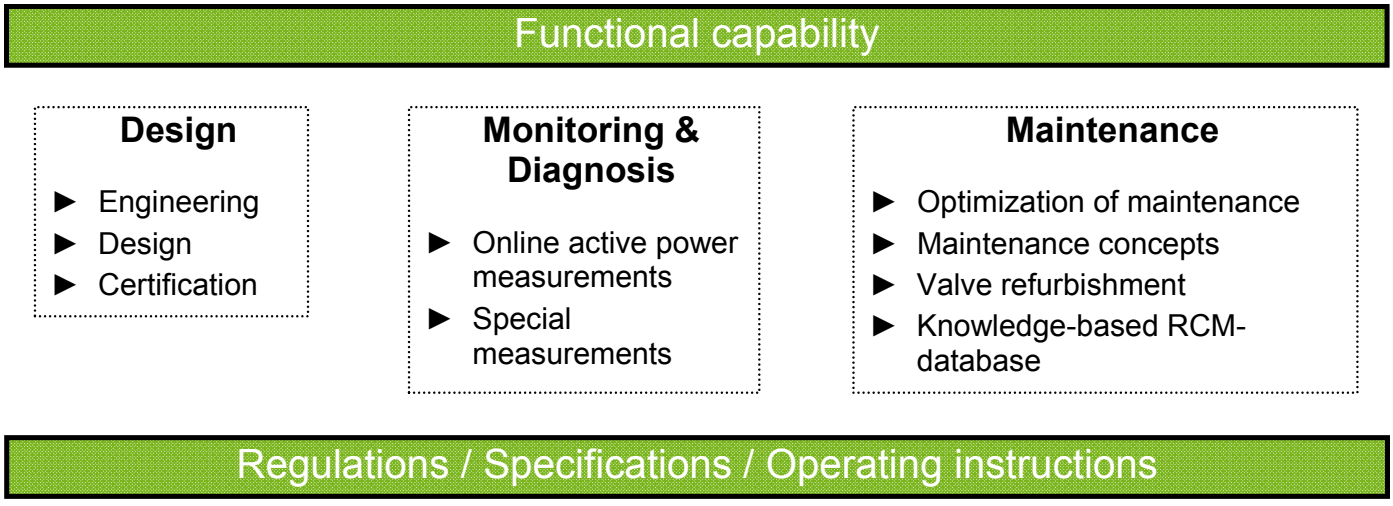



**Figure 6.** Integrated Valve Concept

valve and actuator technology considering specific know-how and long-term experience.

The three main fields

- Calculation / Design
- Maintenance / Repair
- Monitoring & Diagnosis

are the foundation for functional capabilities.

These three main areas cover an integral scope for ensuring continuous steady, safe and reliable function of valves and actuators:

- Valve technology and valve qualification / certification
- Estimation of remaining service life time, predictive analytics
- Maintenance strategies and optimization (preventive vs. predictive approach)
- Valves and actuators monitoring solution ADAM®/ SIPLUG®
- Selective maintenance and repair measures

## 5.1 ADAM® / SIPLUG® Valve Monitoring Solution

Establishing condition-based maintenance strategies for valves requires continuous or periodic monitoring of relevant parameters. Torque and force (esp. to ensure proper seating) indicating valve mechanical conditions are measured directly at the valve via strain gage assemblies, load cells or specific torque sensors. In addition limit-switch signals are recorded to prove proper actuator adjustment.

The idea of continuous condition monitoring as prerequisite for predictive maintenance creates the need for parameters that can be easily measured also during plant operation . For motor operated valves (MOV) measuring of electrical parameters (current, voltage, active power) of valve actuators is continuously possible at the Motor Control Center MCC e.g. via SIPLUG®, what provides different advantages:

- Continuous online monitoring possible during system operation
- Minimization of direct measurements on-site & disruption of normal operation
- Assessment of mechanical parameters (e.g. torque / force, friction coefficient) possible based on actuator characteristics

The ADAM®/SIPLUG® valve monitoring system allows beside traditional at-the-valve testing a full online monitoring of valves and actuators with automatic evaluation and assessment.

Especially for safety-related and operation-related valves this provides valuable information on component condition to ensure proper function and contribute to optimization of maintenance strategies as well as effective maintenance execution.

The modular valve diagnosis system is basically containing the SIPLUG® measuring devices and related ADAM® software.

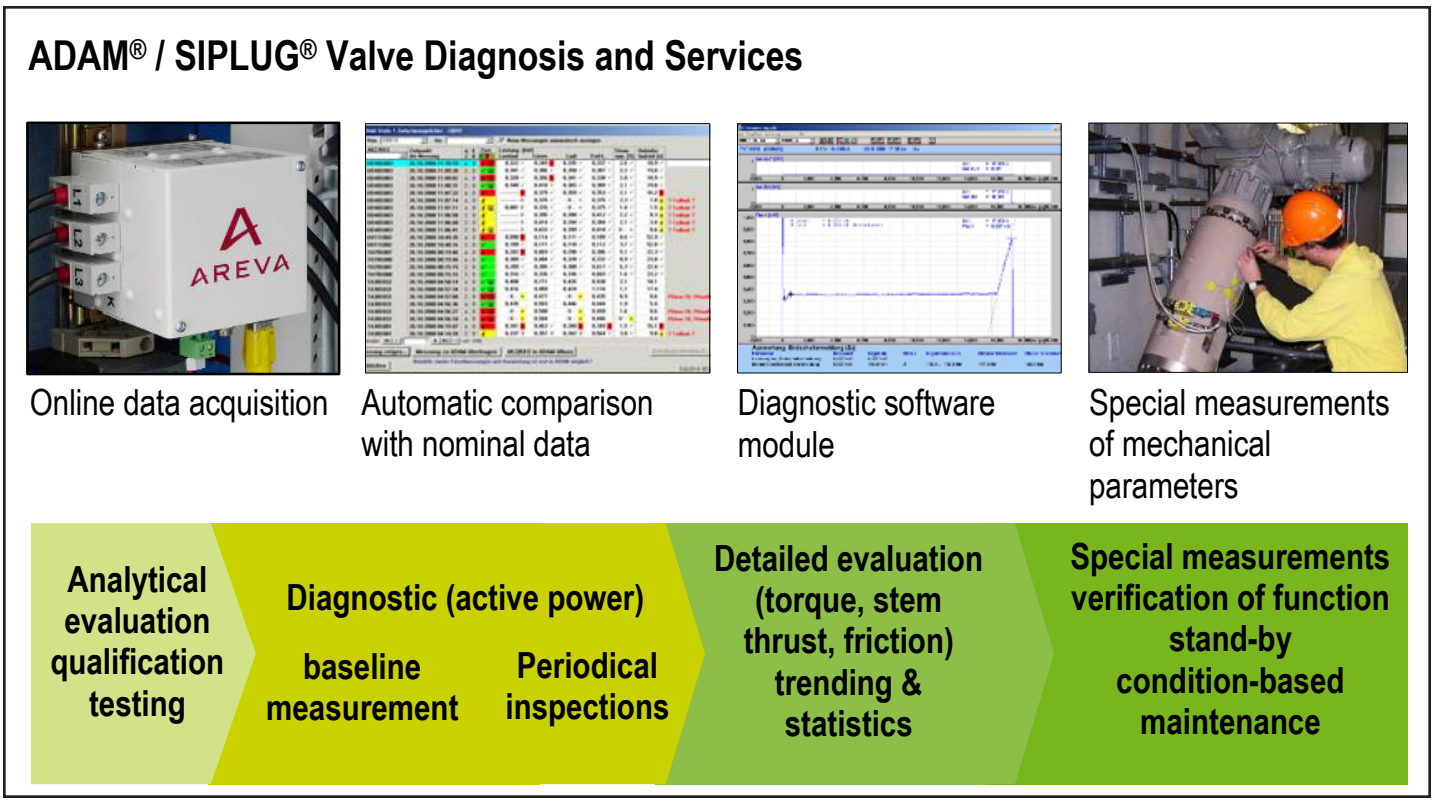



**Figure 7.** ADAM®/SIPLUG® Valves and Actuators Diagnostics Concept


**Figure 8.** SIPLUG® module

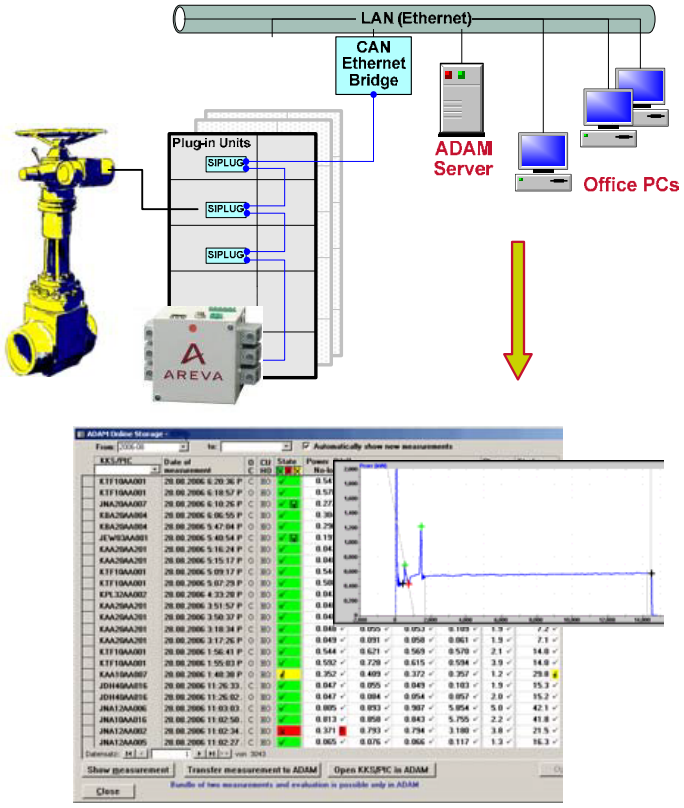



**Figure 9.** SIPLUG® online

Providing dedicated diagnostic solutions for different customer requirements the system is designed for data acquisition inside or outside the plug-in units of the switchgear of nuclear power plants. The plant operator will be able to perform the assessment of electrical and mechanical characteristics of motor-operated valves and their electrical actuators through active power measurement.

The present generation of SIPLUG® modules (Figure 8) are an evolutionary solution for valve diagnosis at the Motor Control Center (MCC).

As it can be installed directly in the outgoing actuator power cables it allows an easy installation inside existing switchgear cabinets requiring less engineering work compared to other solutions demanding full integration into plug-in units.

The technology is containing a controller and a sensor module with current transformers for 5/10/20/50 or 100A adapted to the power range.

For the monitoring of solenoid valves (SOV) specific configuration is available which supports the assessment of the dynamic and electrical behavior of solenoid-operated valves by measurement of voltage and current.

The ADAM® evaluation software and database provides automatic analysis of the monitoring results using the limit values specified for the valves. With installed SIPLUG® online hardware installed the measured data can be automatically transmitted via power plant's local area network or WIFI solutions to the data server. So all measurement information as well as assessment results are available immediately in the offices of plant engineers providing an actual status of valve condition.

A mobile solution can be applied for temporary diagnostics transmitting data via serial or USB interface to a PC or notebook.

One main advantage of the online solution compared to at-the-valve testing is that all valve operations are recorded automatically independent form whether it is a full or partial (e.g. control valves) stroke.

Ring buffer always keeps the last data in the internal memory, even if power supply fails. Consequently a post-fault analyses is possible, if some irregularity happened during valve movement.

Thus, potential problems can be assessed at an early stage for timely definition of measures.

Figure 9. SIPLUG® online

Data are immediately available for further analysis / assessment. A fully automated evaluation (see Figure 9) of each valve operation based on specific criteria and related tolerances provides a full overview on valve status at any time, visualized by simple traffic light indication (green / yellow / red).

As measurements at MCC are automatically done it means zero effort for performance of diagnostics at the same time decreasing the number of on-site activities. This reduced efforts result in decrease of diagnostic cost and dose rates for deployed personnel.

Furthermore online valve monitoring supports maintenance optimization by providing condition data for applying predictive maintenance strategies with full contribution to plant safety and reliability. Minimizing the number of regular time-based preventive activities by implementation of CBM within an overall RCM approach will also reduce annual maintenance cost.

Trending of parameters with regard to linked single part failure modes can also help operators to optimize their spare and wear parts inventory.

Combining the features of valve monitoring solutions with expert knowledge and experience in valves and actuators design, function and maintenance we also provide a full range of related service activities to support plants in all stages of valve diagnosis (see also Figure 7).

### 5.2 In-situ Valve Seat Assessment and Repair

Beside the condition assessment via online monitoring there are other specific methods with regard to material / metallographic analyses that can be applied exemplarily for valve seat hard facing evaluation and assessment. It provides valuable information on remaining hard facing thickness (but also hardness, chemical composition, etc.) allowing a better planning of future maintenance tasks as well as potentially needed repairs.

