

COGNIZANT

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Building leadership culture in China

'Made in CANDU' innovation

COG Collaboration Week special feature

COG GBM features industry leaders:
Lyash, Rencheck and Imbrogno

New Brunswick Power's Brett Plummer

**A veteran nuclear leader and
fisherman on feeling at home
on the Bay of Fundy**



CANDU Owners Group
President Fred Dermarkar

Making the case for nuclear

**COG's role is not advocacy.
But the work we do can make the facts more compelling.**

In Canada and worldwide, nuclear is having a moment.

System regulators and governments are recognizing an urgent need for clean, low-carbon electricity generation options with sufficient output to replace carbon-intensive workhorses like coal. They understand the need to address climate change in the immediate term. Nuclear can check a lot of the boxes.

But scrutiny is a double-edged sword. The proof points must be clear with a case that is easily translated into political sound bites. Of course, it's not often one hears nuclear described as simple. In fact, it is the size, complexity and variables of nuclear that makes public communication and social licence difficult.

In Canada, the nuclear leadership of the operators and Tier 1 suppliers have been taking a hard look at how to most effectively manage their own operations, the supply chain, industry associations and related resources. They are looking to leverage human, organizational and technical factors both in operations and throughout the supply chain to ensure continuous improvement in all facets of performance.

Their focus is on what happens within the plant, the efficiencies they can attain and the levers for performance improvement. But the importance of these efforts is not confined to the interior of nuclear plants. To the contrary, they take on greater import through the external lens of the regulatory, economic and social spheres where decisions are made about the role nuclear will play today and in future energy systems. As much as we, as an industry, care about continuous improvement, our stakeholders and the publics who determine the industry's future, care more.

Job 1 is to operate our nuclear plants and manage our projects in a way that inspires the confidence of electricity consumers and those who represent their interests as safety and economic regulators, as government officials and as host community leaders.

Within the industry, we each have a role to play. At COG,

ours is to ensure that our members (CANDU operators), supplier participants and partners including academia, have the mechanisms through joint projects, shared research and development, forums, peer groups, information exchange and training to collaborate for technical excellence and future innovation. The technical solutions we develop and the learnings we gain together create the proof points of performance excellence that the Canadian Nuclear Association and others can use to help decision makers and publics make informed, fact-based decisions about nuclear as a tool of human development and planetary sustainability.

"Whether it is CANDU or a small modular reactor (SMR), Canadian or international, nuclear has a role to play in providing low-carbon electricity that powers people's lives. COG has a role in ensuring continuous improvement in safe, reliable, environmentally-sound and cost-effective performance that will assure people of its value."

Whether it is CANDU or a small modular reactor (SMR), Canadian or international, nuclear has a role to play in providing low carbon electricity that powers people's lives. COG has a role in ensuring continuous

improvement in safe, reliable, environmentally-sound and cost-effective performance that will assure people of its value.

In this issue of COGnizant, you will read about COG initiatives to achieve just that, including: an introduction to some COG peer groups; joint projects and R&D efforts; our upgraded member workspace at cogonline.org; and the Nuclear Professional Development Seminar (NPDS) training helping to develop industry leaders, worldwide. As well, we have updates on member activities in operations, refurbishment projects and new technologies. This includes a feature on New Brunswick Power's Chief Nuclear Officer Brett Plummer and his team's safety culture and leadership initiatives.

As well, accompanying this issue is a 12-page special feature looking back on the first COG Collaboration Week (CCW), which took place in June 2017. Our next CCW is scheduled for November in Niagara Falls. We hope you will consider participating in this week of cross-functional, international peer learning and collaboration. Together, through events like this and other shared initiatives, we create the proof points of performance excellence that make the case for nuclear, simple.

Refurbishment Updates pp. 22-25



In 2017, the Embalse Nuclear Plant refurbishment (above) hit a significant milestone, Darlington Unit 2 rounded into Year 2 execution and Bruce Power geared up with multiple life extension contract signings.
(Photo courtesy of Nucleoeléctrica)

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(member site: www.cogonline.org)

Cover photo courtesy of NB Power

Changing of the Guard

COG New Brunswick board member Paul Thompson passes the baton to Deputy Chief Nuclear Officer Michael Hare

The CANDU Owners Group (COG) board is saying goodbye to a valued colleague and welcoming a new face.

Long-time New Brunswick Power board member Paul Thompson is passing the reins to incoming Deputy Chief Nuclear Officer Michael Hare.

"We have been so fortunate to benefit from Paul's experience and insights to help direct COG's evolution as an organization," says COG President and CEO Fred Dermarkar. "His dedication as a board member and his friendship to everyone here at COG will be long and fondly remembered."

Thompson, an influential force within the industry, has been a COG board member since 2014. In addition to his role on the COG board, he is a past president of the Canadian Nuclear Society and a lead for many COG committees. His career spanned all three phases of the NB Power Refurbishment Project. Over the years, Paul has been a resource to COG sharing knowledge from four decades of experience in both technical and managerial roles at NB Power and before that at Atomic Energy Canada Ltd.

Hare, who replaces Thompson on COG's board, began his career with NB Power as a system engineer in 1992. He started with nuclear process systems, moving into a supervisory position before transferring to the certification stream. Hare's previous roles include station director, operations manager, refurbishment lay up, commissioning and restart manager and a secondment to World Association of Nuclear Operators as the OP and OR peer reviewer. The depth of his experience will contribute to COG's strength as an organization.

"We look forward to having Michael's voice on the COG board," says Dermarkar. Like Paul, he brings tremendous experience in many facets of projects and operations and will be a tremendous asset for the organization."

Other COG board members include Gary Newman, Senior Vice President Engineering & Chief Engineer at Bruce Power; David Cox, Vice President Operations & Chief Nuclear Officer at Canadian Nuclear Laboratories; and Steve Woods, Senior Vice President Engineering & Chief Nuclear Engineer at Ontario Power Generation.



New Brunswick Power's Michael Hare, incoming COG board member.



New Brunswick Power's Paul Thompson, outgoing COG board member.

Below and left: A rear-view look at Paul Thompson's time as COG board member includes (l-r) chairing the C6 Fleet steering committee, sharing a laugh with President and COG CEO Fred Dermarkar on break at a COG General Business Meeting and a more formal moment with fellow COG board members.



Innovation through research & collaboration



COG president speaks about CNL's contribution to Canada's nuclear industry at CNSC hearing

CANDU Owners Group (COG) President and CEO Fred Dermarkar spoke in support of the 10-year licence renewal for the Canadian Nuclear Laboratories (CNL) research and test facilities in Chalk River, Jan. 25.

In his remarks to the Canadian Nuclear Safety Commission at the hearing in Pembroke, Ont., Dermarkar referenced the important contributions CNL has made to the industry through its R&D activities at the site and through its membership in COG over the past several decades.

"CNL, through its facilities and researchers, is a national

asset that makes Canada stronger," Dermarkar said. "Through its contributions to the nuclear industry, CNL is helping Canada meet its goals for climate change through nuclear energy and helping utilities enhance the safety, reliability and affordability of nuclear energy through innovation... (and) helping to assure and enhance environmental protection."

The Jan. 23-25 renewal hearing included more than 85 submissions. It was webcast live and is available for 90 days on the CNSC website at www.nuclearsafety.gc.ca.

Read Fred Dermarkar's full remarks on COGonline or www.CANDU.org.

Red Cross fundraisers have an appetite for good deeds

They came, they ate and they raised money for a good cause.

On Sept. 12, COG hosted a *Canada 150*-themed staff BBQ.

With the help of their colleagues who ate their way through the event, the COG Charity Committee was able to raise \$440 to support the Red Cross. The funds raised will help prepare for disaster relief here in Canada.

When disaster strikes, the Red Cross relies on a network of trained volunteers and staff across Canada to provide assistance for people including family reunification, personal services, reception, and emergency lodging, food and clothing.

The food for the event was generously donated by *en Ville Catering*.



The COG Charity Committee puts on events throughout the year to raise money for various causes. L-R: Jullaine Hardinge, Jilliane De La Cruz, Donna Tuck and Rachna Clavero.

Around the industry

Upcoming events



In addition to CANDU Owners Group events, there are a number of other industry conferences in the coming months. Some offer opportunities to learn about industry direction and how nuclear can contribute to society. Others provide a forum for sharing technical developments toward performance excellence.

CNA2018

Feb. 21 to 23 - Westin Hotel, Ottawa, Ontario

Explore what is happening today, and what is coming tomorrow in the field of nuclear, at this year's Canadian Nuclear Association Conference, **CNA2018**. This is Canada's Nuclear Advantage. This is the Next Generation. Come and be a part of it!

Registration is now open. For more information, visit www.cna.ca/2018-conference/

Globe Forum

Mar. 14 to 16 - Vancouver, Canada

GLOBE Forum and Innovation Expo is where global leaders from business, government and civil society come together to manage risk and capitalize on opportunities in the clean economy.

For more information, visit <https://www.globeseries.com/forum>

International Conference on Quality, Leadership and Management in the Nuclear Industry

July 16 to 19 - Ottawa, Canada

This summer, nuclear professionals will gather for the 15th Joint FORATOM-IAEA Workshop on Management Systems. Bruce Power will host the international forum aimed to exchange information on management systems and quality management standards. Attendees will be able to exchange experiences, practical examples and case studies related to leadership and organizational culture and the implementation of risk-based approaches, through presentations from industry leaders and working group sessions.

Call for papers: **Feb. 28**

For more details, visit <https://events.foratom.org/mstf2018/>

38th CNS Annual Conference and 42nd Annual CNA/CNS Student Conference

June 3 to 7 - Saskatoon, Canada

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 enhanced security of the global community.

The CNS 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.

The call for papers has been extended:

Abstract submission: **Feb. 14**

Draft paper submission: **Feb. 28**

Full paper submission: **April 1**

For more details, visit <https://www.cns-snc.ca/events/cns2018/>



Upcoming COG member and supplier participant events

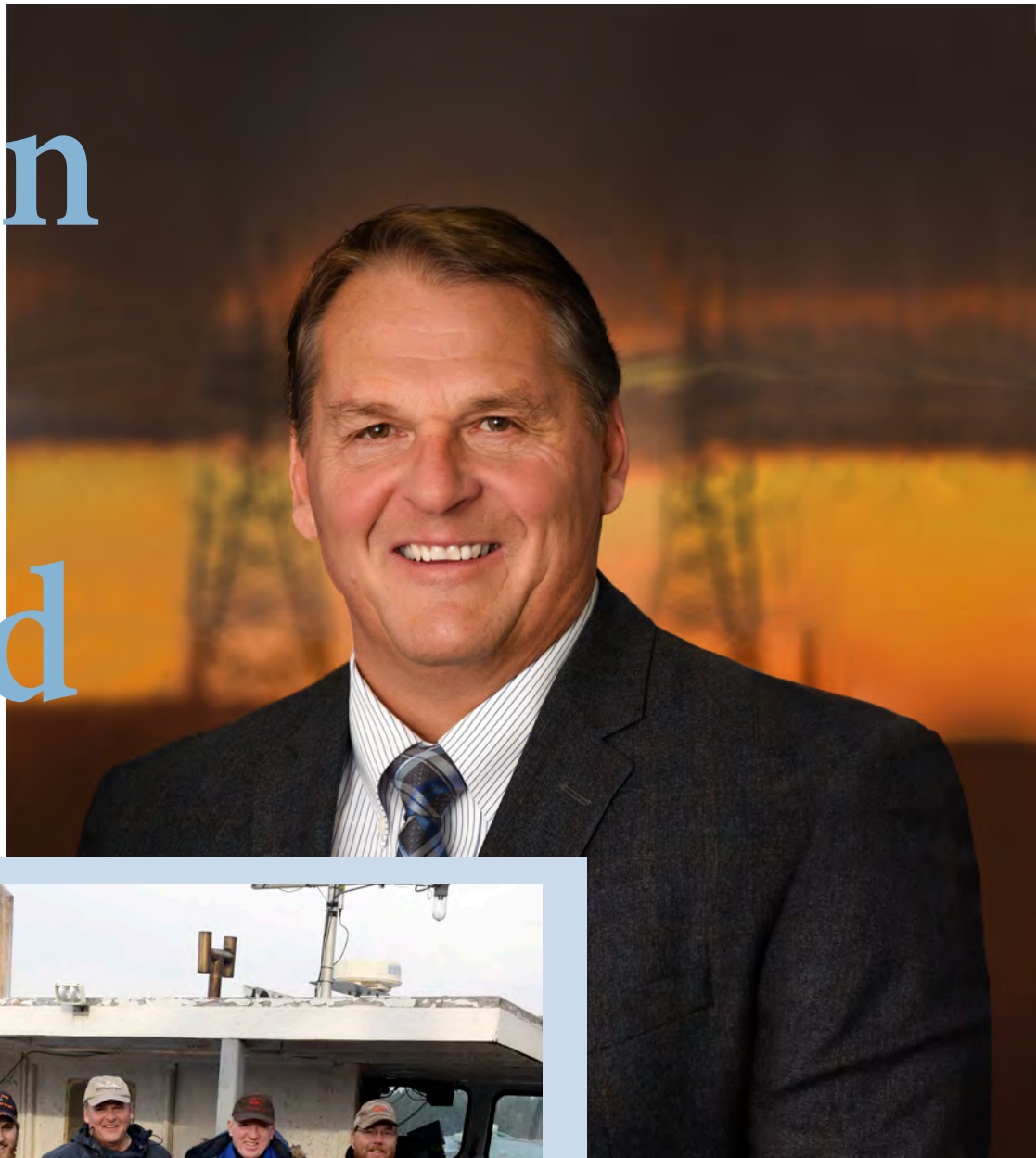
For a full list of COG events, members and supplier participants can download the COG event guide at www.cogonline.org/WCS/Documents/COG-Events-Guide.pdf.