Based on the detailed results of the assessment an estimation on the potential number of lapping cycles keeping the nominal hard facing thickness tolerances can be made.

This prevents internal valve seat leakages or functional problems due to exceeded grinding. At the same time the future maintenance planning is more reliable by minimizing ad-hoc repair actions.

In case of repair needs AREVA's in-situ valve repair solution is a valuable alternative to existing practice of complete valve body replacement.

The technology has the unique ability to conduct several steps in-situ, restoring the sealing seats of gate, check and globe valves to its original state. The system remains unchanged, so all original documents remain valid and applicable. This aspect is important especially when the manufacturer of the valves does not longer exist.

The repair process is fitting the regular valve inspection and maintenance schedule:

- Disassembly of the valve with general inspection
- Initial assessment and analysis also with digital 3D measurement to adapt machining sequence on geometrical deviations of valve bodies
- Turning down of worn or damaged seal seats
- Overlay welding of the new hard facings and
- Finish turning and grinding of the sealing surface to the required quality
- Replacement of the wear parts and reassembly of the valves

Beside significant advantage during outage execution there are also time and cost savings in the planning and realization phase. If the valve needs to be replaced, the planning time may take up to two years e.g. for new construction, licensing, pressure tests of the new valve and meeting of documentation requirements. In contrast, our in-situ valve repair solution facilitates short-term preparation since no valve design modification is realized.

## Conclusions

Nuclear power plant long term operation brings up new technical challenges, since the plants need to be operated reliably on a continuous high safety level for 50 and more years. It is therefore necessary to actively deal with the degradation behavior of equipment and its predictability in order to optimize maintenance programs and reduce maintenance costs but at the same time ensure high safety and high availability.

For this reason effective maintenance strategies must be applied for the surveillance of aging effects and preventive measures need to be implemented to ensure the necessary technical basis for maintaining safety margins throughout the plant.

Ensuring reliable component operation increases the demand for predictive maintenance solutions based on continuous surveillance and efficient monitoring. The process of digital transformation provides new technologies for processing and management of large and complex data as a key factor for future maintenance. It is strongly linked to implementation of Maintenance 4.0 with focus on predictive maintenance, mobile maintenance solutions and asset innovation / life cycle costing.

AREVA already supports plant operators in implementation of up-to-date maintenance concepts. Approaches like RCM ensure an optimized allocation of maintenance priorities / strategies to each single equipment considering functional and safety requirements. Our remote diagnosis platform DIROM4i and monitoring solutions like ADAM® / SIPLUG® with integration of long-term experience on component degradation mechanisms and behavior are applied in various NPPs with regard to predictive condition-based maintenance.

# Specialized Tooling for Inspection and Cleaning of Calandria Relief Ducts

by Andrew Brooks[1], Sahil Gupta[2]

*[Ed. Note: The following paper was presented at the 11th International Conference on CANDU® Maintenance and Nuclear Components, October 1-4, 2017, Toronto, Ontario, Canada]*

## Abstract

This paper presents an overview of the specialized tooling developed for the purpose of full volumetric inspection and high pressure water jet cleaning from the inside diameter (ID) surface of the 18" Calandria Relief Ducts (CRDs) at the Bruce Nuclear Generating Station B (BNGS) (Unit 7).

The Unit 7 CRDs have been degraded from transgranular chloride induced stress corrosion cracking (TGSCC). During the 2016 Unit 7 outage, there was specialized, first-of-a-kind tooling developed in order to inspect and clean the Unit 7 CRDs.

## 1. Background

The Unit 7 CRDs at the Bruce Nuclear Generating Station (BNGS) B have suffered degradation due to chloride induced transgranular stress corrosion cracking (TGSCC). Evidence of TGSCC cracks initiated from the ID surface of the CRD were noted during outage campaigns completed in year 2005, 2008, 2011 and 2014. These inspections were limited to the first 13 inches within the CRD that could be physically observed by the inspector at the rupture disk platform (see Figure 1-1).

The Bruce Units moderator $D_2O$ normally contains ~2ppb chlorides, $D_2O$ vapour and droplets in the helium gas above the moderator water level and consequently picks up this chloride impurity. $D_2O$ condensation and wetting of the CRD inside surface above the water level results in localized concentrated deposition of chlorides. The CRD is fabricated from 304L stainless steel which is susceptible to chloride induced Stress Corrosion Cracking (SCC). There is evidence of areas of localized iron contamination on the inside of the Unit 7 duct, believed to have resulted from grinding of the CRD inside surface during fabrication. The presence of iron significantly increases the susceptibility of the material to chloride induced SCC initiation and growth. Chloride induced SCC initiates and grows where localized chloride deposition occurs, particularly if iron contamination is also present.

The presence of iron contamination in the Unit 7 CRDs is believed to be a reason why Unit 7 is observed to have a higher prevalence of SCC than the CRDs in the other BNGS units. The SCC observed in Unit 7 could be a life limiting issue for the unit as the CRD cracks could eventually leak light water from the shield tank into the Calandria vessel, consequently downgrading the isotopic concentration of the heavy water within the Calandria.

In order to better characterize the flaws observed in the CRD and to investigate the extremities of the CRD piping (near the moderator region), a project was undertaken by Bruce Power to develop specialized robotic crawler delivery system coupled with NDE probes capable of high precision volumetric inspections from the inside diameter (ID) of the CRD. In addition, a high pressure water jet cleaning tool was also developed to reduce the chloride inventory from the ID surface and to prepare the base metal for

NDE inspections. To support these primary inspections and cleaning tool systems, auxiliary support tooling such as a Foreign Material Exclusion (FME) bung, pneumatic controls and $D_2O$ supply cart, etc. were also designed. This paper presents the associated process and tooling aspects developed for the Unit 7 outage.

### 1.1 System Overview

At BNGS, CRD are part of the Moderator Cover Gas System (MCGS) and provides overpressure protection for the Calandria during an upset condition such as an In-core Loss of Coolant Accident (LOCA). Each CRD has a rupture disc (Y1 to Y4) at the end of the duct (see Figure 1-1), set at 20 psig which limits the magnitude of the peak pressure in the Calandria for "emergency conditions".

In addition, MCGS uses helium gas to provide a controlled atmosphere on the exposed surface of the moderator. It is a closed recirculating circuit performing catalytic recombination which reduces the deuterium concentration and prevents the formation of explosive $D_2$-$O_2$ mixtures, see Figure 1-2 for overview.

### 1.2 Fabrication of Calandria Relief Ducts

1 Bruce Power L.P.
2 AMEC Foster Wheeler

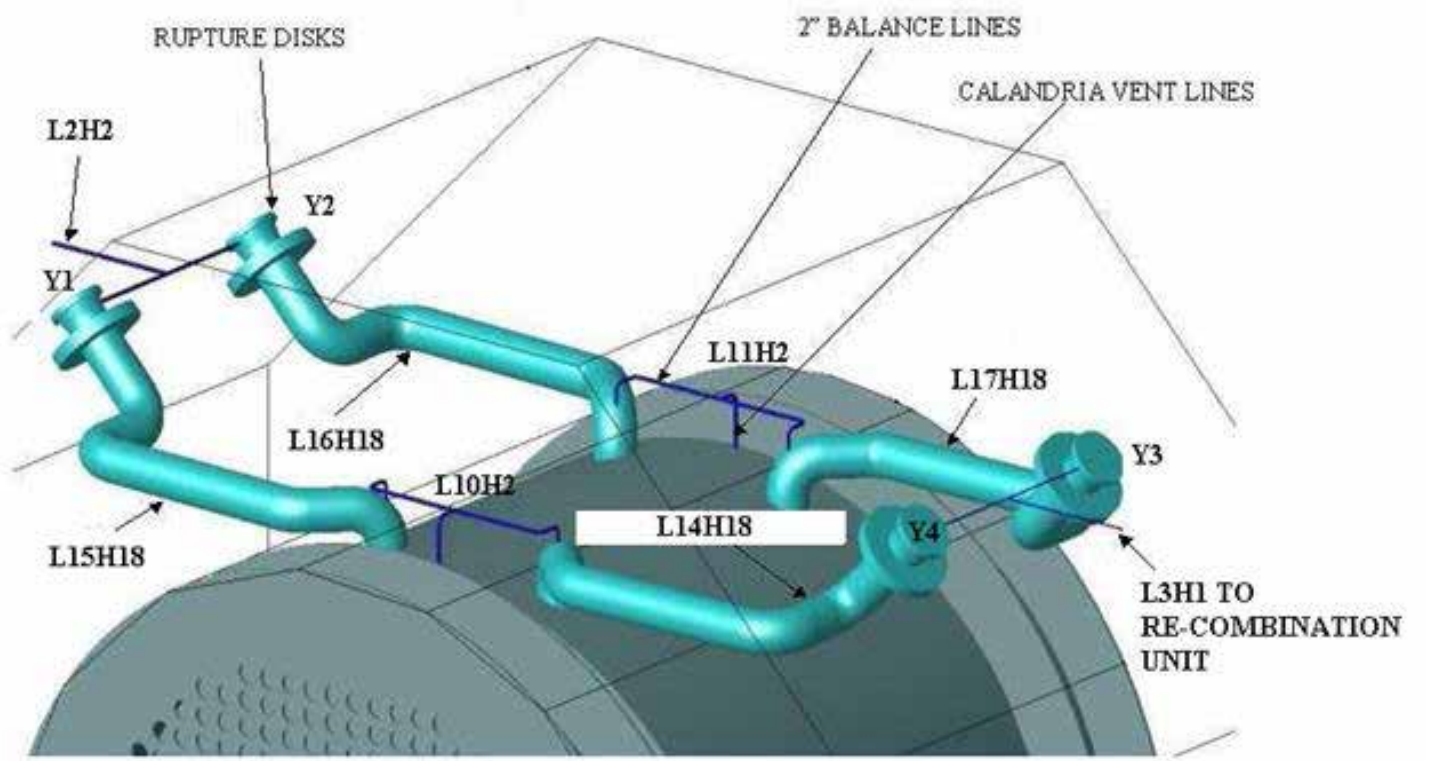



Figure 1-1 : Overview of CRD Configuration

The CRD are part of the MCGS anchored to the Calandria and shield tank at either ends and is subjected to the design requirements of ASME Sec III, subsection ND.

The CRDs were fabricated from 304L stainless steel welded components as follows:

1. 18 inch diameter piping, 3/8"thk – ASME SA358 Class 1 electric fusion welded pipe made from ASME SA240 Type 304L plate. The pipes were solution annealed, quenched and pickled.
2. 18 inch elbows – ASME SA403 Class WP seam weld fittings; solution annealed, quenched and pickled. It has been determined that the elbows were manufactured from 14-15 mm plate for the short radius elbows and 12 mm plate for the long radius elbows.
3. Materials were welded using ER308L (consumable insert) weld material with a specified ferrite content of 5-12%. Gas tungsten arc welding (GTAW) process was used for root welds and Shielded metal arc welding (SMAW) process was used for fill and cap. Consumable inserts were used for the root (GTAW portion) of the weld.
4. The CRDs were manufactured by Canadian Vickers of Montreal as part of the Calandria shield tank assembly in Dec 78/Jan 79. The complete assembly was shipped to site and rolled into place.

Figure 1-3 presents the weld numbering for the CRD pipes at BNGS Unit 7.

## 1.3 Design Conditions for CRD

- Design Pressure = 103 kPa(g) (15 psig).
- Design Temperature = 120°C (250°F), which is above the maximum moderator $D_2O$ temperature for normal and upset conditions.

## 1.4 History

During 2005 outage, a leak was discovered in the U7 MCGS outlet piping from relief duct (see Figure 1-4). Following this discovery, visual examinations of the relief ducts were completed and evidence of corrosion products were found on the ID of the 18" outlet relief ducts (Y3 and Y4). Inlet ducts (Y1 and Y2) also showed minor signs of corrosion.

Limited Ultrasonic testing (UT) was completed on the accessible sections of the CRD outlet pipes and the degradation was found to be approximately 25% through wall flaws in the outlet ducts. Subsequent analysis attributed the damage to chloride induced TGSCC.

Several additional inspections were completed in year 2008; further substantiating the TGSCC nature of the flaws.

In year 2011, additional Non-Destructive Techniques (NDT) such as Phased Array Ultrasonic Techniques (PAUT), Liquid Penetrant Inspection (LPI) (Figure 1-5), metallographic replication (Figure 1-6), and visual examinations were completed to gather forensic

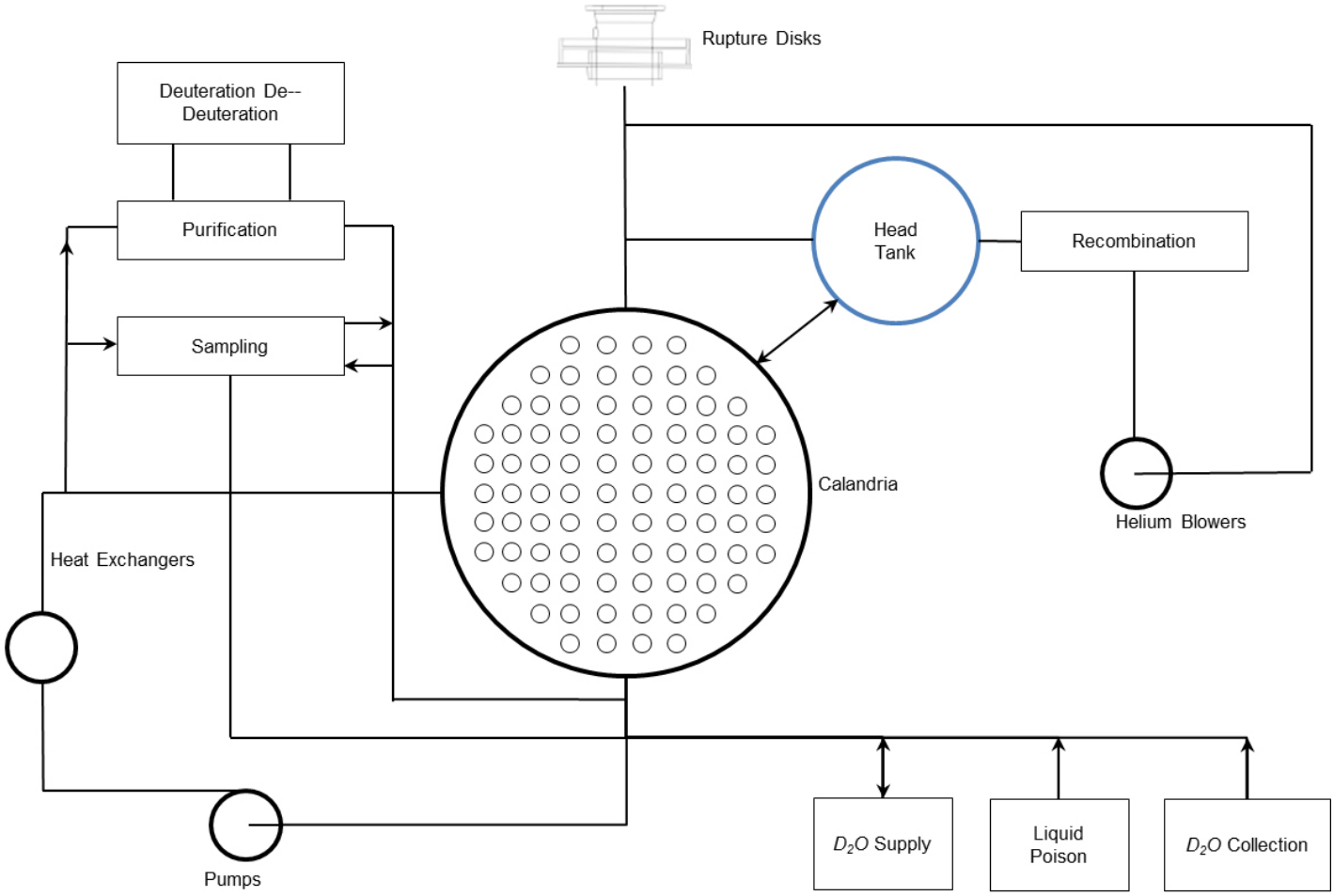



Figure 1-2 : Overview of MCGS – Illustration

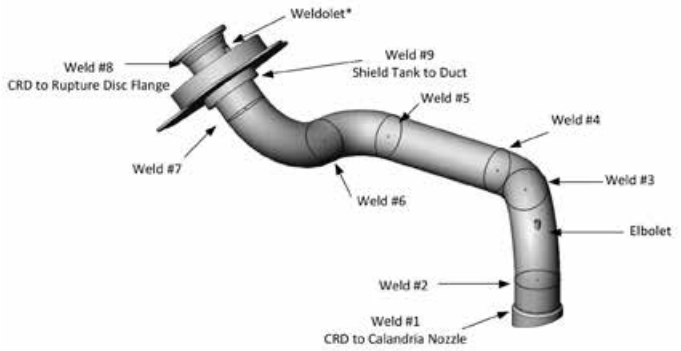



Figure 1-3 : Weld Number of CRD

data and investigate crack propagation within CRD. The results indicated continued SCC and cracking especially on the ID of Y3 at the outlet nozzle.

In 2014, further manual inspections on U7 revealed continued degradation of the U7 ducts. Following the results of the 2014 inspections, a design project was initiated to develop a customized tooling solution to complete full volumetric inspections and high pressure water jet cleaning of the ducts from weld 8 to weld 2 (see Figure 1-3) of the CRD.

## 2. Tooling Inspection Requirements and Qualification Process

The CRD inspection tooling system was designed to detect and characterize inner surface connected TGSCC flaws; the Target Flaw Size (TFS) was 2.5 x 10.0mm. The inspection system was qualified with a probability of detection (POD) of 80% at a confidence level of 90%, and a False Call Rate (FCR) of <15%. All flaws at, or exceeding the TFS were reported to ±5.0m true length ±0.5mm trough wall extent (depth) and ±10.0mm true location.

The development of the inspection tooling followed the CANDU Inspection Qualification Bureau (CIQB) methodology [1]. The CIQB methodology requires producing a specific Technical Justification document to provide confidence that the inspection tooling and inspection procedures met the requirements of the inspection specification, while providing evidence that the inspection results were "the truth."

Following the CIQB guidance, Inspection specifica-

**Table 1:** NDE Techniques and Associated Sensors

| NDE Technique | Identification | Description/Purpose |
|---|---|---|
| **Eddy Current** | ECA | Eddy Current Array for the detection and length sizing of ID connected flaws |
| **Ultrasonic** | PACW-sk0 | Phased array UT probe positioned to detect, characterize and size axially oriented flaws in the CW direction. |
| | PACCW-sk180 | Phased array UT probe positioned to detect, characterize and size axially |
| | PATC-sk90 | Phased array UT probe positioned to detect, characterize and size circumferentially oriented flaws by looking forward (toward the Calandria). |
| | PATRF-sk270 | Phased array UT probe positioned to detect, characterize and size circumferentially oriented flaws by looking toward rupture disk flange. |
| | WT | Phased array UT probe generating acoustic beams from -10° to 10° (LW) and multiple straight beams (0° LW) for monitoring of the CRD wall thickness and evaluation of the surface condition |
| | TOFD-Circ | Time of Flight Diffraction for sizing of mainly circumferential flaws. |
| | TOFD-Ax | Time of Flight Diffraction for sizing of mainly axial flaws. |

tions, qualification plan, inspection procedures were used as inputs to provide specific evidence for the Technical Justification. Following this methodological process, ensured the tooling was capable of the detection and characterization of inner surface connected TGSCC indications within the CRD.

To meet the requirements of the inspection specification a combination of Eddy Current Array (ECA), Phased Array Ultrasonic Testing (PAUT) and Time of Flight Detection (TOFD) were used. The primary purpose of the ECA was to detect and length size the surface connected flaws. The PAUT/TOFD were complementary ultrasonic techniques used for detection and depth sizing.

# 3. Calandria Relief Duct Tooling

The CRD tools were deployed in 2016 outage with the objective to characterise the flaws within the CRD and remove the corrosion inventory from the ID surface to retard the progress of SCC. Several custom design tooling systems were developed to achieve this goal. All systems went through extensive phases of Factory Acceptance Testing (FAT) at the vendor locations using representative full size mock-ups of the CRDs.

Subsequent sections present a brief overview of all the tooling utilized for the outage campaign.

## 3.1 CRD Cleaning Tool System

The 18" cleaning tool featured a high pressure water jet cleaning system (shown in Figure 3-1). It consisted of a high pressure pump (~15,000 psi) and a delivery tool for the cleaning head. The cleaning delivery system navigates the length of the duct and the cleaning head rotates 360° to ensure full surface coverage.

The purpose of the cleaning system was to:

1) Remove the corrosion products (carbon steel oxides, chloride contaminants and other potential loose grit materials) from the inside surface of the ducts to mitigate the progress of TGSCC occurring in the CRD.
2) Provide a clean surface for non-destructive examinations (NDE) tooling.

## 3.2 CRD Inspection Tool System

The inspection tool was designed to perform NDE inspections from the ID surface of the CRD and characterise the flaws in depth, length, orientation and axial locations in accordance with the aforementioned inspection specification.

The system overview is shown in Figure 3-2 and it featured a launch ramp, robotic delivery system, NDE inspection head, FME Bung and corresponding auxiliary supports such as pneumatic carts, $D_2O$ cart and other controls.

### 3.2.1 Delivery System

The Delivery System (DS) was designed as a modular delivery mechanism for the delivery of various CRD heads (inspection head, and FME Bung) and also included the launch ramp used to support the tooling as it navigated the duct and to allow for maintenance on the tools (see Figure 3-3).

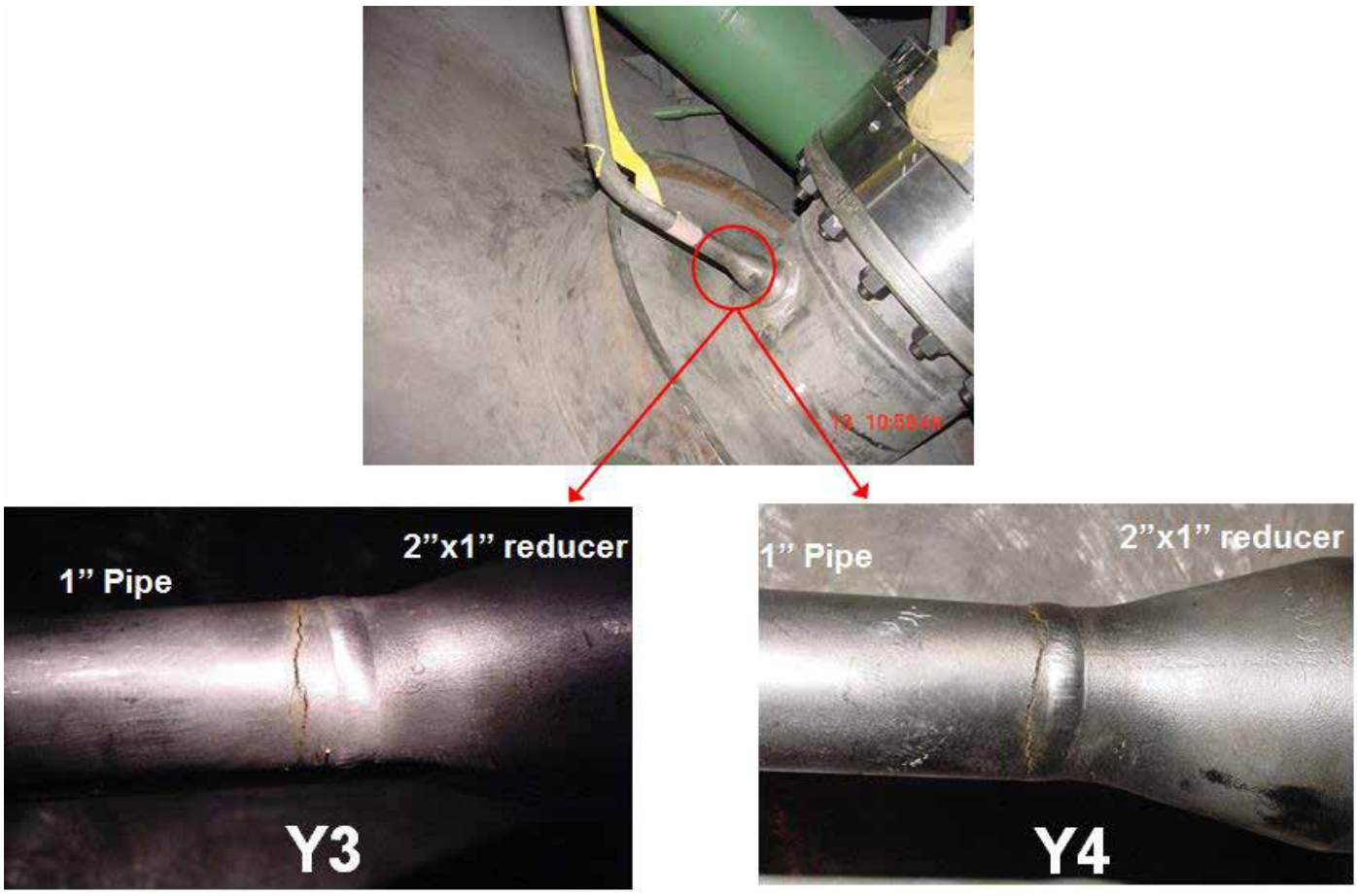



Figure 1-4 : Tie line cracks (2005)