The document features a detailed look at workshops, peer group meetings and training provided through COG. It is updated bi-annually.

Also, visit the COGonline event calendar for up-to-date information on events at www.COGonline.org.

Coming soon: Registration for COG events is getting even easier in 2018. Watch for the launch of COG's new event platform Configio.

Salt in the Blood



**A nuclear leader finds himself at home
on the Bay of Fundy**

Spotlight on operators:
Brett Plummer, VP Nuclear & Chief Nuclear Officer

Salt in the blood

A nuclear leader finds himself at home in the Bay of Fundy

When Brett Plummer came to Point Lepreau two years ago, he brought a bred-in-the-bone understanding of the sea, nuclear plants and the people who rely upon both for their home, food and livelihood.

New Brunswick Power's Point Lepreau nuclear plant is tucked into the northern shore of the Bay of Fundy, in the Musquash local service district, less than 50 kilometres west of Saint John.

The Bay is also home to Fundy National Park, where thousands of visitors come each year to experience the world's highest tides and rarest whales along with dinosaur fossils, semi-precious minerals, waterfalls and trails. The Bay's eco-system has made it a national treasure and home to a thriving fishing industry run by a tightly-knit community.

About 300 miles from the Bay sits Westport Island, Maine, another tightly-knit community whose population of under 700 swells to 1,200 with the summer's tourist season and where a fresh lobster dinner is never hard to come by.

The two towns share a reliance on the sea. They also share a common resident in Point Lepreau's Chief Nuclear Officer, Brett Plummer, a commercially-licensed lobster trapper, who calls both home.

Plummer joined New Brunswick Power in November 2015,

On the cover: (Top) Brett Plummer in his office with the sun setting over Point Lepreau. (Bottom) An avid fisherman with a commercial lobster trapping licence in Maine, Plummer found himself in familiar territory on a fishing boat with (l-r) Brent Ingalls, Joe Abbott and Captain Jeff Abbott.
Photos courtesy of New Brunswick Power

three years to the month after Lepreau, a single-unit, CANDU 6 plant, had returned to service from a mid-life refurbishment. Plummer has spent more than four decades in a nuclear career that included 18 months at the Institute of Nuclear Power Operations (INPO), where he recalls visiting the best-run nuclear plants and the worst. His time at INPO is coupled with deep operating experience in operations and projects at Maine Yankee and Seabrook Station (outside of Boston) as well as life in the U.S. Navy, where for a time, he lived on a nuclear-powered submarine. It's an experience that gave him a healthy respect for two things: reactors and teamwork.

At Seabrook, where Plummer was operations manager, he says, "We created a vision of what we wanted to become, and got everyone engaged and working towards common goals. In a relatively short time, we moved from the middle of the pack to become one of the top performing nuclear power plants in the world." It is a level of performance Seabrook has maintained in the years since, he says. It is a feat Plummer and the Point Lepreau team is now working to achieve.

From project to operations

Back in the fall of 2012, Point Lepreau was celebrating project completion after a long, hard-fought refurbishment. It was also facing fatigue from the rigours of the multi-year project. Many long-time employees, with deep plant knowledge and experience, had been holding on to see the project through to completion. Now, with the refurbishment

accomplished, they were ready to retire and pass the baton. As a transition strategy, New Brunswick Power hired a seasoned management team, including a CNO, from Ontario Power Generation, to give the station experienced leadership as it got its operational feet back under it and started to rebuild its own human resource. The strategy allowed the station to benefit from being part of a larger fleet on which it could draw experience and resource in the short term.

Paul Thompson, a key member of the leadership team during the project period, recalls the challenges the station faced during those first few transitional years. He says the Point Lepreau team had a big learning curve moving from a project mentality back into an operational one



Brett Plummer and the Point Lepreau Nuclear Generating Station team have created a 'teaching' culture to help integrate new staff and re-enforce operationally-focused behaviours in the plant. Above, Plummer (top right) with some members of his team in the PLNGS training simulator. (l-r): Leah Belding, Shift Supervisor-in-Training, Gerry Fairweather, Shift Supervisor and John McNiven, Licenced Control Room Operator.

Photo courtesy: New Brunswick Power

while at the same time working to maintain historical knowledge despite the departure of retirees. As well, he says, plant equipment that had not been part of the refurbishment scope remained on the maintenance log all while the plant was working to produce power and hire and train the new workforce. It was a tough combination of factors and the plant suffered from a high forced loss rate in 2015.

Despite the setbacks, when he arrived late that year, Plummer says, the mindset shift back into operations was starting to take hold.

“There was a lot of work done around establishing a solid set of behaviours, prior to my arrival,” recalls Plummer. “And, the team had excellent corporate support for this as well. We needed to continue to build on that and build the trust within the organization. We are really here together to get this plant to excellence and it’s to everybody’s benefit to do that. I am not sure everyone saw that, initially.”

If people were starting to understand *what* to do, they did not necessarily yet understand *why*, he says.

Controlling the plant

The golden rule of reactor safety is there is no risk to the public and environment from nuclear operation provided the reactor is controlled, the fuel is cooled and the radioactivity, contained. If there was a nuclear bible, control – cool – contain would be part of the 10 commandments. As Plummer talks about his focus at Point Lepreau to date, the word control comes up a lot.

The team, he says, “had to learn how you get ahead of the plant and control the plant instead of the plant controlling you. One of the things we had to learn was you don’t just wait and react and fire fight. You get ahead of it and control it...we don’t want to fire-fight short-term equipment issues.”

After the unplanned outages of 2015, he says, “We had to do a lot of immediate work on equipment reliability. We really needed to change the mindset when it came to equipment reliability and condition monitoring to a prevention culture.”

Plummer says the station took the equipment reliability effort in phases: The first was to assess the plant to ensure there were no immediate vulnerabilities to challenge the plant in the short term. The second was working with system engineers and bringing in mentors to teach and model excellent condition monitoring and walk down of the plant systems; and the third was focused on a longer-term solution: creation of a dedicated team whose job was to reconstitute the reliability documents and processes to ensure the plant was on the leading side of latest methodologies.

To gain the breathing room they needed to further develop the long-term plan, they started pegging off short-term equipment issues with razor-sharp focus that began every morning with a review to understand what the issues were, the associated risks, the appropriate measures and contingencies and to confirm the issue could be resolved in a timely manner.

While the plant is still working on the timeliness, Plummer says, “We are much, much better at identifying the issues

and trying to get ahead of it. That was one of the immediate aspects of moving from construction to operating and being in prevention mode versus reacting.”

Building the team

Once Plummer established the new leadership team, one of their first actions together was to develop a leadership boot camp, which was rolled out across the entire employee population of more than 1,000 people, including contractors. (There is no differentiation between employees and contractors at the plant, Plummer says, adding everyone is equal in both learning and accountability.)

“When you have a culture of teaching and you show people how it should be done, and you explain why it should be done... then people will see the benefit and change their behaviour accordingly. And that’s what we are seeing.”

The goal was to help every person see their own role within the operation and to understand how they personally impact the station’s goals.

A vision to achieve excellence requires a long-term plan that everyone can look at and know what part belongs to them. But before that could happen, Plummer and his leadership team had to do a lot of listening to hear what people had to say about the challenges being encountered across the plant. Once they understood the issues, they worked to transparently address them; in a way people could visibly see what was being done with their concerns and how the planned improvements will take effect.

“We want to get people to the point they trust the leadership and actually feel like they’re part of the team and contributing,” says Plummer. “It’s one team with trust that had to be established. And, I think we are at that point. I think we have established that and we’re rowing in the same direction. We’ve established a team; we’re moving forward together toward excellence. Now if we empower and engage people, we should see that rate of change toward excellence increase.”

Part of the ongoing work has been the continual hiring and training of new employees as Lepreau manages its aging demographic, a task that will stay with them over the next several years as more retirement dates arrive. The arrival of so many new faces provided an opportunity to establish a “culture of teaching,” says Plummer.

“We had to teach the organization how to run an excellent nuclear power plant. When you have a culture of teaching and you show people how it should be done, and you explain why it should be done -- which is one of the emphases of the leadership boot camp -- then people will see the benefit and change their behaviour accordingly. And that’s what we are seeing.”

Training is a big day-to-day focus at the station. There are



The Musquash Fire Rescue Department is a key partner in emergency preparedness for Point Lepreau. Chief Wayne Pollock (second from right) is also co-chair of the plant's community liaison committee. *Photo courtesy: New Brunswick Power*

three control room operator courses running concurrently, dynamic learning activities have been introduced and black belt mentors have been engaged to help the team with the learning curve. For some of the new hires, this includes translating skills honed in another industry and learning how to apply them to nuclear, with its own set of specific requirements. Each time there is an unplanned event whether at Lepreau or elsewhere in the industry, Plummer says, it is a chance to stop and to learn.

"The safety culture aspect is extremely important and the new folks coming in, through no fault of their own, need training to truly understand the importance, significance and the uniqueness of running a nuclear facility. We give folks training in that regard. A large part of the leadership boot camp was focused on the nuclear safety aspect, based on understanding the safety versus production balance, and making sure they're always tilting in the safety position," he says. "One of the things we have recently rolled out is how even in the most routine, perceived low-risk task, you need to run this plant like a nuclear professional, every day."

With his depth of experience, it might have been tempting for Plummer to simply draw up a plan himself for others to execute. But, he is emphatic that every person on the team needs to go through the learning process, assume the ownership and drive the change in their areas of accountability if Lepreau is going to achieve excellence.

He is excited now to see people gaining confidence and momentum in their own program areas and starting to reach out for benchmarking opportunities to bring new ideas back to the station for implementation. It is evidence, he believes, of the learning taking root.

Part of a village

If forms of electricity generation had personalities, nuclear's footprint requires it be an extrovert. With its size, power and

potential to impact the environment, economy and well-being of citizens (positively or negatively), it is the big kid who cannot hide in the crowd.

Similarly, the plant is also impacted, for better or worse, by its surroundings and the people who inhabit them. Just like what is happening with the internal team, Plummer and his team need a trusting symbiotic relationship with its communities for the plant to thrive.

For Plummer, the Point Lepreau community, its geography, its people and habits is very much like those he has lived in all his life. It is, as they say, a cultural fit.

From First Nation communities, to local officials, residents, children's groups, members of the fishing community, as well as labour groups representing employees and contractors, there are many active partners who have

contributed to the station's plan through their input. Many do more. They are partners who help improve the outcomes of the community and the station. This includes both near-site neighbours and those further afield who have a keen interest in the plant's effect on people and the environment.

Earlier this year, the Lepreau team took a road trip visiting Dipper Harbour, Saint John and St. George, to host open houses for people who may not be part of the immediate community but have an interest in the plant just the same.

"Those public meetings, open houses, were done by volunteers from the station and the surrounding communities," says Plummer who describes how the volunteers set up information stations representing all facets of plant activity. "Part of it is for the public to understand it is their neighbours and their community members who are running these facilities, not a bunch of strangers."

A few minutes' drive down the road from the plant is the Musquash Fire Rescue Department. A mighty volunteer force of about 50 responders, the department has always been a key partner to the station. It has become more connected in recent years, reflecting the increased emphasis on emergency preparedness. Fire Chief Wayne Pollack is also co-chair of the plant's community liaison committee. Weekly drills and training integrate the volunteer force and station responders who together have developed a cohesive plan should an event ever require their combined efforts. Every one of them knows their way around the nuclear plant with synchronized precision. The department is a partner in response and also in education.

The station also benefits from a strong relationship with its industry partners, including CANDU Owners Group (COG). New Brunswick has been an active leader, through Paul Thompson's participation as a committee chair, to bring the CANDU6 Fleet together to develop strategies for issues of common interest

with a special emphasis on obsolescence management. Thompson has also provided OPEX from the Lepreau refurbishment to help operators going through the mid-life projects now. And in turn, Lepreau has benefited from OPEX, research and peer groups, including one specifically focused on improving equipment reliability across the CANDU / PHWR fleet, a collaborative effort that has paid off with demonstrated improvements in its members' plants.

Early Results

- It is early days and there is still a lot to be accomplished, says Plummer. But already, the plant is getting wind in its sails.
- Today, the plant has a 10-year plan, with planned maintenance outage dates and the names of accountable individuals beside actions. Staff know there is a job for them in that future and they know what it is and why it is required.
- The plant has a vision, a strategy and a road map, communicated in a 43-page pocket handbook people carry with them as a reminder of what they have learned in boot camp and the key station work priorities and goals.
- In early 2017, the station won the EPRI technology transfer award (all CANDU plants are members of EPRI through COG membership) for the work of Jennifer Lennox, a program specialist in the engineering programs group who joined Lepreau just eight years prior to winning the award. Lennox was recognized for her work in the development and implementation of a program to maintain operability, and ultimately protect reliability of heat exchangers. An immediate benefit was improved management of degradation of the seal oil cooler.
- Point Lepreau has reduced its forced loss rate from 17% a year ago, down to 2.74% this year.

Numbers are great, especially when they are in the green. But at shift end, when Plummer makes the quick trek back home to Little Lepreau, the real value of the team's work and those ever-improving numbers, stretches out in front of him. Fishing boats coming in from the day at sea filled with food for thousands of families while kayakers paddle along the shoreline. The air is clear and the local economy is strong. It's just day-to-day life carrying on along this coast he now calls home; a coast and community very much like the one he came from. 🌸

Point Lepreau at CANDU Owners Group

New Brunswick (NB) Power's Point Lepreau Nuclear Generating Station (PLNGS) is a key member of many COG research and development programs, joint projects, peer groups and events. The station also participates in many other information exchange activities through COG to achieve *excellence through collaboration*.

Information Exchange

Other COG members and supplier participants have benefited from PLNGS's participation in COG Collaboration Week, COG/IAEA Technical Committee Meetings and other events and workshops where Point Lepreau staff frequently share their own experiences with refurbishment, post-refurbishment operations and other relevant industry topics such as obsolescence, life cycle and asset management. Through COG, the Point Lepreau team works with industry peers on regulatory issues and standards common industry-wide.

NB Power's Deputy Chief Nuclear Officer Paul Thompson is a COG Board Member and chairs the C6 Fleet Committee. Thompson is a regular speaker at many COG events sharing his wealth of CANDU knowledge and decades of experience. Point Lepreau is a regular participant in COG's OPEX screening meetings and online forums. Each year, COG's online Question and Answer program generates about 200 responses to questions posed in real time across the CANDU industry.

Joint Projects and R&D

The Point Lepreau plant is a member of several COG R&D program areas including fuel channel R&D, safety and licencing, Industry Standard Toolset, chemistry, materials and components and the health safety and environment program. Research has helped Point Lepreau on issues big and small from fish impingement to feeder integrity to development of environmentally-qualified grease.

Through just one of its joint projects, the fueling machine ram seal project, Point Lepreau is expected to significantly improve the reliability of its fueling machines, reducing the maintenance burden and achieving significant savings.

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Sign in with your secure user name and password today to see the new more user-friendly platform. Work with peers, gain industry insights, get a question answered by peers, join a working group or even nominate a COG research topic or joint project.

Don't have your user name or password, yet? No problem. Just sign up for one while you are there.

www.cogonline.org

CANDU OWNERS GROUP: *Top 10 of 2017*

It was a busy year for CANDU Owners Group, CANDU operators and supplier participants. As we move into 2018, here are 10 achievements to build on from last year:



1

Fuel channel life management: 40 is the new 30

COG's Fuel Channel Life Management program continued to make significant contributions to life extension for Ontario's CANDU plants, by extending life of this critical reactor component. The result for consumers is more electricity from the plants for the same up-front capital cost thanks to several additional years of operation. For Ontario Power Generation (OPG) and Bruce Power, it has meant flexibility to stagger unit refurbishments while continuing to produce safe, reliable electricity for the province. Watch for this research to be applied elsewhere in other CANDU plants.

The technical details

Now in Phase 3 of 4, the FCLM project has already delivered predictive models for fracture toughness to assess pressure tube fitness-for-service; provided sufficient evidence to confirm the integrity of the spacers that are used to maintain a gap between pressure tubes and calandria tubes; and improved knowledge of associated aging mechanisms improving the understanding of life management techniques. The combination of the FCLM deliverables, condition assessments, and extensive engineering analysis has helped confirm fitness for service and extended licensing of OPG and Bruce Power plants.

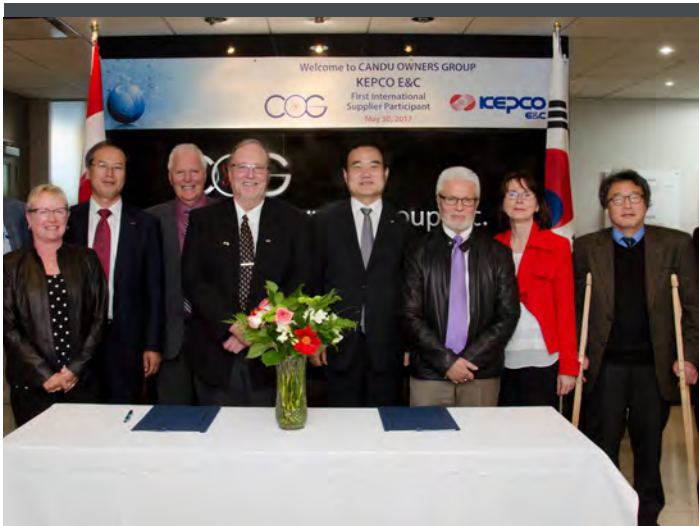
Where pressure tubes were once expected to provide up to 30 years of service, today with improved knowledge of aging, in-service inspection and confirmation of safety margin, some units may serve for up to 40 years before a mid-life replacement.

2 COG Collaboration Week

About 250 participants from Canada and nuclear plants worldwide converged in Toronto for a week of workshops, networking, sponsored dinners and events at the first annual COG Collaboration Week (CCW). An opening plenary of industry leaders and an R&D Expo, featuring current research in COG's six R&D program areas, kicked off the week. As well, there were several peer group workshops and opportunities for cross-function networking before the week concluded with COG's Annual General Meeting. Participants returned home with new knowledge, contacts, performance improvement plans and next steps for industry collaboration through COG. The second annual CCW will be held in November 2018 in Niagara Falls, Ontario.



Read more here: https://www.cogonline.org/COGHighlights/Documents/CCW-FollowupStory_20Jul17.pdf



3 COG's supplier participant program on the grow

In 2017, COG's supplier participant program grew by six new participants, pushing the total number of supplier participants to more than 20. The new suppliers include two international suppliers whose participation will assist in further opportunities to strengthen the supply chain for both Canadian and international COG operators. COG continues to build new aspects of its supplier program to improve knowledge, job readiness and security throughout the CANDU supply chain. Watch for more collaboration between COG and the Organization of Canadian Nuclear Industries (OCNI) on supplier initiatives in 2018.

4 Record participation for COG/IAEA biennial technical meeting

A record number of participants attended the international COG/IAEA 14th Technical Committee Meeting on the Exchange of Experience of Pressurized Heavy Water Reactors (PHWR) hosted by Nucleoeléctrica in Cordoba, Argentina, this fall. Fifty-six presentations were made on a range of topics including refurbishment, asset management, equipment reliability, obsolescence, research, safety and life extension. Presenters from Canada, Romania, Austria, Argentina, China, Korea, Pakistan and India shared technical experience.



Read more here: https://www.cogonline.org/COGHighlights/Documents/TCM_Nov17.pdf



5 More ways to interact with COG

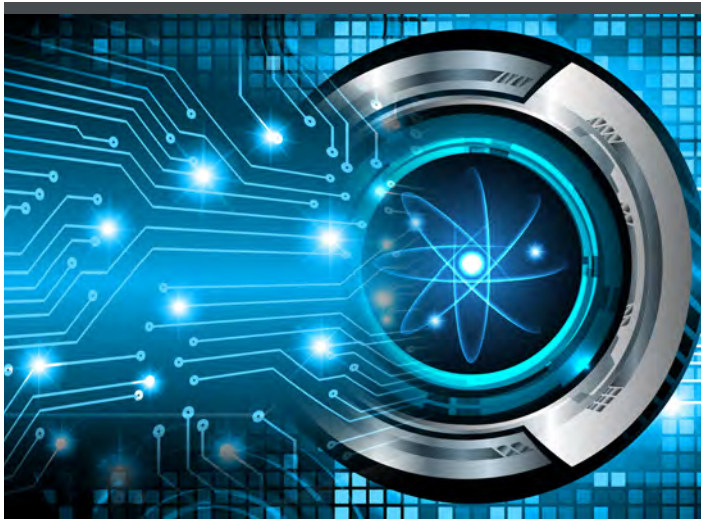
In 2017, COG launched several new or updated platforms to further broaden the reach of operating experience, industry news, trends and ways to collaborate. Its new COGonline member website and collaboration space was launched in December with an upgraded user experience and security. This followed the launch of a fully revamped public website, earlier in the year. In addition to many other upgrades, each of the new websites feature an online version of COG's own industry magazine, COGnizant. Readers can now see news and trends as they happen. COG also joined Twitter sharing updates and participating in conversations about industry news and innovations within the CANDU community. A new event management/registration tool was piloted in 2017 and will be further rolled out in the New Year.

6 New forums and groups on trending nuclear topics

COG established new forums and peer groups for member collaboration on work areas gaining interest within the industry. New groups in 2017 included:

- Small and Medium-Sized Reactor Technology Forum
- Radioactive Waste Leadership Forum
- Decommissioning Waste Management Peer Group
- Emergency Preparedness and Response Peer Group





7 Strategic R&D: Preparing for future innovation

COG's Strategic R&D program provides operators the opportunity to share knowledge and pool resources to identify and meet industry needs. Strategic planning ensures research today will help the industry remain safe, reliable and economically competitive well into the future.

In 2017, achievements in the strategic program included:

- An outage reduction roadmap, rolled out in November and featured at COG's December General Business Meeting;
- Draft roadmaps for fuel channels and other CANDU specific materials and components;
- Enhanced computer codes: Work on assessment and recommendations for the next system thermal hydraulic code and integrated Industry Standard Toolset platform is near completion with a final report tentatively scheduled for presentation at a mid-January workshop;
- More than 50 experts on diverse subject matter areas attended a decommissioning and long-term waste management workshop. Outcomes from the workshop will help inform a report to be issued in early 2018.

8 Industry contribution to Canadian and International standards

COG, working with its members, regularly reviews and provides input to standards of the Canadian Nuclear Safety Commission (CNSC), Canadian Standards Association (CSA) and International Atomic Energy Agency (IAEA).

A sample of undertakings this past year includes:

- Development of the Principles and Guidance to support a Common Approach to Human Performance and Human Factors in the Canadian Nuclear Industry;
- Formation of a task team on Fitness for Duty REGDOC 2.2.4;
- A successful two-day safety and licensing / Industry Standard Toolset (IST) workshop with the Canadian Nuclear Safety Commission where industry work was presented;
- Progress on fuel channel research to address questions related to CSA N285.8 (technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors) including a pilot study on probabilistic evaluations;
- Facilitated industry input to CSA N288 series of standards on environmental management of nuclear facilities and piloted a self-study training package. N288.8 *Establishing and implementing action levels for releases to the environment from nuclear facilities* was published in March 2017. The new CSA N288.9-18 *Guidance for design of fish impingement and entertainment programs at Class 1 nuclear facilities* is scheduled for publication in April 2018;
- Initiation of two projects to assist COG members in implementing new CSA environmental standards; and
- Reviewed and provided comments to several IAEA nuclear safety standards under revision.



9 COG in the community

9

COG in the community

In 2017, COG increased outreach to members, partner organizations, government and other stakeholders through a variety of outreach activities both on specific program areas as well as general education programs. In some cases, the goal was to help members gain increased understanding of the opportunities available to them through COG programs and services. In others, the aim was to help stakeholders better understand nuclear industry accomplishments achieved through COG contributing to safer, cleaner, more affordable low carbon electricity generation. Among the outreach efforts were a presentation to a parliamentary committee, a new COG engagement manager at the IAEA in key areas of member interest; and an international government side event at the IAEA general conference featuring Kim Rudd, Canada's Parliamentary Secretary to the Minister of Natural Resources. COG also presented several information sessions at our members' sites to better orient staff to the opportunities available through COG. As well, COG contributed to publications, including Nuclear Engineering International magazine and published COG's own magazine, COGnizant.



10 COG information and training sessions to build industry knowledge



COG facilitated learning and training of its members and supplier participants through more than 100 workshops, events, training activities and resources in 2017. These ranged from leadership training in the Nuclear Professional Development Seminars (NPDS) to technical training on specific topics such as codes on MAAP4 – CANDU, ELESTRES, ELOCA and TUBRUPT. COG's General Business Meetings featured industry leaders including OPG and Bruce Power presidents Jeff Lyash and Mike Rencheck, Ontario Deputy Minister of Energy Serge Imbrogno as well as representatives from INPO, EPRI and industry researchers to share industry insights. With the University Network of Excellence in Nuclear Engineering (UNENE), COG released The Essentials of CANDU textbook, an online resource for CANDU operators.



Jerry Hopwood, second from left, of University Network of Excellence in Nuclear Engineering (UNENE), and representatives from the organizations who funded *The Essential CANDU* textbook at CANDU Owners Group's 2017 Annual General Meeting.

A CANDU-based textbook with all the 'essentials'

Textbook is the culmination of a multi-year collaboration between UNENE and COG with support from across the industry.

The *Essential CANDU*, a collaboration between the CANDU Owners Group (COG) and the University Network of Excellence in Nuclear Engineering (UNENE), is a comprehensive treatment of nuclear science and engineering using CANDU as the reference design. It emphasizes the fundamental theory behind CANDU technology.

Dr. W. (Bill) Garland, a long-time professor in the Engineering Physics department at McMaster University in Hamilton, Ontario, provided oversight to the textbook as editor-in-chief. Through Bill's efforts and the collaboration of the many contributors, *The Essential CANDU* provides a guide for current nuclear workers and a pathway to share knowledge with the next generation of nuclear workers. Continuous learning and information exchange are key objectives of the COG / UNENE partnership.

The Essential CANDU was produced with the support and contributions from CANDU industry organizations including: Bruce Power, Canadian Nuclear Safety Commission, Canadian Nuclear Laboratories, Canadian Nuclear Society, Hydro Quebec, Kinectrics, Korea Hydro & Nuclear Power, New Brunswick Power, Ontario Power Generation, SNC-Lavalin, Societatae Nationala Nuclearelectrica, and Third Qinshan Nuclear Power Company.