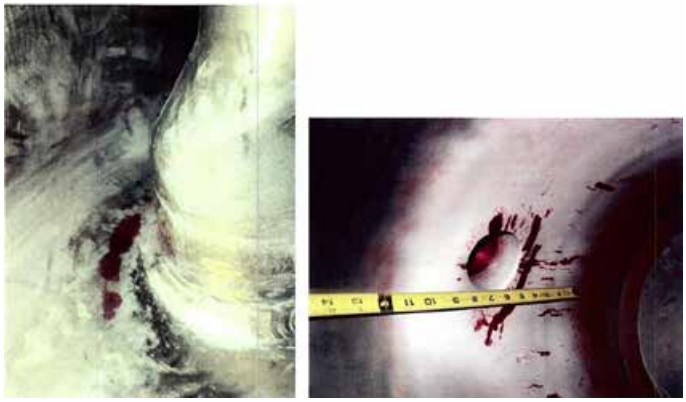


Figure 1-5 : OD & ID View of Circumferential Flaw, 2011

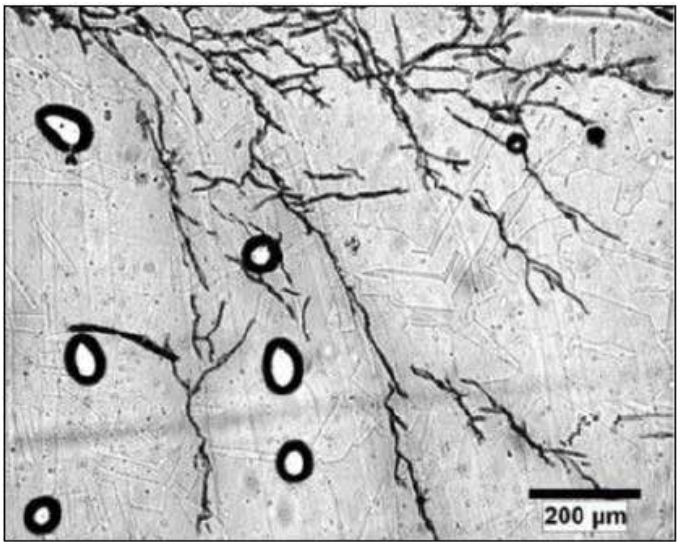



Figure 1-6 : Replica of Y3 OD Crack near weldolet showing TGSCC (2011)

### 3.2.2 FME Bung Tool

The 18" Bung System (Figure 3-4) was deployed to protect the Calandria from potential foreign material ingress and provided suction capabilities for waste water removal from the cleaning and NDE process. It connected to the delivery system (Figure 3-5) and was deployed just above the weld #2 region.

### 3.2.3 NDE Inspection Tool Head

The NDE inspection head housed the 8 inspection probes, and was responsible for 100% volumetric full circumferential inspections of the ducts. The probes were selected to meet the inspection requirements as specified in earlier sections.

The NDE Tool Head incorporates all the examination techniques, a total of 8 sensors, on two (2) heads, see Figure 3-6.

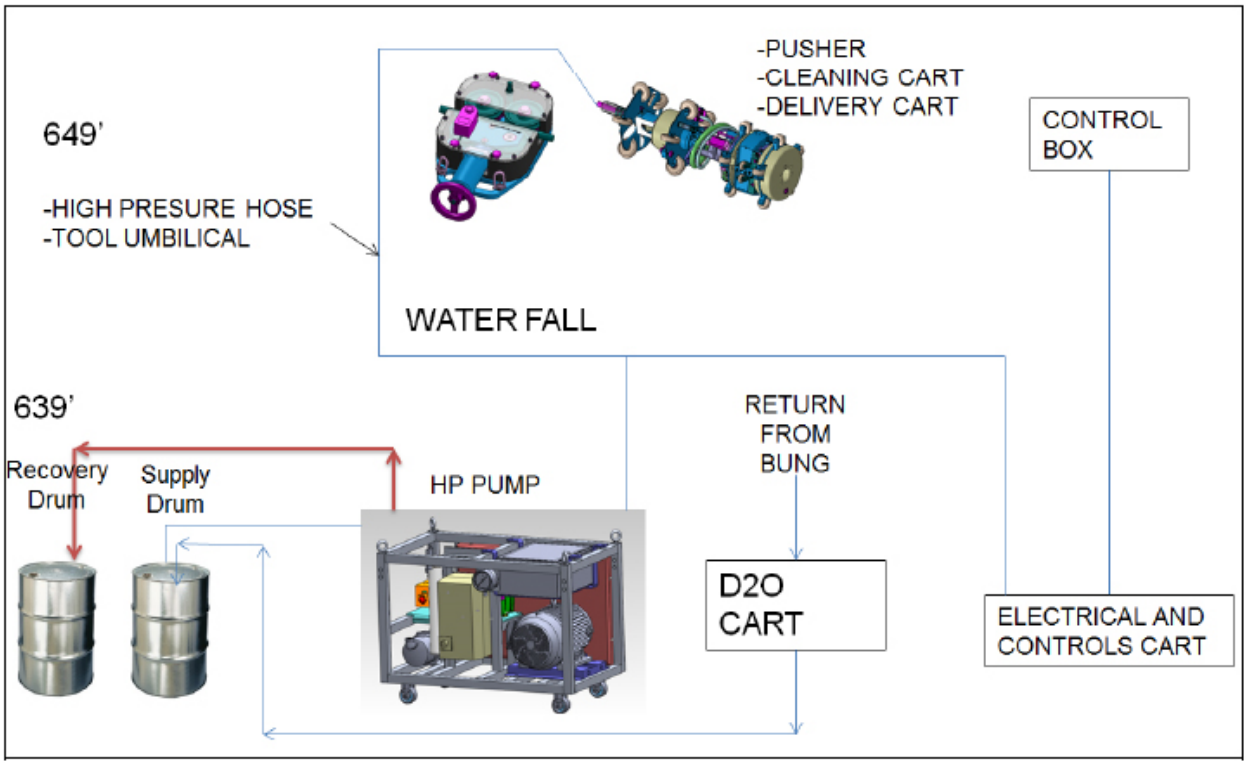



Figure 3-1 : System Overview of CRD Cleaning Tool

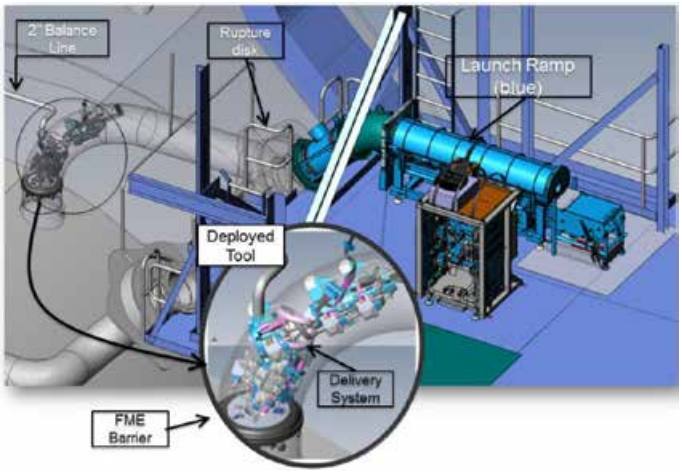



Figure 3-2 : CRD Inspection Tooling System Overview

This NDE head design ensured the tooling would be capable of full circumferential and 100% volumetric coverage. The NDE head was mounted to the Delivery System which positioned the NDE head to the correct position and was responsible for maintaining positional accuracy.

#### 3.2.3.1 Eddy Current (ECA)

The ECA probe was based on orthogonal elements. Each element is made of 2 independent coil windings, perpendicular and cubic. The ECA probe was made of 10 orthogonal elements arranged in 2 rows of 5 and is able to cover 15mm width. The center-to-center distance between columns was 3.3mm and pitch between rows was 2.5mm. This arrangement ensured that there are no gaps between elements along the scan axis.

#### 3.2.3.2 Phased Array Ultrasonic Testing (PAUT)

The PAUT probes were all 5MHz 12 elements (7.2 x 7.2mm) search units. The wall thickness, axial and circumferential probes all had dedicated contoured wedges based on their orientation. The sectorial scanning for each probe was also customized to ensure full volumetric coverage, wall thickness -10° to +10° LW, circumferential 40° to 60° SW and axial 45° refracted angle and lateral beam skewing -28° to +28° SW.

#### 3.2.3.3 Time of Flight Diffraction (TOFD)

The TOFD probes for axial and circumferential were 5MHz Ø 6mm units with a nominal refracted angle of 70° LW. The focus of the TOFD probes was near surface and surface breaking indications.

## 4. Inspection And Cleaning Results

CRD cleaning and inspection tooling were deployed successfully in the 2016 Bruce B Unit 7 outage.

### 4.1 Cleaning Results

The cleaning tool was successful in preparing the base metal surface for NDE inspections and removing the lightly embedded corrosion product build up. Some deeply

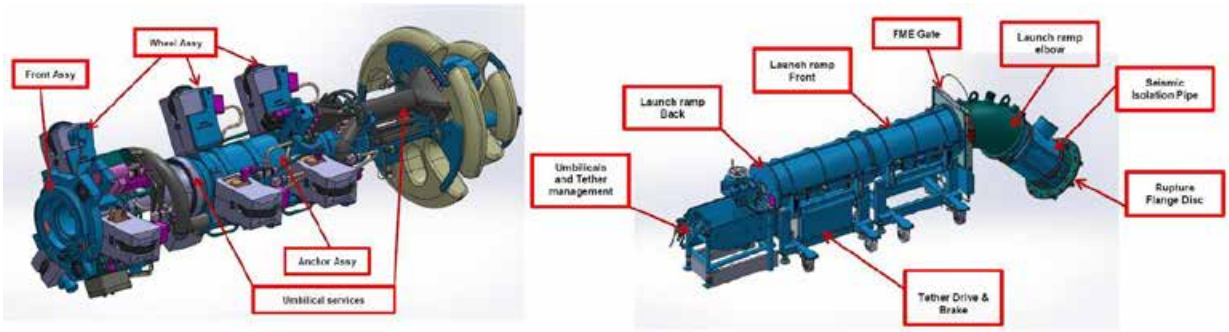



Figure 3-3 : Delivery System – Robotic Crawler (left) and Launch Ramp (right) components

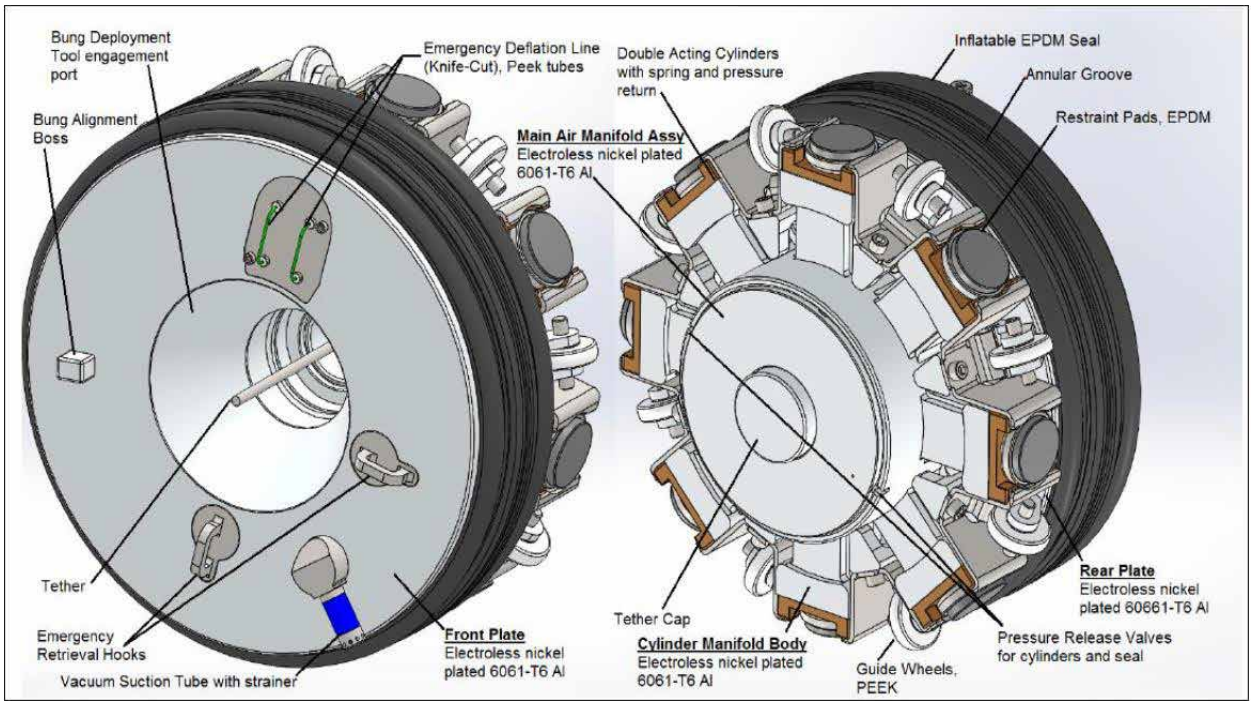



Figure 3-4 : 18" FME Bung –Front and Back View

Figure 3-5 : 18" FME Bung –Attached with Delivery System

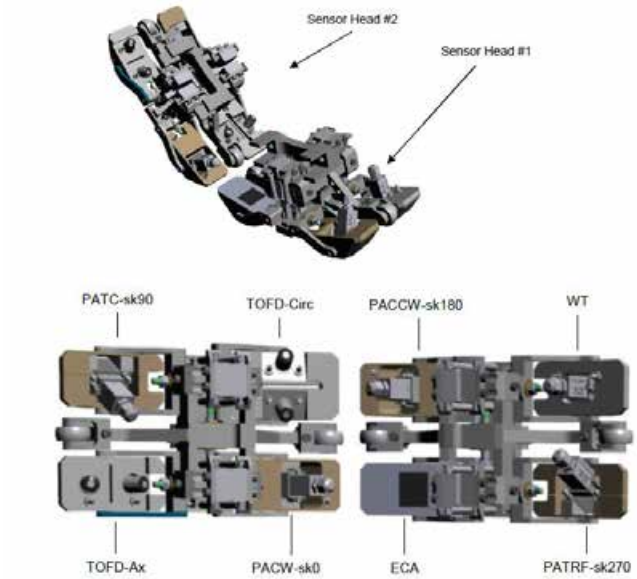



Figure 3-6 : NDE Sensor Heads

embedded particles were left behind in some areas, especially around elbows and bends. Corrosive oxides were also still evident at the welds of the duct based on the visual inspections following the cleaning operation.