The Essential CANDU

is a unique, newly-completed textbook with comprehensive treatment of nuclear science and engineering using CANDU as the reference design.

The textbook is now available in PDF form under the UNENE banner at www.nuceng.ca/candu

For more information on The Essential CANDU and other resources visit www.candu.org/Pages/RESOURCES.aspx



Kinectrics welcomes Amec Foster Wheeler into the fold

Amec Foster Wheeler, a global leader in project, engineering and technical services to the industry has joined Kinectrics, an electricity sector testing, inspections and consulting company.

Kinectrics closed its acquisition of the Nuclear Americas businesses from Wood Group (formerly of Amec Foster Wheeler) in December and the Nuclear Romania business in January. The acquisition creates a stronger, more stable platform for increased innovation, product development and international expansion.

"Over time, customers can expect to see a broader range of services and operational efficiencies from our combined organization, offering them more value on current services provided by the company," says David Harris, Chief Executive Officer of Kinectrics.

The closing of the transactions allows Kinectrics to take on larger, more complex projects, from initial design concept through to deployment for CANDU reactors globally.

"With a large, experienced team of industry experts and a broader portfolio of products and services, we are positioned to better serve our customers today and longer-term at home and in international markets," says Harris.

Read more about the Kinectrics acquisition news:

Kinectrics acquisition in North America:

<http://www.kinectrics.com/About-Kinectrics/News/Pages/Kinectrics-Closes-Acquisition-of-Wood-Group-Nuclear-Americas-Businesses.aspx>

Kinectrics acquisition in Romania:

<http://www.kinectrics.com/About-Kinectrics/News/Pages/Kinectrics-Closes-Acquisition-of-Wood-Groups-Nuclear-Romania-Business.aspx>



NUCLEAR PROFESSIONAL DEVELOPMENT SEMINAR

The **CANDU Owners Group** Nuclear Professional Development Seminar (NPDS) is a three-week course for senior plant staff (second or third-level managers from all disciplines) to benchmark and learn best practices in leadership and management. Through case studies and industry experience, attendees review management issues and solve real problems encountered in nuclear plants. Limited class size allows participants to maximize discussions and participate on an individual level. Participants are offered on-going support and mentorship from industry leaders along with their in-class learning and visits to high-performing nuclear stations.

Objectives of NPDS

1. To establish clear and well-understood standards for senior plant staff conduct
2. To enhance the ability of senior plant personnel to identify, analyze and solve management problems encountered in nuclear plants
3. To strengthen lesson transfer between nuclear sites
4. To provide on-going support for key plant staff through mentoring practices

Week 1: Classroom training



- Leadership concepts
- Standards of performance in the nuclear industry
- Human performance
- Cross-functional working relationships
- Leadership styles
- Safety culture
- Human behaviour
- Problem solving

Week 2: Site visits



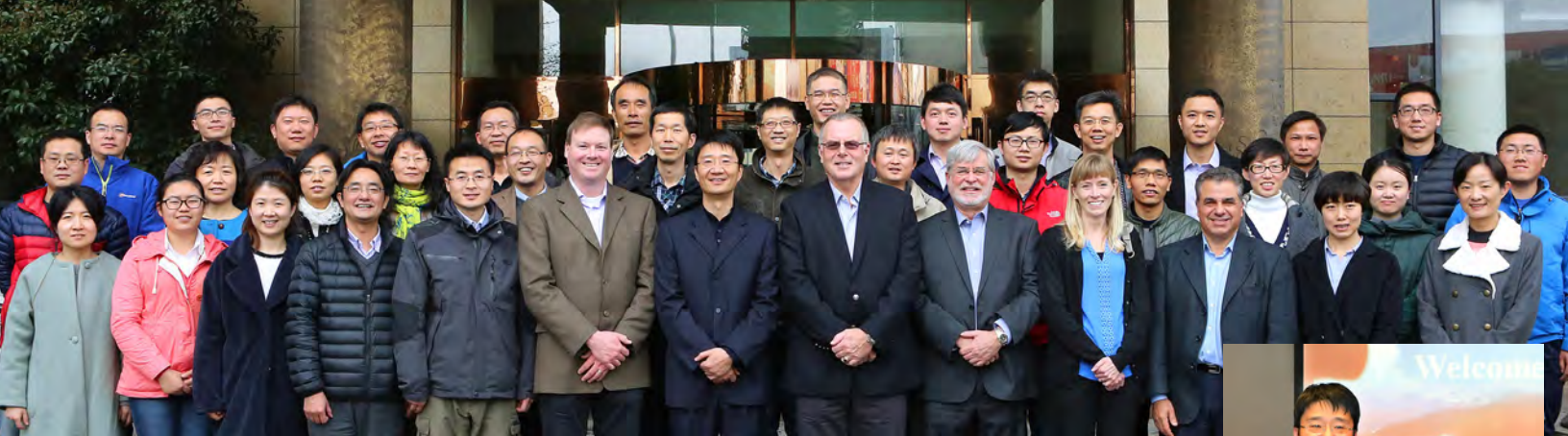
- Observe leadership and management practices
- Observe other ways of doing business
- Establish contacts and exchange information
- Benchmark against best practices in the nuclear industry
- Take insights back to home stations

Week 3: Action planning



- Review of site visits
- Work/life balance
- Managing priorities/relationships
- Success sharing
- Communications
- Problem solving
- Teamwork
- Action planning

For more information, upcoming dates and registration, visit www.CANDU.org/Pages/NPDS.aspx or contact Jilliane De La Cruz, Training Coordinator, 416-595-1888 x5162, Jilliane.DeLaCruz@CANDU.org



Leading by example

China National Nuclear Operation invested in COG's leadership training program. After seeing the results, they came back for more.



Deputy CNNO General Manager
Zou Zhengyu

Leadership is at its most powerful when it is shared across an organization.

That is the learning of the China National Nuclear Operation (CNNO) management team, who is using the CANDU Owners Group Nuclear Professional Development Seminar (NPDS) to effect strong leadership behaviours and positive culture changes across its entire organization.

After a few senior leaders had an early introduction to NPDS, the team decided to expand the training through the company, says Zou Zhengyu, Deputy CNNO General Manager.

"We realized that one person is not enough to change a company but a group of people can make enough changes that everyone will notice," he says.

The three-week program covers best practices for leadership, management and personal growth specifically for nuclear industry professionals.

"From my own experience at NPDS, I knew I wanted to share the concepts of this training with other managers at our plants," says Zou. After returning from his own training, Zou says he shared the knowledge he gained from case studies and industry experience at NPDS with his team. Those materials, slightly altered to reflect his own company's culture, along with his own strengthened leadership skills, had a noticeably positive impact.

The success of Zou's efforts on the ground in China received such positive feedback that the company decided to send more participants back to Canada for the full course. And, each time groups returned from training, more changes were noticed within the plant, says Zou. Today, almost all CNNO middle managers have experienced the NPDS program in Canada.

The positive impacts have been felt both in the plant and in employees' personal lives, says Zou.

In daily operations, the training has provided a guideline for employees to achieve a common goal and allows them to find solutions in a more people-focused manner.

"After NPDS, employees feel as though they are part of

one team. We all have one target and a common language that allows us to understand each other more easily. Because leaders have been trained as a team, they work together on their action plans which makes it easier for department coordination."

NPDS has also impacted the way employees live their own lives, exercising the impact of work-life balance, he says. Many employees have begun to change their own personal habits including doing more exercise, quitting smoking and giving more priority to family life. Through NPDS training, CNNO staff better understand the value they can bring when their own lives are in harmony, says Zou. And, he adds, employees can see the impact they have on others once they have become experienced in applying the learnings for themselves.

"We've learned that we cannot change other people. We can only change ourselves. By changing ourselves, we may affect other people," says Zou.

Anyone interested in the NPDS program can get more information on the NPDS page on COGonline or the COG public website. Or, contact John Sowagi at John.Sowagi@CANDU.org. NPDS is now also available through the World Association of Nuclear Operators (WANO) website.



COG's Acting Director of Knowledge Management John Sowagi, above at right, providing feedback to CNNO staff about the CNNO NPDS program.



From left to right: OPG President Jeff Lyash, Bruce Power President Mike Rencheck and Ontario Deputy Minister of Energy Serge Imbrogno talk about nuclear innovation and the opportunities that come from a low-carbon electricity system at the CANDU Owners Group, Sept. 25 General Business Meeting.

Clean air, innovation & jobs

Ontario's reliable, low-carbon electricity provides a platform for economic growth and prosperity in other sectors, fueled by more than 60% nuclear along with a mix of primarily hydro & renewables. Through continuous innovation in projects and operations, OPG and Bruce Power intend to make it so for decades to come.

Ontario's electricity system, with more than 60% of generation from nuclear power, is well positioned to take the province into an era of climate-friendly economic growth, according to leaders of the province's two nuclear operators, Bruce Power and Ontario Power Generation.

"This is one of the lowest-carbon electricity systems in the world," OPG President and CEO, Jeff Lyash told nuclear executives at the CANDU Owners Group (COG) General Business Meeting, Sept. 25 at the Darlington Energy Centre.

"And where does that put Ontario? It gives us the opportunity to hold on to this base to maintain that low-carbon emission and use it to decarbonize other sectors of the economy and do it cost effectively," he said, referencing transportation and commercial sectors, in particular.

Lyash made the remarks during a panel discussion with Bruce Power President and CEO Mike Rencheck and Ontario Deputy Minister (DM) of Energy Serge Imbrogno. The three leaders, and panel moderator, COG President and CEO Fred Dermarck, discussed the role of nuclear in Ontario's electricity system and the use of innovation and technology to drive improvement in nuclear projects and operations, alike.

The government's update of Ontario's long-term energy plan (LTEP) was released, Oct. 26. DM Imbrogno said, as governments worldwide seek to address climate change and develop greener economies, Ontario's electricity mix gives the province an opportunity to lead on three fronts.

"There's the system benefit – as we all know, its (nuclear's) base level power that gives us 24/7 electricity that we need. It's

got capacity. It's got energy. It's got everything we need," said Imbrogno. "On the environment side, it's essentially GHG-free so when we are trying to meet our climate change goals, it is a major player in that. And (for the economy), the supply chain is everywhere in Ontario, not just where the utilities are housed but across the province."

From electricity to healthcare

Bruce Power's Rencheck, highlighted crucial health benefits Ontario has achieved as a result of shutting down coal plants and moving to a cleaner generation mix.

"In 2005, there were 53 smog days. In 2014 and 2015 – zero smog days. That means kids with asthma can go out and play without having to worry about getting rushed to the hospital."

The nuclear operators have diversified beyond electricity generation to contribute to other health-related uses of nuclear – including life-saving cancer diagnostic and treatment applications used by thousands of patients annually.

"Medical isotopes is another area of innovation. Canada is the world leader in isotope production and distribution," Rencheck said. "These are the types of innovations our industry can deliver in addition to supplying clean, reliable, 24/7 baseload electricity."

Refurbishment and life extension on-time, on-budget

Of course, benefits can only be achieved if Ontario's nuclear fleet can deliver both on the current refurbishment project at OPG's Darlington and the life extension program at Bruce Power as well as safe and efficient operations.

Refurbishment and life extension activities at both sites are tracking very well to plan -- on budget and on schedule, the leaders said. And both organizations are aggressively pursuing

innovations, including artificial intelligence and improved data analysis to achieve further efficiencies in both projects and ongoing plant operation.

This kind of innovation is enabled by the government's long-term planning and the contract Bruce Power signed with the government in 2016, said Rencheck. Both provide a stability other jurisdictions are lacking.

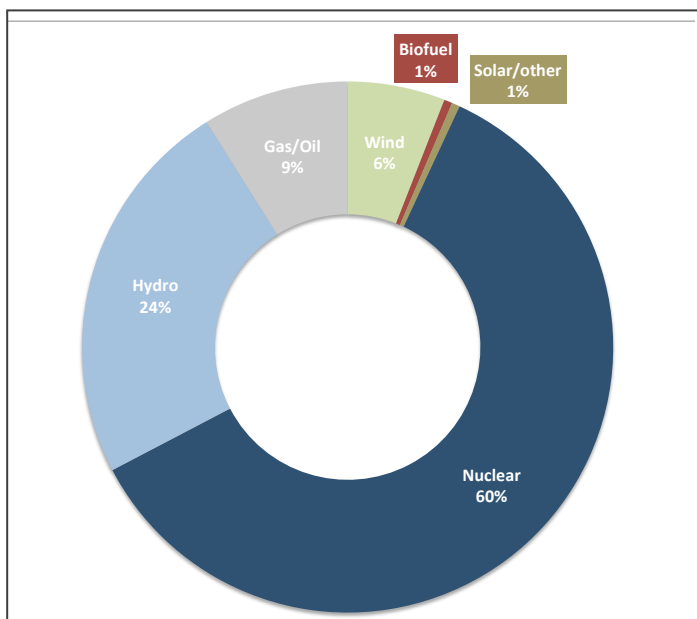
Achieving excellence through collaboration

Dermarkar said, through COG, the industry has created an important foundation for success in both operations and projects. COG facilitates collaborative research, development and projects worth more than \$60-million annually and manages a well-established global network of shared operating experience.

Dermarkar pointed to Pickering Nuclear as an example of how research, collaboration and the utility's own program efforts, collectively, have led to significant achievement in safety, cost and longevity of Canada's oldest operating plant. Pickering, he noted, is experiencing some of its best-ever performance results.

Reflecting on the commitment by OPG and its partners across the industry to deliver on the refurbishment project at Darlington, OPG's Lyash said Ontario has an electricity system with the capability "to generate huge amounts of energy -- cost-effectively, reliably and safely -- without GHG (greenhouse gas)."

He added, "You can take the electricity sector and use that as leverage for transportation, commercial and other companies. I don't see how you can do that without a strong foundation in nuclear power."



Ontario's 2016 electricity supply mix
 Source: Independent Electricity System Operator (IESO)

LEARN MORE ABOUT ONTARIO'S NUCLEAR PROJECTS...

OPG's Darlington Refurbishment

Economic Benefit: \$89.9 billion during the project and the following 30 years.

Jobs: 14,000 per year

<http://www.opg.com/darlington-refurbishment/>

Bruce Power Life Extension Program

Economic Benefit: \$4 billion annually

Jobs: 22,000 jobs directly and indirectly in operations plus 3,000-5,000 additionally through investment programs

<http://www.brucepower.com/about-us/life-extension/>

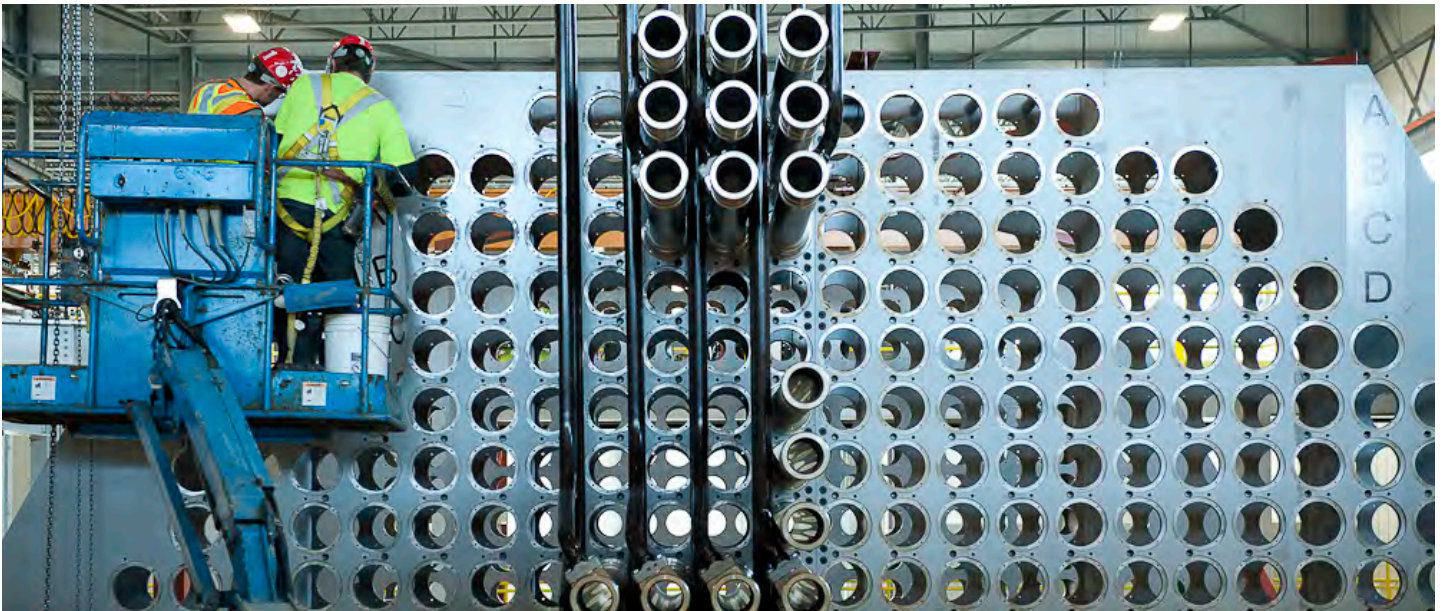


Photo courtesy: Ontario Power Generation

Darlington Refurbishment rounds the corner into Year Two

OPG execution phase continues on time and on budget

Ontario Power Generation (OPG) recently achieved the one-year mark in the execution phase of Darlington Nuclear's refurbishment, this fall and remains on time and on budget with more than 40 per cent of the Unit 2 reactor work completed.

"Our focus continues to be the successful completion of all four units," says Dietmar Reiner, Senior Vice President Nuclear Projects. "This 10-year project will extend the life of the plant by more than 30 years boosting Ontario's gross domestic product by \$90-billion and creating more than 14,000 jobs."

The refurbishment team has successfully removed 960 feeder tubes from the reactor, has started the fuel channel disassembly process, and completely disassembled the turbine generator equipment for the first time since Darlington was built in the early 1990s, Reiner said in a report on project status this past November. In January, OPG achieved another milestone when the last of the 960 end fittings were removed.

The retube waste processing building has also been completed and construction of the heavy water storage facility will be resuming shortly.

From now until spring, workers will be dismantling the core of Unit 2, preparing it for the installation of new components that will extend its power-producing capability. The first stage in this phase involved the removal of items from the vault such as feeders and severing of pressure tubes. The work in the second phase focuses on disassembling the reactor core, including the removal of pressure tubes, calandria tubes and end fittings. Other work includes electrical maintenance, water system replacement and continued maintenance of up to 1,000 valves.

For more information on the OPG refurbishment visit www.opg.com/darlington-refurbishment

By the numbers

The Darlington Refurbishment Unit 2 reactor hit its one-year milestone recently. The Unit 2 refurbishment:

is more than
40 per cent
complete

is a
10-year
project

will boost Ontario's
gross
domestic product by
\$90-billion

will provide
30 years
of extended life

created
14,000
jobs

replaced
960
feeder tubes



Photo courtesy: Bruce Power

Bruce Power builds capacity

Life extension gears up with contracts and millions of dollars of preparatory work in the plant.

Bruce Power's Life-Extension Program remained on time and on budget as it hit the two-year mark at the end of 2017. The project, which runs until 2053, will extend the life of the units through inspections, asset investments and the advancement of the Major Component Replacement (MCR).

As part of the Life-Extension Program, Bruce Power will complete MCR projects in Units 3-8 beginning in 2020. With the life-extension and other investments, Bruce Power anticipates operation of the plant will continue until the mid-2060s.

Collaboration with the community, suppliers, unions, OPG and the industry, including through the CANDU Owners Group, is a key part of the company's strategy to improve operations and achieve life-extension goals while adding value for stakeholders.

Economic development

Bruce Power and the County of Bruce teamed up to establish a regional Economic Development and Innovation Initiative to leverage economic opportunities for Bruce and surrounding communities. As part of the initiative, Bruce Power established a business investment specialist to help suppliers locate to the area and to provide a range of resources to ensure successful transitions for companies and their employees.

About 20 nuclear companies opened – or announced plans to open – offices, production facilities and warehouses in Bruce, Grey and Huron counties.

The role of suppliers in life extension

Partnership with suppliers is an integral part of Bruce Power's strategy for its life extension and major component replacement project.

In 2017, Bruce Power and its supplier partners signed hundreds of millions of dollars in contracts. Some of the most significant contracts are listed to the right. For more details on individual contracts, go to <http://www.brucepower.com/news-and-media/partnerships/>.

Major contracts announced in 2017

\$130 million +

Unit 6 steam generator replacement: AECOM, Aecon and AREVA NP Joint Venture

\$6 million

Support standby general improvements: TransCanada Turbines Ltd.

\$17 million

Perform upgrades to standby generators: Motion Electric Motor Services

\$4 million

Supply fuel channel mock-ups: Promotion Nuclear

\$2 billion

Fuel supply and reactor components for 10 years: Cameco

\$56 million

Generator work at Bruce A: GE's Power Services

\$35 million

Feeder pipe material for Bruce B Unit 6: Laker Energy Products

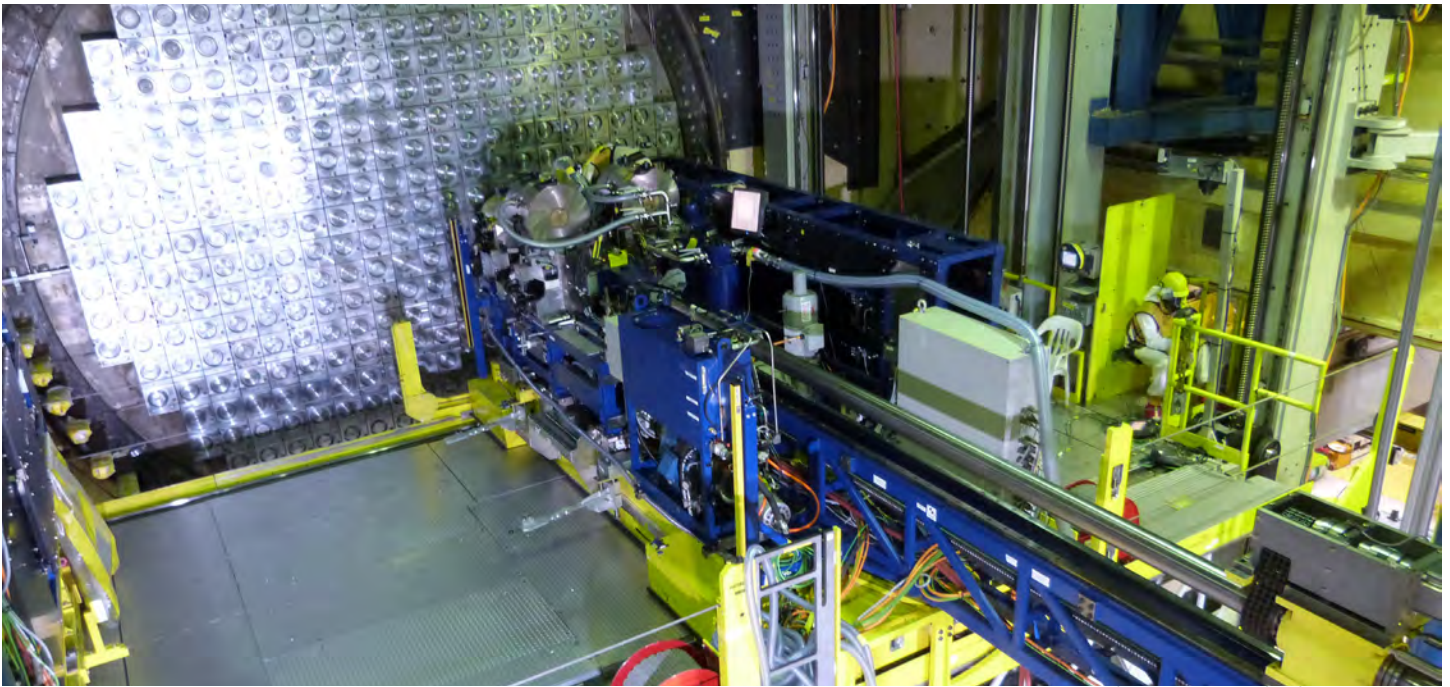


Photo courtesy: Nucleoeléctrica Argentina

Nucleoeléctrica Argentina hits major milestones on Embalse refurbishment

Fuel channel assembly, critical to project success, delivered

Nucleoeléctrica Argentina (NA-SA) completed the assembly of 380 new fuel channels in the reactor of the Embalse Nuclear Power Plant, one of the most important tasks of the Life Extension Project for the Cordoba plant. The December milestone closely followed the successful removal of calandria tubes in September.

Embalse Nuclear Power Plant completed its final operating cycle on Dec. 31, 2015 after 30 years of performance. It was recognized internationally for its excellent performance and was ranked among the Top 10 nuclear plants in the world. Planning of its life extension began in 2007 and implementation began in 2016. The project continues with the installation of upper and lower feeders and NA-SA estimates the plant will enter service again in 2018.

The extension will allow the plant to deliver energy for another 30 years and increase its current generating capacity by more than six per cent. Additional benefits include the reduction of greenhouse gas emissions, the production of Cobalt 60 for the medical industry and the creation of up to 3,000 new jobs. It will maintain work for more than 1,000 families over the next 30 years of service.

Worldwide experience

Embalse has benefitted from the operating experience of other CANDU plants, which underwent life extension ahead of it. NA-SA credits CANDU Owners Group member plants, including New Brunswick Power's Point Lepreau and South Korea's Wolsong, for sharing lessons learned in previous life extensions, which have contributed to its success.

For more information on the Embalse Nuclear Power Plant Life Extension, visit: <http://www.na-sa.com.ar/centrales-nucleares/embalse/>.

By the numbers

As Embalse continues to hit major milestones through the implementation of its life extension, take a look at the impact in and around the plant.

380
new fuel channels
assembled in
December.

3,000
new jobs created as part
of the project.

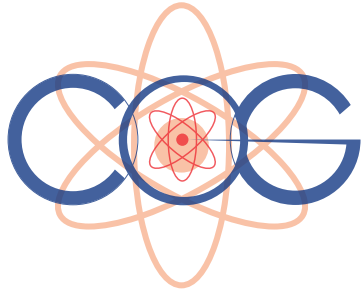
The project will increase
generating capacity by

6 per cent.

380
new calandria tubes
installed in September.

Maintain work for
over **1,000**
families over the next
30 years.

30
additional years of
service for Embalse.



Return to Service Workshop

*On April 25-26 COG holds its first Return to Service Workshop
in Toronto, Canada.*

Return to Service Workshop topics include:

- Planning
- Outage organization
- Pre-outage activities
- Outage
- Re-start
- Post re-start operations
- OPEX and lessons learned

Interested in presenting?