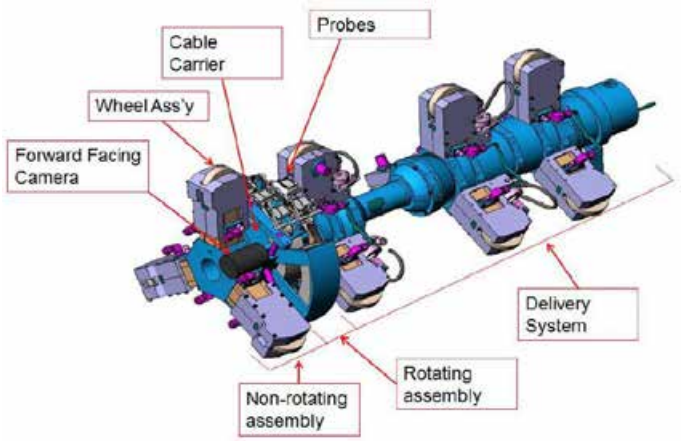



Figure 3-7 : NDE Tool Head attached to Delivery System

### 4.2 Inspections Results

The inspection system properly detected and characterized the surface breaking TGSCC indication (Figure 4-1 and Figure 4-2) within the duct and has allowed Bruce Power to establish a monitor program for this component. The results from this inspection aligned with the previous visual inspections performed on this system (Figure 1-5).

The flaws within the CRDs pose no threat to reactor safety, but there is the potential for these flaws to grow and cause downgrading of the moderator isotropic if the light water from shield tank leaks into the ducts and gets added to the moderator.

## 5. Final Remarks

The CRD inspection and cleaning systems were successfully deployed for the first time in 2016 in Unit 7. Inspection data from the NDE was able to characterize the degradation of the ducts, the indications were in clusters found primary in the straight pipe sections.

During subsequent engineering evaluation, the structural stability of the CRDs was evaluated based on established industry practices. The inherent material properties of the stainless steel ducts, combined with the relatively low operating stresses, allow for large circumferential and axial flaws to be present before structural failure can occur. The engineering evaluations show that the ducts are structurally sound. Corrective actions and repair techniques for CRD are under development.

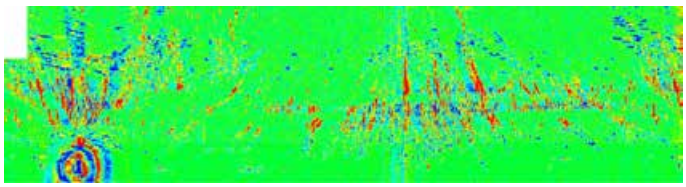


Figure 4-1 : Sample Eddy Current Inspection Results

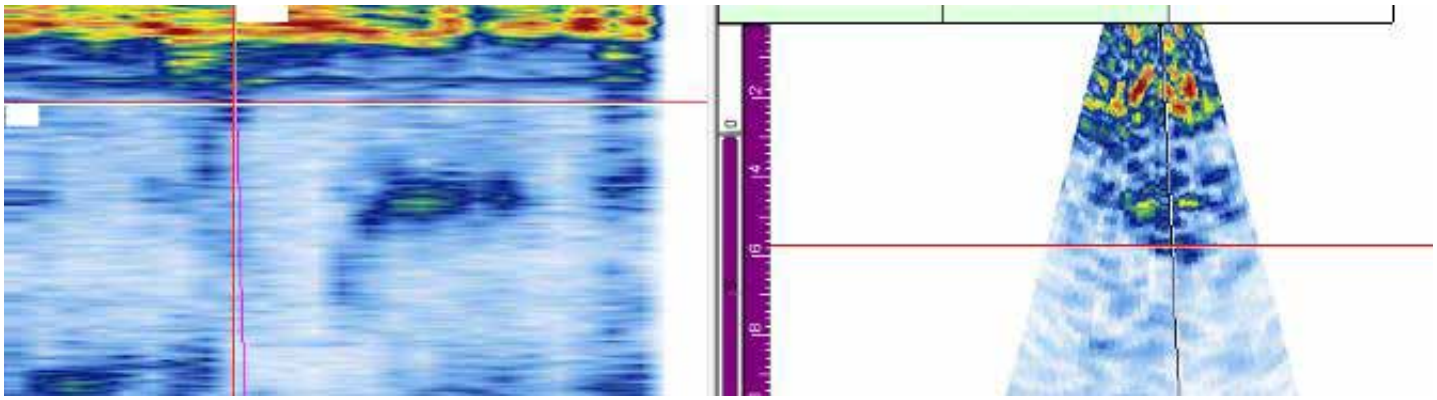


Figure 4-2 : Sample Phased Array Inspection Results

## 6. References

[1] CANDU Inspection and Qualification Bureau, Inspection Qualification Dossier, CIQB-ISN-1-5, 28AUG2008.

## 7. Acknowledgements

Bruce Power would like to express our gratitude to the Kinectrics and Nucleom Inc. for the design and qualification of the tooling systems developed during the course of this project and also providing event free outage execution.

Furthermore, we also thank various technical reviewers for their support which ensured proper engineering oversight was maintained ensuring the success of this project.

## News from Branches

### CHALK RIVER BRANCH – Andrew Morreale

Alpha Therapy Research at CNL (September 26, 2017): On Tuesday September 26th, the CNS-CRB hosted a talk from Dr. Patrick Causey of the Radiobiology and Health Branch at Canadian Nuclear Laboratories on "Researching Targeted Alpha Therapy at the Canadian Nuclear Laboratories". This was a very interesting discussion on alpha emitting isotopes with therapeutic potential for cancer treatment.

Upcoming events and talks to look out for:

- The CNS Chalk River Branch has upcoming talks in late May and June including:
  - October 17, 2017: In celebration of Nuclear Science week (October 16-20, 2017) we will host on Tuesday, the CNS Chalk River Branch Annual General Meeting and talk "Splitting Atoms, Canadian Style (unvarnished Canadian nuclear history)" by Morgan Brown of CNL.
  - October 31, 2017: "The United Kingdom's Nuclear Industry Landscape: a UK Nuclear Institute Perspective" by Alys Gardner of Abbot Risk Consulting. Conducted as part of the International Speaker Exchange between the CNS and the UK Nuclear Institute.

### SHERIDAN PARK BRANCH – Rajendra Jain

The Sheridan Park Branch activity report is as follows: A branch executive meeting was held on Aug 17, 2017 to discuss branch activities. A presentation titled "Point Lepreau Nuclear Generating Station Tsunami Hazard Assessment" by Derek Mullin, Senior Technical Advisor at Point Lepreau Nuclear Generating Station is organized on September 06, 2017.

### OTTAWA BRANCH – Ken Kirkhope

On September 12, the Ottawa Branch hosted a Special Dinner Event with guest speaker Dr. Kathryn A. McCarthy, Vice-President, Research & Development, of Canadian Nuclear Laboratories. Dr. McCarthy gave a presentation on the 10-Year Plan for Science and Technology Activities at the Canadian Nuclear Laboratories (CNL). The CNL recently completed a 10-Year Plan that lays out an exciting vision that builds on the long and proud history of nuclear science and technology that began in Canada with the Chalk River Laboratories in the 1940's. CNL's diverse capabilities have contributed to the full spectrum of nuclear technology in Canada. The event, hosted by Dr. Wei Shen, was very well attended by more than 35 CNS members and non-members, and considered a success on many levels.

The branch executive is lining up other events for the year, and is making various arrangements in support of the CNS - UK Nuclear Institute (UKNI) exchange program scheduled for this fall.

### NEW BRUNSWICK BRANCH – Derek Mullin

The NB branch executive is:

| | |
|---|---|
| Chair: | Derek Mullin |
| Past Chair: | Mark McIntyre |
| Secretary: | Rick Sancton |
| Treasurer: | Elif Can Usalp |
| Outreach & Education: | Kathleen Duguay |
| Member-at-Large: | Paul D. Thompson |
| Member-at-Large: | Michael Hare |

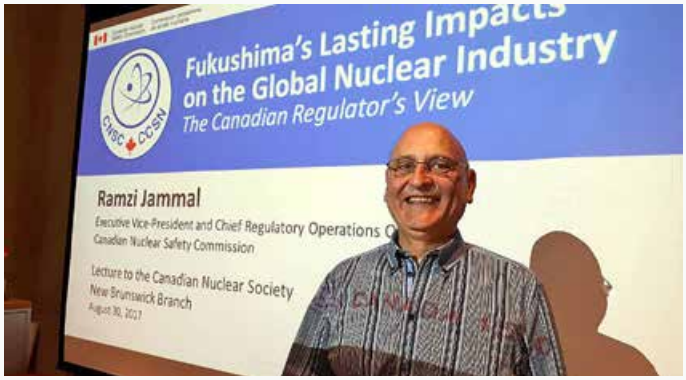
**Branch Events**

For the following events, the New Brunswick branch would like to extend its sincere thanks to Mark McIntyre of WorleyParsons for providing a great venue in historic uptown Saint John for its evening lectures.

***Mark Elliott***

On July 11, 2017, the New Brunswick branch hosted a lunch and learn at Point Lepreau Nuclear Generating Station and an uptown evening lecture by Mark Elliott entitled "Lessons Learned from a Nuclear Career: Reflect, Learn & Move Forward". The lecture imparted Mr. Elliott's experience and recipe for success for young staff heading towards leadership positions. Mr.

Elliott is a member of the Corporate Nuclear Oversight Team for New Brunswick Power, a member of the Nuclear Safety Review Board for EDF-Energy in the U.K., and is a member of the Board of Directors for the Nuclear Waste Management Organization. Both events were well attended with upwards of a total of 60 attendees.




***Ramzi Jammal***

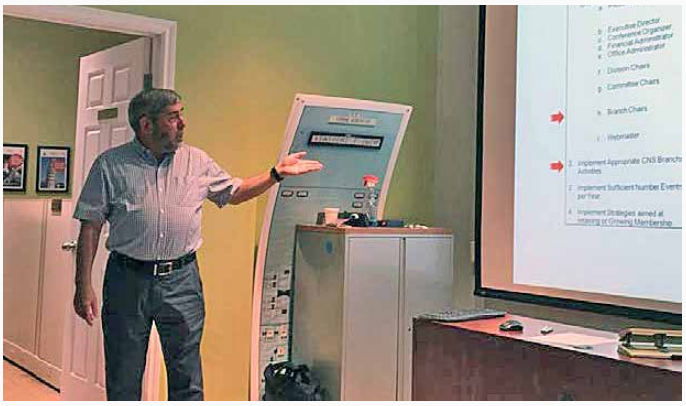
Ramzi Jammal, Executive Vice President and Chief Regulatory Operations Officer for the Canadian Nuclear Safety Commission, delivered both a lunch and learn discussion with Point Lepreau Nuclear Generating Station staff and an evening lecture in uptown Saint John on August 30, 2017. The topics differed for each event.

The on-site lunch and learn was an informal discussion with plant staff on "The CNSC Regulatory Perspective on challenges common to the Canadian Nuclear Industry". With fantastic support of the plant communications staff and senior management in promoting the event and encouraging staff to attend–subject to plant operational constraints–63 interested staff attended.

The evening session was a social mixer and presentation-based lecture on "Fukushima's Lasting Impact on the Global Nuclear Industry". The presentation described in detail how the effects of the earthquake and tsunami in Japan in March 2011 resulted in a shift in regulatory focus from accident prevention to accident prevention and mitigation. This was also very well attended. The conference room was full with 34 attendees ranging from Point Lepreau employees, retirees and interested members of the Association of Professional Engineers and Geoscientists of New Brunswick (APEGNB) with a broad range of young and experienced.

The evening lecture was tweeted by the CNSC at https://twitter.com/CNSC_CCSN/status/903014174925651968. It was also communicated on the CNSC website main page under "Latest News" at http://cnsc-ccsn.gc.ca/eng/ for August 30, which also includes a link to a copy of the presentation at http://www.nuclearsafety.gc.ca/eng/resources/presentations/2017.cfm#seniormanagement.

In total, 97 individuals attended the lunch and learn and the uptown evening lecture.



***Jacques Plourde***

On September 11, Mr. Jacques Plourde of J.A.Plourde Performance delivered a double feature to the NB Branch that discussed:

- **The CNS Strategic Plan - What's in it for the Branches?**

  The CNS has just renewed and modernized its strategic direction for the next 5 years. Branches are the key to sustaining and growing the CNS.
- **Nuclear Insurance - A Risk Control Engineer's Perspective.**

  Risk at insured nuclear sites is evaluated on an ongoing basis by a team of specialists, and the results fed directly into their coverages and premiums. With the new Nuclear Liability and Compensation Act in Canada, there is a lot more at stake for both the insurer and the operator.

The event was attended by 18 individuals ranging from new nuclear staff to nuclear retirees who were well engaged and asked many insightful questions.

### UOIT BRANCH – Eleodor (Dorin) Nichita

The Branch's representative, Tyra Gordon, has continued to work with the organizing committee of the DC-UOIT Toronto-area job fair scheduled for October 21st.

### TORONTO BRANCH – Andrew Ali

No report for the period.

### BRUCE BRANCH – John Krane

No report for the period.

### GHS BRANCH – Kendall Boniface

No report for the period.

### DURHAM REGION BRANCH – Co-Chairs Jacques Plourde and Nick Preston

## WESTERN BRANCH – Matthew Dalzell

### General

The Branch carried on a number of activities through the summer and into September.

### Branch Activities

Nominations were held for positions on Branch Executive from July 15 to August 31. No positions were contested. Although five nominations were received for four Member at Large positions, it was decided to invite all five nominees to serve.

The Western Branch Executive for 2017-2019 is:

- Dr. David Malcolm, Inuvik, Co-Chair (two-year term)*
- Mr. Matthew Dalzell, Saskatoon, Co-Chair (one-year term to September 2018)*
- Dr. Kurt Stoll, Saskatoon, Secretary-Treasurer
- Dr. Robert Varty, Edmonton, Membership Coordinator
- Mr. Aaron Hinman, Edmonton, Education and Outreach Coordinator
- Mr. Arthur Situm, Saskatoon, Technical Coordinator and Branch Webmaster
- Dr. Duane Pendergast, FCNS, Lethbridge, Member at Large
- Mrs. Dazawray Landrie-Parker, Saskatoon, Member at Large
- Dr. Barbara Szpunar, Saskatoon, Member at Large
- Dr. Ashok Khanna, Dhanband Jarkhand, India, as Member at Large
- Mr. Shaun Ward, Lethbridge, Member at Large
- Dr. Jason Donev, Chair of the Calgary Chapter ex officio

*subject to approval of CNS Council

The Branch Executive thanks the nominating committee, Rob Varty, Duane Pendergast and Kurt Stoll for their work. We also recognize and thank Duane Bratt, Cody Crewson and Ron Matthews for their service as charter members of the Western Branch Executive.

The Calgary Chapter had a meeting on August 19. The Saskatoon Chapter held an impromptu lunch meeting on October 2 and will be co-hosting a pub for Nuclear Science Week.

### Outreach Activities

**Jason Donev** spoke at community meetings in Manitouwage, Hornepayne, Ignace and Wabigoon Lake Ojibwa Nation, in Ontario. The talks were well-received in all of the communities. Jason met with the mayors, municipal employees, First Nation leaders, community liaison committees and educators from the communities and discussed possible CNS collaboration on activities. They are all quite excited about the possibility of being communities that will become centres of nuclear industry activity and hope to be involved with the CNS and WiN. Several people are excited to be attending both the CNS fire safety and other conferences and the WiN conference as well.

Planning is also well underway for Nuclear Science Week (October 21-28) activities, including:

- a Nuclear Coffee Break and Nuclear Science Week pub featuring Kirsty Gogan, CEO of Energy for Humanity, in Saskatoon on October 17.
- a talk by Jason Donev on how science fiction has influenced our perception of radiation at the Rothney Astronomical Observatory in Calgary on October 21.

### Nuclear Safety Culture Foundation Course

During July 2016, Hatch Ltd's Chief Nuclear Engineer approached CNS with respect to putting on a Nuclear Safety Culture Foundation course aimed at employees new to the nuclear industry. The intent was to aim the course at the "person off the street" and present an integrated nuclear safety culture framework that includes elements of defence in depth, technical conscience and human error reduction. CNS Council was informed of this request by Hatch Ltd. and agreed to proceed with development of a course. Team members developing the course included Keith Stratton, Stephen Yu, Nick Preston, Michael Smith, Rob Clemens and John Roberts (Chair).

Our team have received input and advice from utilities (including Bruce Power and OPG) and service providers (including COG, BWXT, Hatch, Kinectrics and SNC-Lavalin), which helps the course content to remain relevant to the industry current activities.

Following a course pilot, or dry-run, in August 2017 the first course was delivered to Hatch employees on 16th November. Response from course participants was positive (92% rating). A second course will be held again to Hatch employees at Hatch's offices.

Naturally, the course will need continuous updating reflecting continuous improvement!

Current course content is directed at engineering/knowledge workers. The course uses a Systematic Approach to training, including defined terminal and enabling objectives and testing, leading to a qualification that is recognized across the Canadian nuclear industry; which is a unique plus! It is planned during 2018 to develop material more appropriate for those individuals who also work "on the tools" and/or "in the field". We anticipate this material would be ready for delivery later in 2018.

If you have questions, please direct them to John Roberts - alchemy@tnt21.com

John Roberts on behalf of the team:

Pamela Tume (Team co-Chair), Stephen Yu, Doug Gould, John Kaminski, Ken Keown, Bill Pike, Rob Clemens, Keith Stratton, Nick Preston, John Roberts (Team Co-Chair).

# CNS-UKNI Speaker Exchange Program Kicks Off in November

by COLIN HUNT

*Dr. Alys Gardner and Ottawa Branch President Ken Kirkhope.*

The first in a series of exchanges in the speaker exchange program between the Canadian Nuclear Society (CNS) and the United Kingdom Nuclear Institute (UKNI) commenced in November with the speaking tour of Dr. Alys Gardner. Addressing the Ottawa Branch of the CNS, Dr. Gardner was in the middle of a week-long speaking tour of the CNS Branches across Canada.

Her address was given to the Ottawa Branch at the main meeting room of the Canadian Nuclear Safety Commission (CNSC). During the course of her 90-minute address, Dr. Gardner gave a detailed overview of the British nuclear industry, its development and its current activities and prospects. Her talk was attended by more than 100 in the audience, making it perhaps the largest event the CNS Ottawa Branch has ever held.

According to Dr. Gardner, the current British nuclear industry is divided into seven principal areas of activity: research and development, security and safeguards, new construction, power generation, enrichment and fuel fabrication, waste management and decommissioning, and defence.

In all of these areas, Britain is looking at expansion and new development, and Dr. Gardner outlined the new developments in each. New construction is the current largest topic in British public discourse, and she outlined the current state of each of the three projects: Hinkley C, Wylfa and Moorside.

Looking to current nuclear technology, Dr. Gardner indicated that recent work by Electricte de France indicated that the bulk of the existing reactor fleet composed of Advanced Gas Cooled Reactors should continue to operate to the end of the 2020s. At that time, she indicated that new nuclear generation must be in place to assume the burdens of the existing reactor fleet.

Turning to the future, Dr. Gardner indicated with most informed Canadian observers that Britain agrees that small modular reactors are quite likely to form a large part of the industry's future. She noted that there was no possibility of meeting the government's emission reduction plans without a large contribution of nuclear power to Britain's future energy supply.

Civilian nuclear power is not the only area of nuclear development in Britain. The country's existing fleet of Trident ballistic missile submarines is now due for retirement. Accordingly the Defence Ministry is now finalizing plans for the replacement Dreadnought program as well as preparing for eventual decommissioning of its existing strategic submarine fleet.

Dr. Gardner indicated that nuclear in Britain was now very much a growing industry. At this time, the country will need an additional 100,000 skilled workers by 2021 simply to carry out the existing projects. This worker shortage is exacerbated by the retirement of many of Britain's existing nuclear workers over the next five years.

Complicating matters for Britain's nuclear industry is the advent of Brexit. Dr. Gardner noted that the British government has provided formal notice to withdraw from the Euratom treaty. This withdrawal will have an impact on nuclear materials, international nuclear expertise, research and development programs, and nuclear facilities directly. There was a consequent need to formalize Britain's nuclear arrangements quickly, and she suggested that either the Swiss or Canadian models might be appropriate for Britain's international arrangements.

The UKNI is a society of nuclear industry professionals similar to the CNS. It has a current membership of approximately 2,500. Its goals and activities are also similar to the CNS. The Speaker Exchange Program commenced with an initiative of the CNS Council to exchange speakers with other nuclear societies with which the CNS has collaborative agreements. Dr. Alys Gardner was the speaker to the CNS branches in 2017, and the CNS will be reciprocating in 2018 by sending a speaker to Britain to meet with their branches.

# GENERAL news

(Compiled by Colin Hunt from open sources)

## Nuclear power remains the best option to meet Ontario's future electricity needs

That's the conclusion of Ontario's Financial Accountability Officer (FAO) following an exhaustive assessment of the province's plan to refurbish 10 nuclear reactors at the Bruce and Darlington Nuclear Generating Stations, and extend the life of six reactors at the Pickering Nuclear Generating Station.

The FAO's report found that refurbishing Ontario's nuclear stations is the preferred generation option from both economic and environmental perspectives. The report estimates the average cost of nuclear at $80.70 per megawatt-hour (MWh) through to 2064. That's lower than Ontario's current average overall cost of electricity of $115/MWh. It is also priced lower than electricity sourced from wind, solar, gas or bio-energy.

Energy Minister Glenn Thibeault said in a statement November 21 that the report confirms that his government has carefully considered the nuclear projects at Bruce Power and Ontario Power Generation (OPG).

"The FAO report also makes it clear that there is currently no alternative clean, emission-free generation which could replace nuclear generation at a comparable cost for Ontario ratepayers," Mr. Thibeault said.

According to the Ontario Energy Board, water power is currently the only electricity generation that's cheaper than nuclear as bio energy, wind, gas and especially solar are all dramatically higher in cost. While some contracts for wind and solar have come in at much lower prices, replacing nuclear base power with these renewables would be far more expensive than refurbishment, the report says.

It also noted that Quebec is forecasting less surplus electricity in the future.

## NRU Reactor marks 60 years in operation

On Nov. 3, 1957 at 6:03 a.m., the world's oldest operating nuclear reactor went critical beginning a remarkable life as a generator of science and technology advancement.

Although its operational life will be ending in less than five months, the National Research Universal reactor continues to generate isotopes used to treat or diagnose over 20 million people in 80 countries every year. It is the neutron source for the National Research Council Canadian Neutron Beam Centre and is the test bed for Atomic Energy of Canada Limited (AECL) to develop fuels and materials for the CANDU reactor.

*NRU 60th anniversary - CNL staff and municipal leaders.*

"We all know it as a grand old lady," declared Canadian Nuclear Laboratories (CNL) president and CEO Mark Lesinski as he addressed some of the 500 men and women solely responsible for the day-to-day operations of the NRU adding this lady is not showing signs of aging. "This reactor is running better than it ever has. This has been a great run. Sixty years is extraordinary."

CNL vice-president of operations Dave Cox expressed pride in not only reaching this milestone but in the long years and decades of dedicated from the scientists and technicians who've kept it running. He estimated that 500 million worldwide have benefited from the isotopes alone, while other significant advancements in research and development have been made.

"This reactor was designed in the day of slide rules and before computers," said Cox. "There aren't many plants in the world that have operated as long as we have."