*Send proposal to Sergio Russomanno at
Sergio.Russomanno@CANDU.org.*

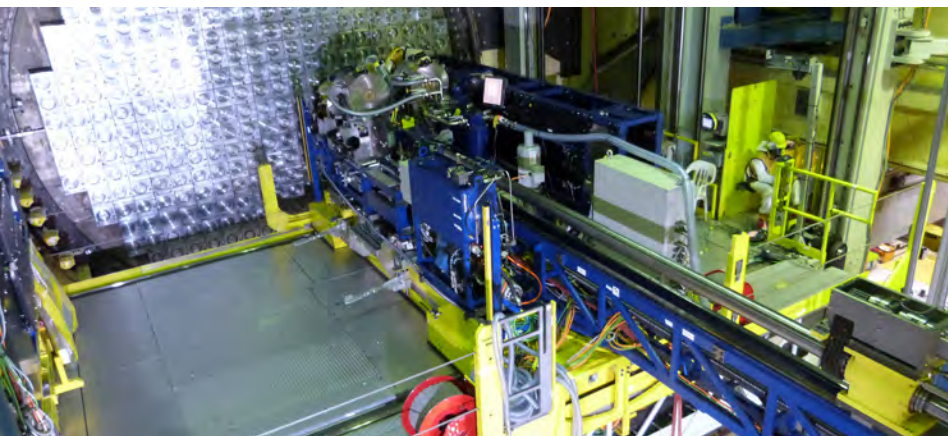
Call for presentations close February 28.

With multiple CANDU utilities currently undergoing planning and implementation of refurbishment, COG is pleased to announce a workshop on post-refurbishment return to service in Toronto on April 25 and 26.

COG members involved with life extension work are invited to attend and participate in the first workshop of its kind. This is a unique opportunity to meet with international colleagues to exchange operating experience and lessons learned related to refurbishment.

*Visit www.COGonline.org for
accomodation information*

**For more information, visit the Return to Service Workshop
event listing on www.COGonline.org.**



To register, visit the events page
on www.COGonline.org

For more information contact:
Sergio Russomanno at
Sergio.Russomanno@CANDU.org



Achieving the CANDU promise

As CANDU operators create their own version of the US industry's Nuclear Promise, they are finding innovations in technology, culture and collaboration are the go-to elements in the quest for greater efficiency and even some new value propositions beyond generation. Jacquie Hoornweg reports

Ontario Power Generation (OPG) president and CEO Jeff Lyash is standing in front of about 50 industry leaders at the CANDU Owners Group (COG) general business meeting. It is a quarterly forum for exchanging operating experience and sharing initiatives and industry trends across the CANDU fleet. Lyash is animated as he recalls a recent experience with an immersive virtual-reality (VR) software the company is developing to qualify staff in radiological safety.

Sensory data communicated through a headset transports users to replicas of spaces inside the plant. In this case, it is an area where workers undertake activities to move between radiological zones. Lyash briefly explains the testing scenario he went through then concludes, "When I was done, I set the paddle down on the table." The only problem – the table was virtual and the paddle, which represented the pancake monitor used to check objects for radiation, had landed on the floor.

Leveraging technology

Lyash's story illustrates how far computer

technology has progressed. Use of the VR simulation will change how OPG conducts its qualifications and other training, too, says Lyash. He is enthused by the technology and the results: more effective and efficient training. For example, the software will notice nuances a human tester would not in the user's technique and can correct more precisely.

The use of software also means the human trainers can be deployed elsewhere, where their skills are more needed.

It is not hyperbole to say artificial intelligence (AI), along with the associated VR and augmented reality (AR) are creating a paradigm shift in the nuclear business model. Activities run the gamut from inspections, to onboarding of new employees, to tool testing and skill practice, to identification and diagnosis of long-term equipment behaviour and human performance trends.

AI is being used to keep employees safer. For example a recent 'Google glasses' application developed at OPG gives workers an instant visual of dose changes, rather than relying on vibrations from the dosimeter on their body.



Bruce Power and Ontario Power Generation President and CEOs Mike Rencheck and Jeff Lyash have delivered a common message to the Canadian nuclear industry: "We are in this together". (Photo credit: Ontario Power Generation)

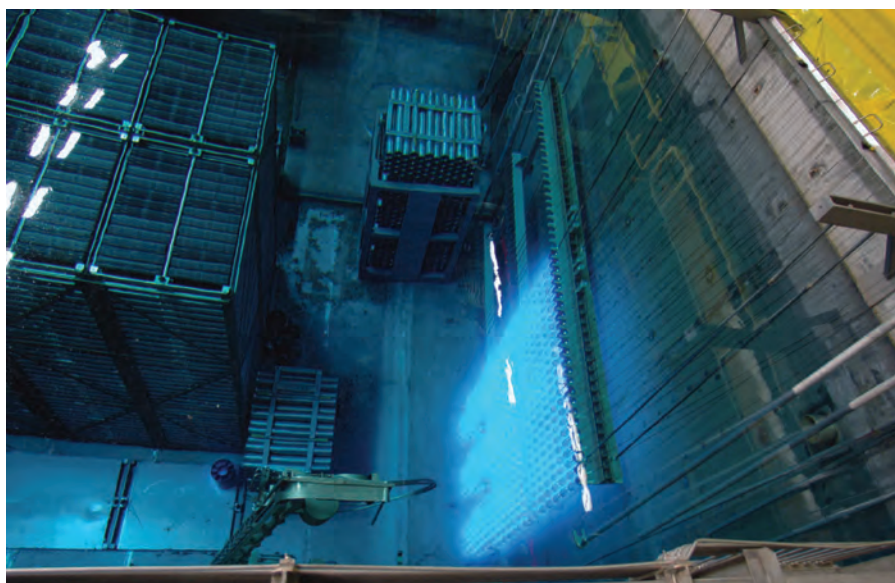
Lyash's talk also illustrated OPG's own recent use of technology as a way to address the company's cost curves and its need for human resource as it wrestles with the complexity of operating Darlington, a four-unit station, while simultaneously tackling unit-by-unit refurbishments there.

Some strategically-dispatched AI could prove to be timely for OPG as it prepares for staff reductions and revenue losses that will come at the end of operation of its six-unit Pickering station in 2024. Innovation is already helping Pickering achieve some of its best-ever performance as it continues in its fourth decade of operation. Innovation must help the company during the plant decommissioning and as it looks for new business opportunities to replace it.

A few hours west of OPG's stations is the 8x800MW Bruce plant, the world's largest operating nuclear complex.

On most days, the two companies' nuclear plants combined provide more than 60% of the power used by Ontario and the 14-million people who live and work there. That is a hefty part of the Ontario government's plan to use a low-carbon electricity mix in future infrastructure. Hydro, renewables and some gas round out the low-carbon generation.

In 2016, Bruce Power began its own life extension programme, a continuous optimisation and asset management programme to take place over several decades. Starting in 2020, that will include major component replacement projects that will take place until 2033.



Adding value: Harvesting cobalt is one way CANDU operators are finding added value from their generation assets. (Photo credit: Bruce Power)



Bruce Power president and CEO Mike Rencheck is investing in technology to achieve this. “Cars can drive themselves,” he points out. “Why are we still manually typing in condition reports and going to computers to research old documents?” With artificial intelligence, the information should bring itself forward at the work face, he says. In fact, it is already in the works.

One of many Bruce Power technology investments has been BRIMS, the Bruce Reactor Inspection and Maintenance System, a remotely-operated machine made in Ontario for maintenance and inspection activities at Bruce. The machine gives the operator better knowledge of the condition of the reactor fuel channels and significantly reduces the time required to perform inspections. It also reduces the need for workers to be active in high-radiation areas.

The advanced inspection capability the BRIMS machine offers, along with other innovations, has helped Bruce Power add more than 27 years of reactor operating life to the plant, Rencheck says. That optimisation is reducing costs and adding revenue, which means long-term sustainability and higher confidence amongst the company’s shareholders.

Optimisation is part one of the plan, says Rencheck. Part two is asset management. “We’re investing \$400 million a year in renewing our plant assets and that will happen every year for the next decade, two decades, three decades into the future. Our first year, in 2016, our projects were implemented on time and on budget and in 2017, our projects were implemented on time and on budget.”

The ‘on-time, on-budget’ message holds true for OPG’s Darlington, which just hit the one-year anniversary on the execution phase of its first unit refurbishment. Rencheck and Lyash both say they see more opportunity to integrate technologies and other innovations, well beyond what is being done now. Their plan to get there includes each other, COG and the other CANDU operators and suppliers.

Leveraging collaboration

Collaboration in the nuclear industry is not new. It has always been the foundation of COG’s programme. Another contributor to the life extension capability at Bruce Power and continued operation at the OPG plants is the COG-facilitated fuel channel life-management programme (see *NEI* June, p32-33).

Research results and related management plans, (which COG’s international members are also looking to employ) helped achieve regulatory approval for continued operation of the Ontario plants by demonstrating that an appropriate safety margin could be achieved for longer than originally anticipated. The outcome was several additional years of operation, resulting in billions of dollars of added revenue and importantly, continuity for the province’s electricity system. It has also meant significantly-improved flexibility for the two companies as they map out the projects ahead.

While collaboration has always been a guiding principle, what has changed, and what is going to help achieve CANDU’s version of the nuclear promise, is the level of sharing and the integration between Canadian organisations.

In Canada, nuclear generators are either government-owned or have long-term contracts, allowing for open collaboration where the operators can leverage each other’s work.

“Among the three main operators in Canada (the other being New Brunswick Power) a common approach to training qualifications, a common approach to engineering, shared experience on asset management and operations and outage execution,” provide across-the-board benefits, says Lyash. “If we jointly develop tooling and technical advantages, all Canadians benefit because these companies are not in competition.”

Rencheck says the Canadian operators also owe much to their CANDU counterparts at Embalse in Argentina. That plant’s refurbishment is a few steps ahead of the work at Darlington and has provided valuable experience for the Canadian operators. Embalse has benefitted too. It used new calandria tools developed at OPG for its own refurbishment, while providing a live testing ground for OPG.

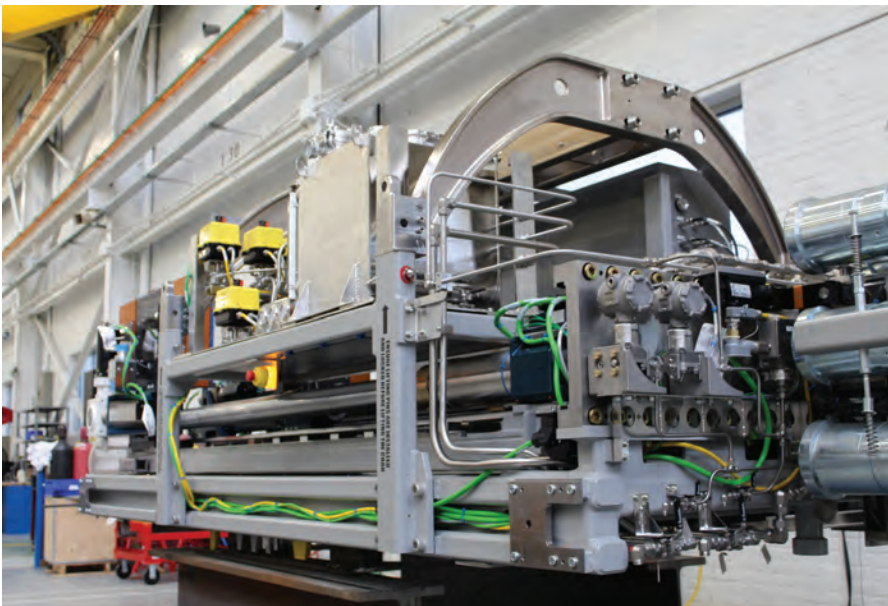
New Brunswick Power, now a few years beyond its own refurbishment, has documented its experience and is preparing its Ontario counterparts for what lies ahead. NB Power’s innovations in asset management have included a recent EPRI technology transfer award for a heat exchanger initiative.

International CANDU collaboration brings tremendous benefits to all of COG’s members, says Fred Dermarkar, the organisation’s president and CEO. COG membership includes all CANDU and PHWR technology operators worldwide. The private, not-for-profit organisation invests approximately \$65-million in R&D and joint projects annually on behalf of its members.

“The research advances the technology – safety, reliability and environmental and cost performance – for everyone, at a fraction of the cost a company would spend if it undertook the effort independently,” says Dermarkar. “Yet, each operator gains the full benefit.”

Additionally, shared services allow the entire fleet of CANDU operators to leverage the resources of plants worldwide. For example, in 2016, Korea Hydro and Nuclear Power saved tens of millions of dollars with just three quick-saves, using COG’s spare parts programme to find urgently-needed parts and avert lost production time.

Paul Thompson, senior strategic advisor to the chief nuclear officer at NB Power says COG initiatives can be especially valuable to a single-unit or smaller operator. Identifying common solutions and implementing these initiatives across many plants not only eliminates wasted duplication; it saves money and opens up more solution options.



Bruce Power’s BRIMS machine provides high-quality inspections that have helped increase productivity while reducing worker dose. (Photo credit: Bruce Power)



A common supply chain approach

Canada has been fortunate to maintain an intact supply chain – particularly fortuitous given the combination of massive project work and a far more supplier-oriented business model than any time in the country’s history.

As suppliers became key partners, integral to operating and project success, so too has the need to ensure they have as much line of sight on nuclear safety and effective operation as plant employees. Suppliers, and their employees, are not rooted to a single plant. Previously, every time they moved from one job to another, they had to relearn expectations and processes. But that is

changing, Rencheck says.