Running 230 days a year, the NRU produces 75 per cent of the world's supply of Cobalt-60 which is used in radiation therapy machines that treat cancer in 15 million patients in 80 countries each year. It also produces xenon-133, iodine-131 and iodine-125, which are used in a variety of diagnostic and therapeutic applications. It also serves as Canada's national facility for neutron scattering, the technique where a beam of

neutrons shines through a sample of material allowing scientists to determine many details about the crystal structure and movements of the atoms within the sample. In 1958, the NRU became the first reactor in the world to change fuel rods while in operation.

## Wood Group Sells Amec Foster Wheeler's North American Nuclear Operations to Kinectrics Inc.

Wood Group has agreed to sell Amec Foster Wheeler's North American nuclear operations to Kinectrics Inc for around $10 million (£7.6 million).

The sale value is calculated after adjustments for defined benefit pension related debt and is subject to closing adjustments.

Wood Group said the sale includes Amec Foster Wheeler's nuclear operations in the US and Canada along with a small operation in Romania.

Amec Foster Wheeler, which Wood Group recently acquired in a £2.2 billion all-share takeover, stated in June it had decided to retain its European nuclear business after putting the entire unit up for sale in March in a bid to tackling its £1 billion debt pile.

The decision to retain the European nuclear business was made following consultation discussions with Wood Group.

The North American business sale is expected to close in the fourth quarter of 2017, subject to competition clearance in Canada, and the Romanian business sale is expected to close early in 2018, subject to regulatory approval in Romania.

## Fraser Institute study finds nuclear, hydro-electric are lower cost options for Ontario

The Ontario government released an update to its long-term energy plan last month, projecting that the cost of electricity for homes and businesses will keep rising over the next 20 years.

Specifically, the average monthly electricity bills for residents and large industrial customers in northern Ontario will jump 52% according to a study by the Fraser Institute.

The Institute analysis also noted a report from the Ontario Energy Board in 2016 found that nuclear and hydroelectric generators, despite providing the majority of electricity output in Ontario, received much lower rates than wind, solar and biofuel generators.

The Fraser Institute also observed that between November, 2016 and October, 2017, the rate paid to wind generators ($140 per megawatt-hour or MWh, a common unit for measuring power) was more than double that of hydro and nuclear generators.

In addition, the rate paid to solar generators ($480 per MWh), was more than seven times the rate paid to nuclear generators ($66 per MWh) and more than eight times the rate paid to hydroelectric generators ($58 per MWh).

In 2016, combined solar, wind and biomass generated less than 7% of electricity in Ontario. Between 2005 and 2015, the province increased its renewable capacity – solar, wind and bio-energy – by 18%. But because of variability of renewable sources, the government also had to secure more natural gas capacity as a back-up, increasing Ontario's gas capacity by 9%.

As a result, the province realized a 26% increase in capacity from 2005 to 2015. Meanwhile, the demand for electricity declined, partly due to rising electricity costs.

## CNWC supports Ontario's Long Term Energy Plan

The Canadian Nuclear Workers Council (CNWC) is pleased with the central role nuclear energy plays in the Ontario Government's Long-Term Energy Plan (LTEP).

The updated Plan, released on October 26, recognizes the importance of Ontario's publically owned nuclear reactors to the environment and economy. Ontario remains committed to the cost-effective refurbishment of the Bruce and Darlington nuclear reactors and continued operation of the Pickering Nuclear Station to 2024. The four-year operating extension of Pickering will support the refurbishment outages during this period by reducing greenhouse gas (GHG) emissions and the cost of electricity service to Ontario homes and businesses.

The CNWC also commends Ontario's support to create new export opportunities for nuclear innovations such as Small Modular Reactor Technology, nuclear fuel research and hydrogen production.

## Next Major Phase of Darlington Refurbishment Begins

*Work on Unit 2 turbine.*

Canada's largest clean energy project remains on time and on budget as the refurbishment of Ontario Power Generation's (OPG) Darlington Nuclear Generating Station


started on November 27 its next major phase - the removal of the reactor components of Unit 2.

The new phase will continue to June 2018, and includes removing vital reactor components from Unit 2, such as end fittings, pressure tubes and calandria tubes. The work on Unit 2 is now 40 per cent complete and up to now has included successfully defueling and separating the unit from the rest of the station, and preparing the reactor for disassembly.

The Darlington Refurbishment project and the subsequent operation of Darlington Nuclear for thirty years will have a positive $90 billion impact on Ontario's economy, and create 14,000 jobs per year to 2055. The Darlington Refurbishment is a made-in-Ontario project, with 96 per cent of the project's budget invested in this province, supporting hundreds of Ontario companies.

Sixteen of 18 major projects required to support Unit 2 refurbishment are now complete, with another scheduled for completion in early November. While the final project, the Heavy Water Storage Facility, has faced challenges, OPG is managing these issues within the overall scope of the project and has factored them into the total cost.

It's expected Unit 2 will take approximately 40 months in total to refurbish before re-joining Ontario's power grid. Planning for refurbishment of Unit 3, the next to undergo the mid-life update, is underway.

## Bruce Power, Cameco, Nordion Provide Reliable Supply of Cobalt-60

For the past six decades, High Specific Activity (HSA) Cobalt-60, used in the treatment of cancer, has been produced in Canada at the National Research Universal (NRU) reactor at Chalk River, Ontario. The NRU reactor will reach its end-of-life by March 31, 2018. Under agreements between Nordion, Bruce Power and Cameco, the production of HSA Cobalt-60 has been successfully migrated to CANDU nuclear power reactors.

Cameco Fuel Manufacturing Inc., in Cobourg plays a major part in the production process by providing specialized carriers and loading them with Cobalt-59 for insertion into the CANDU power reactors at Bruce Power's generating station. After 24-30 months inside the reactor, the adjuster sets are removed and safely transported to a Nordion facility where the Cobalt-60 is removed and manufactured into finished product for delivery to customers around the world.

*Harvesting cobalt.*

"This partnership between Cameco, Nordion and Bruce Power to produce medical isotopes makes perfect sense, and builds on Canada's contributions to nuclear medicine," said Kim Rudd Parliamentary Secretary to Canada's Minister of Natural Resources. "It will ensure a stable and reliable supply of Cobalt-60 for use in healthcare and other applications that benefit people around the world."

The Province of Ontario provides 50% of the world's supply of Cobalt-60, all of it through Nordion. These isotopes are used for specialized cancer treatment and to sterilize 40% of the world's single-use medical devices, including sutures, syringes, surgical gowns and masks. They're also used to sterilize pharmaceutical wares and cosmetics, and irradiate spices and other consumer products that include fruit, seafood, poultry and red meat.

Nordion and Bruce Power have entered into an agreement to secure the long-term supply of Cobalt-60 for medical and other applications through the life of the four Bruce B reactors, which will operate up to 2064 once life-extension maintenance programs are completed over the next two decades.

## CNL Releases Summary Report on Small Modular Reactor RFEOI

On October 17, Canadian Nuclear Laboratories (CNL) released a summary report to its Request for Expressions of Interest (RFEOI) on small modular reactors. This initiative yielded responses from 80 organizations around the world, including 19 expressions of interest in siting a prototype or demonstra-

tion reactor at a CNL campus. CNL launched the RFEOI this summer to gather feedback and initiate a conversation on the potential for an SMR industry in Canada, and the role CNL can play in bringing SMR technology to market.

Responses came from a broad range of stakeholders, including SMR technology developers, potential end users, host communities, supply chain companies and academic institutions. There were areas of general agreement, including the positive economic benefits to Canada, alignment with Canada's commitment to fight climate change, important applications for remote communities, and the potential to enhance nuclear safety through next-generation nuclear technology.

With respondents from across the globe, the breadth of technologies proposed reinforces the need for ongoing research. The designs featured enhanced safety systems and greater levels of efficiency, many also propose novel fuel types and engineered systems; these aspects will require intensive study and investigation prior to licencing and ultimately deployment. Responses to the report also explored the possibilities of SMR technology beyond the generation of electricity. A number of responses indicated interest in integrating SMRs as part of a more diverse energy strategy, with applications as varied as district heating, co-generation, energy storage, desalination, or hydrogen production.

## CNL Announces Near Surface Disposal Facility Project Update

Canadian Nuclear Laboratories (CNL), Canada's premier nuclear science and technology organization, announced November 24 that it has requested an amended timeline for its Near Surface Disposal Facility project. CNL is currently working with the Canadian Nuclear Safety Commission (CNSC) to establish a revised schedule for final regulatory submittals, including the submission date for the final Environmental Impact Statement (EIS).

Last month, CNL made the decision to only include low-level radioactive waste in the proposed facility. This decision was based, in part, on public remarks and federal technical submissions received through formal comments on the draft EIS. CNL also received requests for additional technical information from the CNSC. To respond, and to provide adequate time for third-party review, CNL has determined that the schedule for final EIS submittal and the licensing hearing will need to be amended.

"CNL believes the proposed Near Surface Disposal Facility project is critical to the renewal of the Chalk River Laboratories," commented Kurt Kehler, Vice-President of Decommissioning and Waste Management at CNL. "It is an environmentally responsible solution to address waste material generated from historical operations at our nuclear sites."

CNL's Near Surface Disposal Facility will be an engineered containment mound at the Chalk River Laboratories site to safely dispose of solid, low-level radioactive waste.

The Near Surface Disposal Facility will provide safe disposal of:

- Legacy waste from 65 years of operations;
- Waste from the remediation of contaminated lands;
- Debris from decommissioning outdated infrastructure at Chalk River Laboratories as part of ongoing site revitalization.

## Cameco Suspends Production at Key Lake, McArthur River

Cameco announced November 8 that due to continued uranium price weakness, production from the McArthur River mining and Key Lake milling operations in northern Saskatchewan will be temporarily suspended by the end of January 2018 and that the company's annual dividend will be reduced to $0.08 per common share in 2018.

"With the continued state of oversupply in the uranium market and no expectation of change on the immediate horizon, it does not make economic sense for us to continue producing at McArthur River and Key Lake when we are holding a large inventory, or paying dividends out of proportion with our earnings," said Tim Gitzel, Cameco's president and CEO.

As a result of the suspension, the workforce at the operations will be reduced temporarily by about 845 workers (560 employees and 285 contractors). About 210 workers (160 employees and 50 contractors) will be retained to maintain the facilities in safe shutdown state.

Cameco plans to meet its commitments to customers from inventory and other supply sources during the suspension, which will be reviewed on an ongoing basis until inventory is sufficiently drawn down or market conditions improve. The duration of the suspension and temporary layoff is expected to last 10 months.

## US Test Reactor Resumes Operations

**A test reactor at the US Department of Energy's Idaho National Laboratory was restarted November 15 after more than 20 years on standby. The Transient Reactor Test Facility (TREAT), used to test nuclear fuels and materi-**

*TREAT reactor Idaho National Laboratories.*

**als under extreme conditions, had not operated since being shut down in 1994.**

The DOE proposed in 2013 to re-establish the capability to conduct transient testing of nuclear to aid in the development of new, advanced, safer and more efficient reactor fuels. It subsequently decided to restart TREAT. The reactor was restored to operational status after the completion of an extensive inspection, refurbishment, evaluation and assessment program, culminating in the low-power run conducted on November 15. The resumption of operations was achieved 12 months ahead of schedule and cost nearly $20 million less than the $75 million originally estimated.

## Upgraded Krško Simulator Operational

**Canada-based L3 MAPPS has completed an upgrade of the full scope simulator at the Krško nuclear power plant in Slovenia. The upgrade was carried out as part of a safety upgrade programme to modernise the plant.**

As part of the upgrade, the simulator's UNIX operating system-based simulator has been replaced with a virtualized Windows-based platform running L3's Orchid simulation environment. A new compact input/output system has been installed that will be used to drive a new simulated emergency control room, which replaces remote shutdown panels spread throughout the plant. The nuclear island and conventional island models have been migrated into Orchid. The models have also been upgraded to reflect plant changes made as part of NEK's safety upgrade program following the March 2011 accident at Japan's Fukushima Daiichi plant.

L3 MAPPS - which was awarded a contract by Nuklearna Elektrarna Krško (NEK) in April 2016 - said October 25 that the upgraded Krško simulator is now "ready for training".

## Drilling Begins in Canadian Repository Search

**Canada's Nuclear Waste Management Organisation (NWMO) has begun drilling the first borehole to obtain geological core samples, in its search for a potential deep repository for the long-term management of the country's used nuclear fuel.**

Drilling began on 6 November in a rock formation known as the Revell Batholith about 35 kilometres west of Ignace, Ontario. The hole is being drilled using a skid-mounted diamond drill rig. Work at the site is expected to continue for at least three months, with subsequent analysis taking about a year. Findings from the study will be reviewed by geoscience, environmental, engineering and repository safety specialists.

## In Memoriam

It is with regret that we announce that long-time CNS member Edgar Rande passed away on Sept. 18, 2017 at the age of 94. To the end he valued his membership in the Canadian Nuclear Society very highly.