“Common engineering procedures, entry training, security screening – these mean contractors can have single processes. It’s more efficient and now we can focus on working to create new ideas instead of focusing on how to do work. We are able to bring ideas to fruition to get results.”

COG ramped up its supplier participant programme to ensure suppliers have a forum to connect with the operators regularly, in an open exchange about expectations and to further develop knowledge and shared operating experience in the supply community. COG, in turn, is collaborating with the Organisation of Canadian Nuclear Industries to ensure learnings make their way through the entire supply chain.



The OPG Xlab team has led development of a number of innovations from 3D printing to virtual reality training

announced a partnership with Nordion to provide medical-grade cobalt, a critical and unique component of radiotherapy in cancer treatment. The agreement filled an urgent need for the sustainability of supply. Beyond generating electricity, ultimately, the business is about generating value.

What do the operators see with the fulfillment of CANDU’s promise? Decades more generation for the current plants as a start. And within the industry there is a growing hope that new build, perhaps in the form of small modular reactors, might be the future reward for strong performance.

For the CANDU industry, life has never been so challenging, but it also has not often been quite so exciting either. ■

Delivering the US Nuclear Promise

Companies that operate America’s nuclear energy facilities have partnered on a multiyear strategy to transform the industry and ensure its viability for consumers as well as its essential role in protecting the environment.

This strategic plan, called Delivering the Nuclear Promise®, strengthens the industry’s commitment to excellence in safety and reliability, assures future viability through efficiency improvements, and drives regulatory and market changes so that nuclear energy facilities are fully recognised for their value.

The Nuclear Energy Institute

Value beyond generation

Cost is only part of the calculation in a company’s bottom line. As they develop technologies, OPG and Bruce Power are finding spin-off uses and going beyond electricity generation to maximise the value from their assets.

OPG’s Pickering and Bruce Power supply cobalt-60 to Nordion, a global health science organisation. Cobalt-60 is used to sterilise medical devices and supplies as well as for decontamination of spices and consumer goods. Bruce Power has also recently

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Members of the Fire Protection workshop in the CANDU Owners Group lobby.

Excellence through Collaboration

CANDU Owners Group (COG) employees, members and supplier participants collaborate throughout the year in a variety of peer groups and workshops. During the meetings, participants are able to share OPEX and best practices on various topics to increase the safety, reliability and cost of the nuclear industry. Over the next several pages, read about some of COG’s peer groups, the workshops and the continuous improvement activities they are working on.

To see a full list of groups or to learn how to get involved, just click on the Peer Groups button from the homepage of the new COGonline.org member website.

Asset Management Peer Group

Most recent meeting: Oct. 13, 2017

The Asset Management Peer Group facilitates collaboration among CANDU owners on asset management methodologies, governance and processes. They support the Engineering Peer Group on asset management and long-term operation strategic direction.

Current takeaways, initiatives and achievements:

The peer group:

- Supports and contributes to the IAEA International Generic Aging Lessons Learned program. It also helps with the development of associated age management programs (AMPs), time limited aging analyses (TLAAs) and review of IAEA safety reports;
- Contributes to the development of a new Canadian standard on aging management;
- Develops asset management performance indicators; and
- Shares station OPEX.

Fire Protection Workshop

Most recent meeting: Oct. 30-31, 2017

The Fire Protection workshop provides participants with the chance to exchange and review fire protection-related experience among COG members. The workshop identifies and develops common approaches to fire protection program issues.

Current takeaways, initiatives and achievements:

The most recent workshop initiatives:

- Addressed the need to integrate academic qualifications with practical experience for fire protection training. Opportunities for community colleges and universities to provide advanced diplomas/degrees that will meet the needs of COG members when hiring;
- A breakout session of INPO FP metric allowed the opportunity for hands-on use;
- Discussion on lessons learned regarding the annual physical fitness requirement for FP personnel; and
- External training resources were discussed for all FP staff. External training can be delivered to members via COG, if members’ specific requirements and objectives are identified.

Obsolescence Workshop

Most recent meeting: Oct. 11-12, 2017

The Obsolescence workshop brought together representatives from CANDU stations worldwide to learn from each other's successes and share challenges. The event provided a forum for vendors to showcase their expertise and engineering capabilities in response to identified needs from CANDU stations.

Current takeaways, initiatives and achievements:

- Positive feedback on COG Procurement Engineering Peer Group Task Team's work on the alignment review of Standard Purchasing Clauses (SPCs). Vendors showed interest in reviewing and providing input to SPCs, agreed by the Procurement Engineering Peer Group;
- Launch COG Benchmarking project on obsolescence program;
- Proposed for COG to develop and offer Commercial Grade Dedication training course;
- COG will develop a proposal for an obsolescence management program and get strategic input from senior executives to overcome challenges associated with standardization and equal sharing.



Training Managers Peer Group

Most recent meeting: Nov. 6-7, 2017

The Training Managers Peer meets twice a year to provide a forum for evaluation and discussion of training related issues affecting member utilities.

The group focuses on training for authorized nuclear operators and shift managers to improve communication and knowledge sharing. Participants develop unified positions on training issues and promote awareness of regulatory issues affecting training programs.

Participants share current and new training programs from across the fleet and work closely to ensure all programs meet the Systematic Approach to Training (SAT) requirements.

Current takeaways, initiatives and achievements:

- Three key areas of interest for the Training Managers Peer Group are: Training efficiency, one-time savings, and repeated savings. The group feels strongly that training programs should meet requirements in a cost-effective manner;
- One of the most successful programs implemented by this group over the past few years was the adoption of the Electrical Power Research Institute (EPRI) Standardized Task Evaluation (STE) program. The program is being put to use by workforce providers to help utilities streamline worker qualifications, cut training costs, and more effectively meet their needs for skilled, dependable, and readily available supplemental workers.

Environmental Qualification Workshop

Most recent meeting: June 6-7, 2017

Advancing the opportunity to comment on the CSA N290.13 revision was a key takeaway from the two-day Environmental Qualification (EQ) workshop. The annual meeting allows members to discuss EQ related items, OPEX, sponsor expectations, and more.

EQ engineers and experts from Ontario Power Generation (OPG), Bruce Power, NB Power, KHNP (Korea), SNN (Romania), PAEC (Pakistan), SNC-Lavalin, Canadian Standards Association and others gathered to discuss EQ-related operational experience and key issues.

Current takeaways, initiatives and achievements:

- OPG shared lessons learned from the Rosemount 1150 to 3150 series replacement at Pickering; and
- The group obtained an agreement on issuing room condition monitoring guideline and determined additional follow up actions for common issues.

The Environmental Qualification Workshop participants.





Environment Workshop

Most recent meeting: Oct. 24-25, 2017

Participants from COG member utilities, regulators, the Canadian Standards Association, environmental consulting firms and universities gathered at the COG Environment Workshop to improve technical knowledge of environmental issues and broaden the knowledge of resource groups.

The workshop included 10 presentations on environmental regulations, current research and Canadian standards development. Panels of experts from each site discussed seven major environmental challenges for the nuclear industry and the audience shared ideas to address these challenges in future collaboration.

Current takeaways, initiatives and achievements:

- The workshop provided over 17 potential new areas for future collaborations. These areas will be reviewed by the Nuclear Environmental Affairs Peer Group and prioritized to be included in the current list of collaboration opportunities.

Decommissioning and Long Term Waste Management Workshop participants.



Decommissioning and Long Term Waste Management Workshop

Most recent meeting: Feb. 21, 2017

Over 50 experts, from fields as diverse as remote inspection and groundwater modelling, met to discuss the research and development needs of nuclear plant decommissioning. The workshop provided insights into the state of the art and future requirements posed by the dismantling of nuclear power plants that have reached the end of their useful lives.

Current takeaways, initiatives and achievements:

- Unique engineering and scientific challenges posed by the need to combine proven techniques and innovation to achieve the safe closure and economic dismantlement of these plants, while protecting the workers and environments; and
- The workshop represented a key milestone in the study by Canadian Nuclear Laboratories and Kinectrics directed by COG on behalf of its members. The unique characteristics of CANDU plants require consideration for potential impact during decommissioning. The aim is to issue the study in early 2018 and to form the basis for a multi-year strategic R&D Program.

Pressure Boundary Workshop

Most recent meeting: Nov. 13-14, 2017

The Pressure Boundary Peer Group focuses on providing a consistent approach to achieve regulatory requirements. In their most recent workshop, the group discussed the future direction of governing standards through members' active participation on technical committees and task forces, which leads to practical applications of standards.

The peer group holds semi-annual workshops supplemented with conference calls. They share OPEX and audit areas of concern. Suppliers and manufacturers participate to enhance understanding and communication of common issues.

Current takeaways, initiatives and achievements:

- The use of nameplates to complement information in history docket;
- Waste reduction opportunities for commodities being supplied in smaller units rather than in bulk will help to reduce waste;
- Electronic acceptance of receiving documents;
- Investigate and review application to nuclear of composite wrap repair methods approved for natural gasline applications (CSA 662); and
- Vessel re-certification in unregistered systems.



Supplier Participant Meetings

Most recent meeting: Oct. 12, 2017

COG's supplier participant group shares perspectives, best practices and lessons learned in the industry. Participants compile messages on common challenges in execution of services for customers, engage with customers and resolve common issues for the benefit of the industry. They work collaboratively to ensure a strong supplier network supporting the CANDU nuclear industry.

Current takeaways, initiatives and achievements:

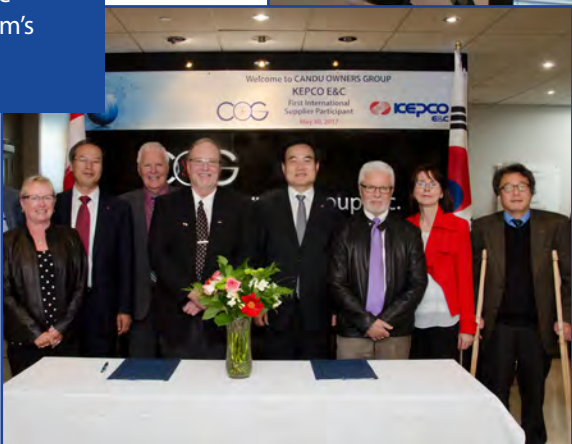
- The role of suppliers in delivering the nuclear promise is top of mind for the supply community. Other topics of interest included a review of the *INPO Principles for Excellence in Nuclear Supplier Performance*; presentations on export permits, vendor performance trends on Darlington Refurbishment and COG's OPEX database structure and effectiveness.

Meetings are held every two months and supplier participants are also invited to COG general business meetings and various COG workshops of interest to them.



New! International participation in the Supplier Participant program

Two international companies, KEPCO E&C and China Nuclear Power Operations Technology Corporation recently joined COG's supplier participant program. International members joining the program will enhance COG's ability to influence a much wider range of the CANDU supplier community and enrich the program's key OPEX sharing activities.



Engineering Peer Group

Most recent meeting: Jan. 18, 2018

The Engineering Peer Group (EPG) provides industry senior management with a forum to identify and address generic issues related to engineering activities at CANDU nuclear power plants.

Currently, the group provides oversight and executive sponsorship to numerous workshops including Asset Management Peer Group, Equipment Reliability Peer Group, Non-Destructive Examination Peer Group, Chemistry Managers Peer Group, and Procurement Engineering Managers.

The EPG receives report outs from peer groups to ensure key takeaways and actions have been appropriately captured and communicated to utilities. EPG members provide strategic guidance to their sponsored peer groups and workshops to ensure maximum benefits and takeaways are achieved for all participants and member organizations. Each station provides an update on their performance, successes, OPEX, lessons learned and status on a number of performance indicators.

Radiation Protection Seminar, Workshop and Peer Group

Most recent meeting: Aug. 21-23, 2017

The Radiation Protection (RP) Seminar and Peer Group Meeting is a three-day event where stations report on their top two or three key issues throughout the past year. Vendors are invited to display their latest technologies and present their latest ideas. Following presentations, participants work in a round table environment to identify key takeaway items.

At the last meeting, EPRI RP professionals discussed the latest advances in RP and INPO provided an update on the latest industry issues as well as progress on "The Nuclear Promise."

Current takeaways, initiatives and achievements:

- Discussions regarding best practices in RP;
- Collective/industry responses to the CNSC and WANO on various changes;
- Benchmarking activities from site to site; and
- Tracking RP performance through the use of a set of radiation protection performance measures which help with trending analyses.

The radiation protection workshop included displays from vendors during the three-day event last August.





A full-size fuel channel model greets visitors to the CANDU Owners Group office in Toronto. The model's presence reflects the significance of the fuel channel life management programme

Ageing well

Forty is the new 30 for CANDU nuclear plants. Ageing reactors are getting an extended lease on life as research demonstrates that safe continued operation of fuel channels is possible for longer than originally anticipated.

The CANDU Owners Group (COG), a member organisation for CANDU nuclear plant operators worldwide, invests more than \$65 million in R&D and joint projects on behalf of its members, annually.

Much of the investment comes from its Canadian member plants, where the youngest reactors are now reaching middle age and the oldest units have provided close to 50 years of service. Although the last new-build in Canada was in the early 1990s, the industry is thriving. In Ontario, two of the three nuclear plant sites are undergoing massive multi-billion dollar, mid-life refurbishment projects while the one-unit New Brunswick station is hitting its stride post-refurbishment.

In Ontario, success came with a challenge. Nuclear accounts for about 60 percent of the electricity used in the province. The task at hand is to refurbish 10 units at two nuclear plants for continued operation into the mid-2050s to 2060. Both plants came due for refurbishment at roughly the same time, while a third plant in the same jurisdiction was approaching permanent shutdown. The consequence could have been losing almost half of the province's electricity generation within a few years.