## CNS Membership Note

It is time to renew your CNS membership for 2018. 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 2018. 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

# 2018 Canadian Nuclear Achievement Awards
# Call for Nominations

We are announcing the Call for Nominations for the 2018 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 19, 2018.** The Awards will be officially presented during the CNS Annual Conference held June 3 – 7, 2018 in Saskatoon, Saskatchewan, 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.


**38th Annual Conference of the Canadian Nuclear Society and**

**42nd Annual CNS/CNA Student Conference**

***The Nuclear Future: Challenges and Innovation***
***Notre avenir nucléaire : défis et innovation***

**2018 June 3 - 6**
**Sheraton Cavalier Saskatoon Hotel, Saskatoon, SK**

# Call for Papers

The peaceful application of nuclear science and technology has contributed clean, safe and resilient energy to mitigate climate change challenges; diagnostic and therapy tools that improve individual health; and means that enhance security of the global community.

It is anticipated that enhancement of these benefits through research and development will continue well into the 21st century, accompanied by an increase in public confidence and acceptance of nuclear science and technology.

The Canadian Nuclear Society (CNS) will host its 38th Annual Conference at the Sheraton Cavalier Saskatoon Hotel in Saskatoon, Saskatchewan, Canada, 2018 June 3-6. This conference provides a forum for communication of new ideas, information exchange of progress and achievements, and a forum to discuss energy-related issues in general. Technical topics of interest are listed on the following page. The CNS 38th Annual Conference will feature:

- Plenary sessions with invited speakers to address such topics as large scale refurbishment projects, options for future new-build, etc.
- 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.
- An embedded topical meeting on Small Modular Reactors (SMR) with focused plenary and technical sessions dealing with the potential of and challenges to licensing and deployment of SMR in Canada.
- Exhibits with industrial leaders showcasing their latest nuclear products and technology.
- A Student Conference with student posters
- Social events (such as opening reception, lunches, conference banquet, wine-&-cheese reception, coffee breaks and conference banquet) that facilitate discussions and networking on subjects of common interests.

The 42nd Annual CNS/CNA Student Conference will be held in parallel at the same venue, which facilitates interaction between experts and the future generation of nuclear scientists, engineers, and specialists,. 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: **2017 December 30**
Draft paper submission: **2018 February 14**
Full paper submission: **2018 April 1**

**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 material that is 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.cns2018conference.org.
- Submission should be made via: http://www.softconf.com/h/CNS2018Technical
- Notes: At least one of the authors must register for the Conference by the "early" registration date (2018 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


**38th Annual Conference of the Canadian Nuclear Society and**
**42nd Annual CNS/CNA Student Conference**

***The Nuclear Future: Challenges and Innovation***
***Notre avenir nucléaire : défis et innovation***
**2018 June 3 - 6**
**Sheraton Cavalier Saskatoon Hotel Sheraton, Saskatoon**

**CALL FOR PAPERS – TECHNICAL TOPICS**

| | |
|---|---|
| **New Reactors and Construction Challenges** | Establishing new build program; International collaborations; Risk-informed safety regulation; Policy; Regulation and risk assessment; Probabilistic & deterministic risk analysis; Addressing life extension and license renewal; Design and construction; Economics and financing; New - site licensing; New developments and designs; Gen-III+ designs/ Gen IV advanced systems and components; Passive safety |
| **New Technology Research and Development** | Advanced reactor physics, radiation physics and health physics; Thermal hydraulics; Fusion; Hydrogen production ; Efficiency enhancements; Space and mining applications; New nuclear codes and standards |
| **Small Modular Reactor Embedded Topical Meeting** | *Canada has emerged as a leading market for SMR development, driven by supportive regulatory regimes, research support and numerous deployment opportunities.*<br>*Plenary sessions on deployment opportunities, design, licensing and deployment challenges. Technical sessions on SMR concepts, their applications in mining, remote locations as well as new-build opportunities and related topics.* |
| **Operation and Aging Management** | Refurbishment and life extension; Economics; Maintenance; Reliability; Quality Assurance / Inspection; operational risk assessment; Outage management; 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** | Post Fukushima perspectives: 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** | Experience from Fukushima; Social impacts; Educating & partnering with public; Opinion surveys; Radiation protection; Linear-no-threshold issues; Radiation health effects; Lessons learned; Outreach |
| **Competitive Challenges and Cost Reduction** | Design and construction; Manufacturing and modularity; Economics and financing; Supply chain assurance; Outage management; Market and competitive challenges |
| **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; Isotope production and use; Agricultural applications |

**Canadian Nuclear Society**
**Société Nucléaire Canadienne**
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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 2018: 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 such as 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, 2018**.

**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 2018: 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 être suffisant pour 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 2018**.

# Calendar

## 2018

| | |
|---|---|
| **February** | **CNA Nuclear Industry Conference and Tradeshow**<br>Westin Hotel<br>Ottawa, Ontario<br>cna.ca/2018-conference |
| **March** | **CANDU Technology & Safety Course**<br>cns-snc.ca |
| **April 22-26** | **PHYSOR 2018**<br>Cancun, Mexico<br>physor2018.mx |
| **May 2018** | **Nuclear 101**<br>cns-snc.ca |
| **June 3-6** | **38th Annual CNS Conference & 42nd Annual CNS/CNA Student Conference**<br>Sheraton Cavalier Hotel<br>Saskatoon, SK<br>cns2018conference.org |
| **June 17-21** | **ANS Annual Meeting**<br>Philadelphia, PA<br>ans.org/meetings |
| **Sept. 30-Oct. 3** | **PBNC 2018**<br>San Francisco, CA, USA<br>pacificnuclear.net/pnc/pbnc<br>ans.org/meetings/c_2 |
| **Fall** | **Waste Management, Decommissioning and Environment Restoration for Canada's Nuclear Activities**<br>cns.snc.ca |
| **Fall** | **International Conference on Simulation Methods in Nuclear Engineering**<br>cns-snc.ca |
| **Fall** | **International Technical Meeting on Small Reactors**<br>cns-snc.ca |
| **Nov. 11-15** | **2018 ANS Winter Meeting**<br>Orlando, FL, USA |

## 2019

| | |
|---|---|
| **February** | **CNA Nuclear Industry Conference and Tradeshow**<br>Westin Hotel<br>Ottawa, Ontario<br>cna.ca/2019-conference |
| **March** | **CANDU Technology & Safety Course**<br>cns-snc.ca |
| **May** | **Nuclear 101**<br>cns-snc.ca |
| **June** | **39th Annual CNS Conference & 43rd Annual CNS/CNA Student Conference**<br>cns2019conference.org |

## From The Publisher *continued from page 2*

of the Swedish government is as dead as Marley's Ghost. Perhaps it's ironic justice: Sweden led European nations into nuclear phaseout policies; perhaps it will lead them out.

The past year has been equally successful for the CNS. A strong CNS Annual Conference in Niagara Falls was followed by two highly successful technical conferences: the 2nd International Fire Safety and Emergency Preparedness Conference; and the 11th CANDU Maintenance and Nuclear Components Conference, all as reported in this and previous Bulletins.

All of these events have shown an enthusiasm and growing strength within those in Canada's nuclear industry for its current and future prospects. All of the CNS conferences, both general and specialized, attract hundreds of students annually.

The interest of students looking at future careers in nuclear science and technology is indeed strong. During October, the CNS held its first ever career job fair. Hundreds of students, both post-graduates and those near graduation, attended the day-long event. Nearly 50 companies were on hand to introduce them to their companies, what they did, and what the employment prospects are. So strong was the interest from both students and sponsors that the CNS will indeed hold such events again in 2018 and beyond.

Because that's where the future lies. Not just in gadgets and toys and position papers, but in the drive and enthusiasm of the young to carry on and grow Canada's rich and extensive history in nuclear science and technology. They see far more clearly than the industry's critics the true promise that Canadian nuclear technology has both for Canada and for people around the world.

Long ago, when we believed in a greater prosperity for all, the old Hydro-Electric Power Commission of Ontario (HEPCO) coined the phrase "Live Better Electrically". By and large, HEPCO and its successor Ontario Hydro lived up to that slogan with the rapid transformation of Ontario's infrastructure from direct combustion of fossil fuels into new electro-technology.

What we can see today with the new generation is that Live Better Electrically will indeed continue, and that it will be sustained by the atom.

*CGH*

# 2017-2018 CNS Council • Conseil de la SNC

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## 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**

# We are not really alone

by NEIL ALEXANDER

Nuclear power starts with the field tilted against it. People are fearful of big technologies that they are not familiar with and do not fully understand.

The field tilts still more because in the public's mind nuclear power is inextricably linked to terrifying weapons and through those weapons to cancer, the most terrifying of diseases.

Then, because of these fears our dirty laundry gets aired very publicly so that many many more people notice if an incident at a nuclear plant leads to loss of a life than would hear about a windmill catching fire and killing someone (and yes, if you didn't know already, they do this with surprising frequency).

So, whenever we go out to talk about nuclear power, we enter a space that we know we share with an elephant called "safety". In making sure that we acknowledge the presence of the elephant we tilt the playing field still further.

And this despite the fact that we clearly have facts on our side. Nuclear power, notwithstanding its well publicized incidents, over my life time (and my grey hair shows this has statistical significance), has killed less people for the amount of energy it has generated than any other energy source. If safety is really the issue then nuclear power should be the preferred generation choice.

But once the safety cat is out of the bag all sorts of imaginary challenges have to be dealt with.

In responding the first thing that becomes evident is that it isn't just that the pitch is tilted but that at the very least the referee of public opinion is keeping a closer eye on us than on the opposition. Protestors can just make stuff up and they will not be penalized for it. They can exaggerate without consequence. They can, and do, discredit by casting aspersions on the character of people representing the industry.

We can do none of these things. One error of fact and we're done, one oversimplification, we're done. Suggest that Greenpeace is actually a large corporation doing stuff that benefits the corporation. Oh dear, I am done.

It all seems very unfair.

And sometimes it feels like it is just us.

But it isn't.

The attack on science, logic and common sense is widespread and affects many other industries. Imagine how the vaccine people feel. Save lives and be vilified for it. Unsafe pipelines have failed to get approval so that oil can be moved by train. And the genetic modifiers can't get approval to eliminate vitamin A deficiency and the annual deaths of over 670,000 under fives that it causes.

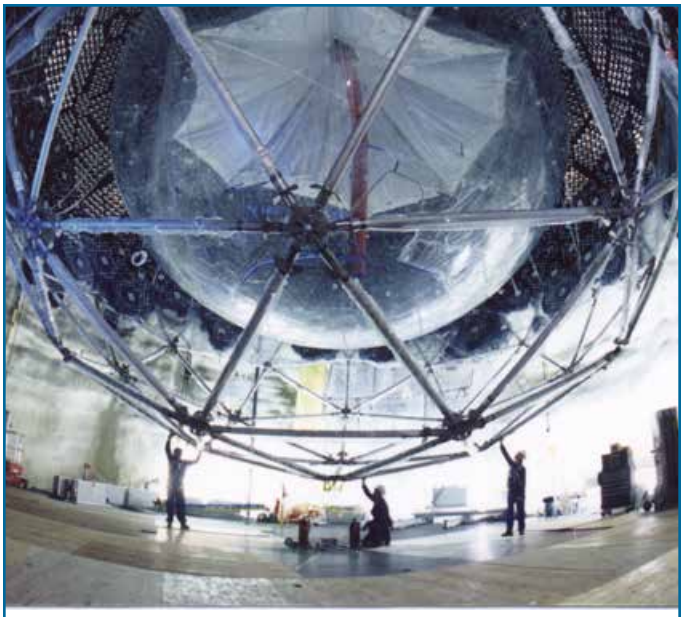
They are all on a similar tilted pitch trying to understand what rules they have to play by and what the opposition will be allowed to get away with.

That is why I am excited by initiatives such as the Centre for the Study of Science and Innovation Policy at the Johnson-Shoyama Graduate School of Public Policy that cut across industries to try to understand the fundamental issues so that in the future we might make technology decisions that achieve our objectives rather than pander to "informed" opinion.

A lot of money is being spent on new technologies, including new styles of reactors, and no matter how safe, or economic, or efficient they are, it will all be wasted if they hit the brick wall of poor policy making.

A few dollars spent on understanding that brick wall is a great investment.

And finally, I would like to apologise for using a mix of at least four metaphors in the space of less than 650 words. Sadly, Elephants don't play field sports or do laundry, no one cares if there is a cat in the room, you can't really put an elephant in a bag and none of these things get stopped by immovable physical objects. I had no choice. Honestly.



*Deep below the earth's surface, scientists seek to understand the fundamental basis of nature at the Sudbury Neutrino Observatory*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www.CNL.ca/SMR

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Your participation through a short survey will help us identify the challenges and opportunities faced in bringing an SMR to successful deployment. We would like to have your input and invite you join the discussion at www.CNL.ca/SMR.

Submission deadline: July 31.