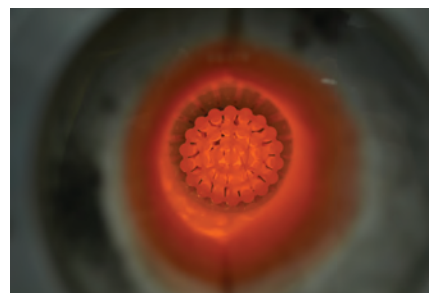
Instead, Ontario Power Generation (OPG) obtained regulatory approval to extend the life of the province's oldest nuclear plant, Pickering. OPG was aided by industry research conducted through COG, collaboration between members and research suppliers and advances in operating and maintenance methods. Parts of the

Pickering plant were originally conceived to run to 2014, but evidence from research on fuel channel life helped achieve regulatory approval to continue operations until 2020. More research is underway and its goal is to result in approval of a further extension to Pickering's operations to 2024.

The same research has validated safety margins at the two plants in refurbishment. OPG's Darlington station and Bruce Power's Bruce station received approval for lifetime operating extensions to 235,000 and 247,000 equivalent full power hours (EFPH), respectively. Operators can now stagger the shutdown of units for refurbishment or major component replacement, while other units continue to produce electricity. Research continues to confirm a further extension for the Bruce units to 300,000 EFPH.

The extensions are possible, in part, because of the conservatism built into the original lifespan of the units. Nevertheless, regulatory requirements are stringent and approvals have only been granted after rigorous defence of the safety margins. That is where the collaborative research conducted over many years comes in.

"Significant conservatism was built into the design basis for these units at the beginning because the designers did not have the operational experience, the analytical capability and the sophisticated inspection tooling we have today," says COG president and CEO Fred Dermarkar. "We now have the benefit of decades of research, thousands of reactor-years of experience as well as a far greater capability for inspections. All of this informs our understanding of the safety



CANDU Owners Group and Canadian Nuclear Laboratories achieved a major milestone in 2016 when they completed a programme examining high temperature fuel bundle behaviour (Photo: CNL)

margins. It also contributes to knowledge for development of effective preventative maintenance and operating methods. Together these factors have not only validated safety margins but also increased the safe operation and capability factors of the plants for much longer periods."

Today, says Dermarkar, 'age' is relative. It depends on how well the plant was maintained, the knowledge the operator has of the condition of installed components and, through research, an understanding of how the components will perform in the future.

Fuel channel life extension

One major research initiative contributing to extended operation at the Ontario plants is COG's fuel channel life management (FCLM) programme. Research to validate the safe operating lifetime for pressure tubes has helped COG member stations extend their operating cycle prior to refurbishment by four to five years and potentially longer.

CANDU reactors were originally targeted for a 30-year design life at an 80 percent capacity factor. As nuclear fleets aged, operators needed more definitive predictions of when individual components could no longer be kept in service and when major replacements or refurbishments would be necessary.

The FCLM work has improved the understanding of degradation of fuel channel components. By uncovering the factors that contribute to ageing – primarily hydrogen uptake and irradiation – plans, tools and methodologies could be developed to acquire and analyse data from inspections, operating history and surveillance for more accurate calculations of life expectancy. Testing and analysis was conducted on both components removed from in-service power reactors and similar materials that have undergone accelerated ageing in research reactors.

Now in Phase 3 of 4, the FCLM project has already: delivered predictive models for fracture toughness to assess pressure tube fitness-for-service; provided sufficient evidence to confirm the integrity of the spacers that are used to maintain a gap between pressure tubes and calandria tubes; and improved knowledge of associated ageing mechanisms.

The combination of the FCLM deliverables, condition assessments, and extensive engineering analysis has helped confirm fitness for service and extended licensing of all the Ontario plants.

Where pressure tubes were once expected to provide up to 30 years of service, today with improved knowledge of ageing, in-service inspection and confirmation of safety margin, some units may serve for up to 40 years before a mid-life changeout.

Bruce Power has a contract with the Ontario government to provide power until 2060. At end of life, the Bruce units, which went into service in the mid-80s, will have operated for almost 80 years with one pressure tube changeout at the midpoint.

New frontiers

Research such as the fuel channel life management programme and the fuel bundle modification research (see sidebar story), as well as dozens of other research and joint projects underway through COG, are making reactors safer and more efficient.



A cutaway from a fuel channel model shows the bundle within the tube with the annulus spacer

Because CANDU technology includes more than one design configuration, some work is specific to the CANDU 6 reactor design, which is used by international operators in countries including Romania, China, Argentina and Korea as well as at New Brunswick. In other cases, lessons from research conducted for the Ontario reactors are relevant and have lessons for the C6 design. It is all part of a commitment to use collaboration as a means to create operational excellence that prompted creation of COG back in 1984.

At Pickering, some of the units are enjoying their highest lifetime performance results; something attributed to operator knowledge from research and experience gained over almost 50 years.

“The work completed by COG to better understand the ageing of life-limiting reactor components has given us confidence that these components can operate safely well beyond what we originally anticipated. It has also saved ratepayers billions of dollars for premature replacement electricity generation that would have been required without this work,” says Dermarcar.

“In my mind, it confirms the idea that the safest and most efficient plants rely not only on excellence in operations, maintenance and engineering, but also on excellence in the R&D that provides a platform for innovation.” ■



Managing ageing through modification

With the benefit of decades of operational experience, the CANDU heat transport system (HTS) has had many modifications since its original design to improve its operability and emergency response. Research continues today on specific aspects of the HTS to further validate safety margins and support risk assessment, as well as define predictable outcomes.

One of the effects of ageing in the HTS is a non-uniform change in the dimension of reactor pressure tubes through diametral creep. This causes a crescent-shaped gap to develop between the top of the fuel bundle and the pressure tube, allowing some of the coolant to take the path of least resistance and bypass the fuel bundle. Coolant flows through the centre of the bundle are reduced, reducing critical heat flux (CHF), and the corresponding margin to fuel element dry-out under postulated accident conditions. Reduced CHF decreases the operating margin for a nuclear reactor, and, if not mitigated, leads to the derating of reactor power (up to 15 percent of full power by the time the reactor is ready for fuel channel replacement) to maintain safety margins.

A COG programme aimed to recover some of the safety margin through a modification to the 37-element bundles that increased flow through its centre, compared a reference element bundle. Testing has been completed and has confirmed the modified bundle has higher and more consistent dryout power than the reference bundle, validating a higher safety margin.

The initial research supported the Canadian regulator’s risk-informed decision-making and determination of the maximum predicted fuel sheath temperature under postulated accident conditions. Further research on the modified 37-element bundle CHF experiments with new axial flux distribution includes:

- A full scale 37M-bundle simulation with a new symmetric near-cosine peak style axial flux distribution; and
- CHF and post dryout experiments in water at representative reactor conditions at 0%, 3.3% and 5.1% creep, to expand the previous data obtained.

The analysis is currently underway for these experiments and further study is planned.

Left: Research on modified fuel bundles helped to improve safety margin and contributed to greater regulatory certainty. Some CANDU Owners Group research was conducted from the Stern Laboratories control room. Pictured are Blair Chin, loop operator, Bob Hayes, test engineer, Rick Fortman, power control engineer, and Phong Vu, data acquisition technician

COG moves the ball forward

Retirements, promotions and new faces

In recent years, COG has strategically hired high-potential, mid-career individuals in preparation for future retirements. In the past six months, we have said goodbye to long-time colleagues. But, happily, COG had team members ready to take on more responsibility and welcomed others to fill the big shoes left by those moving on to new adventures.

Corporate Affairs and Finance



Rod McIvor
Changing role

For more than three decades, Rod has capably led the finance function. Rod joined COG at its inception as an independent not-for-profit corporation.

Under Rod's leadership, COG has achieved a track record of successful financial audits and built in strong reporting mechanisms to allow COG members to get a clear picture of how their contributions are spent and the value received in return.



John Moore
New! Director, Corporate Services

John takes on the newly-formed role as Director, Corporate Services (CS) and Acting Chief Financial Officer (CFO).

The CS role includes new accountabilities including oversight of COG's human resources, performance improvements, corrective action program, procurement and vendor management.

John, with 30 years nuclear industry experience, most recently managed COG's fuel channel life management work in Joint Projects and Services.



Ann Palen
Promotion

Ann assumes the role of senior business manager reflecting excellent performance in her current role as business manager for the past eight years.

She will now assume responsibility for the day-to-day financial operations of the business, working with the management team and COG's board in her new role.



Jerom Yu
New Role

Jerom has been promoted to the position of business services manager - finance.

Jerom joined COG in 2013 as operations accountant and has distinguished himself in the role, taking on the additional role of member relationship manager for CNNO.

Additionally, Jerom recently passed his Common Final Examination, a major milestone on his way to obtaining his Chartered Professional Accountant designation.

Nuclear Safety and Environmental Affairs (NSEA)



Martin Reid
Off to new adventures

After almost 10 years as part of the COG management team, Martin retired from his position as Director, NSEA in December 2017.

Martin joined COG as Director, Information Exchange in 2008 before moving over to NSEA. He brought extensive industry experience including a career at Ontario Hydro / OPG. Under Martin's leadership, NSEA grew to provide increasing value to COG members. Martin's leadership extended into other areas of COG and his presence will be missed by all.



Rachna Clavero
New! Director NSEA

Rachna assumed the role of Director, NSEA in August 2017 following four months as interim director. She joined COG in 2015 originally as the Strategic R&D program Manager.

Prior to joining COG, Rachna held positions at AECL, Candesco and the Ontario Ministry of Energy. Much of her career prior to joining COG has been in the area of safety and licensing.

Research & Development (R&D)



Wei Shen, PhD
Joins COG Safety and Licensing

Wei joins the COG team as program manager for the Safety and Licensing program, after almost 30 years in the CANDU and PWR industry including engineering design, safety analysis, software development, fuel management and uncertainty analysis.

Wei has worked at the Shanghai Nuclear Engineering Research & Design Institute (SNERDI) in China, Atomic Energy Canada/Candu Energy Inc., and most recently with the Canadian Nuclear Safety Commission. Wei was recently named a Fellow of the Canadian Nuclear Society.



Holly Anderson
New! Strategic R&D

Holly will be taking on the role of program manager for the Strategic Research and Development program.

In her previous role, Holly managed the Safety and Licensing program where she was responsible for the successful facilitation and administration of R&D projects related to nuclear safety and licensing on behalf of the COG membership.

Goodbye Harry

COG said goodbye to Harry Sherwood in December. Harry has held the project manager position in the Fuel Channel Life Management program for the past four years.



Joint Projects and Services (JP&S)



Macit Cobanoglu Changing gears

Macit leaves the role of Director, JP&S in the new year to assume a part-time role at COG managing the C6 Fleet and Supplier Participant programs.

He joined COG in 2014, bringing with him more than 30 years of experience in the nuclear industry.

Under Macit's leadership, COG has seen a significant increase in participation by its international members and enhancements in the JP&S program structure.



Sonia Qureshi New! Director JP&S

Sonia will take on the role of Director, JP&S in the new year. Sonia brings a unique blend of technical engineering proficiency and commercial business expertise with 20 years of experience in the CANDU nuclear energy sector.

Since joining COG almost two years ago, Sonia has worked as a program manager in the Information Exchange department. She led the first-ever COG Collaboration week and also managed the 14th COG/IAEA Technical Committee Meeting.



Taruna Matharu Promotion

Taruna has been promoted to the position of project coordinator in JP&S. She has been with COG for 11 years, working with both the Information Exchange and JP&S teams.

Taruna's new responsibilities will include providing support to the JP&S program managers and project managers on their day-to-day activities. She will also support the C6 Fleet and Supplier Participant programs.



Thanuja Janathasing New Role

Thanuja assumes the role of project manager in the Fuel Channel Life Management program from Harry Sherwood.

Thanuja joined COG from Canadian Nuclear Laboratories (CNL) earlier this year and brings nearly a decade of experience in project management and fuel channels related work.

Knowledge Management (KM)



John Sowagi New! Acting Director

John has been promoted to the newly-created role of Acting Director, KM.

Under John's leadership, the KM function has grown over the past few years in both significance and scope.



George Williams Joins COG

George joins as the program manager for KM with the primary focus of helping with the growing demands of leadership development. George previously worked at Bruce Power and has more than 30 years of experience in the nuclear industry.

Information Exchange (IE)



Mark Skuce joins COG

Mark joins COG as an IE project manager. He will be responsible for facilitating engineering and asset management peer groups and will lead COG Collaboration Week. Mark will also support the Board Secretary role.

Mark brings over 25 years of experience with Ontario Power Generation.

Other Milestones



Kelly Curtis 15 years of service

For 15 years, Kelly, COG's technical service specialist has provided COG technical expertise across a spectrum of IT areas makes him an invaluable member of the team. Kelly also serves as COG fire warden, improving workplace safety for all employees. Thanks to Kelly for all of his excellent work over the last 15 years and his ongoing commitment to our success.



Jullaine Hardinge 5 years of service

Jullaine celebrated five years at COG in December. In her role as administrative assistant with COG's R&D program, Jullaine plays an integral role in facilitating R&D projects on behalf of COG members.



Janet Leclair Joins COG

Janet joins COG as a human resource contractor. She brings more than 20 years of experience working with a variety of clients.

Janet's arrival is in response to COG's growth in the last few years. She will provide HR guidance to both the management team and employees.

For more information, visit us at

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