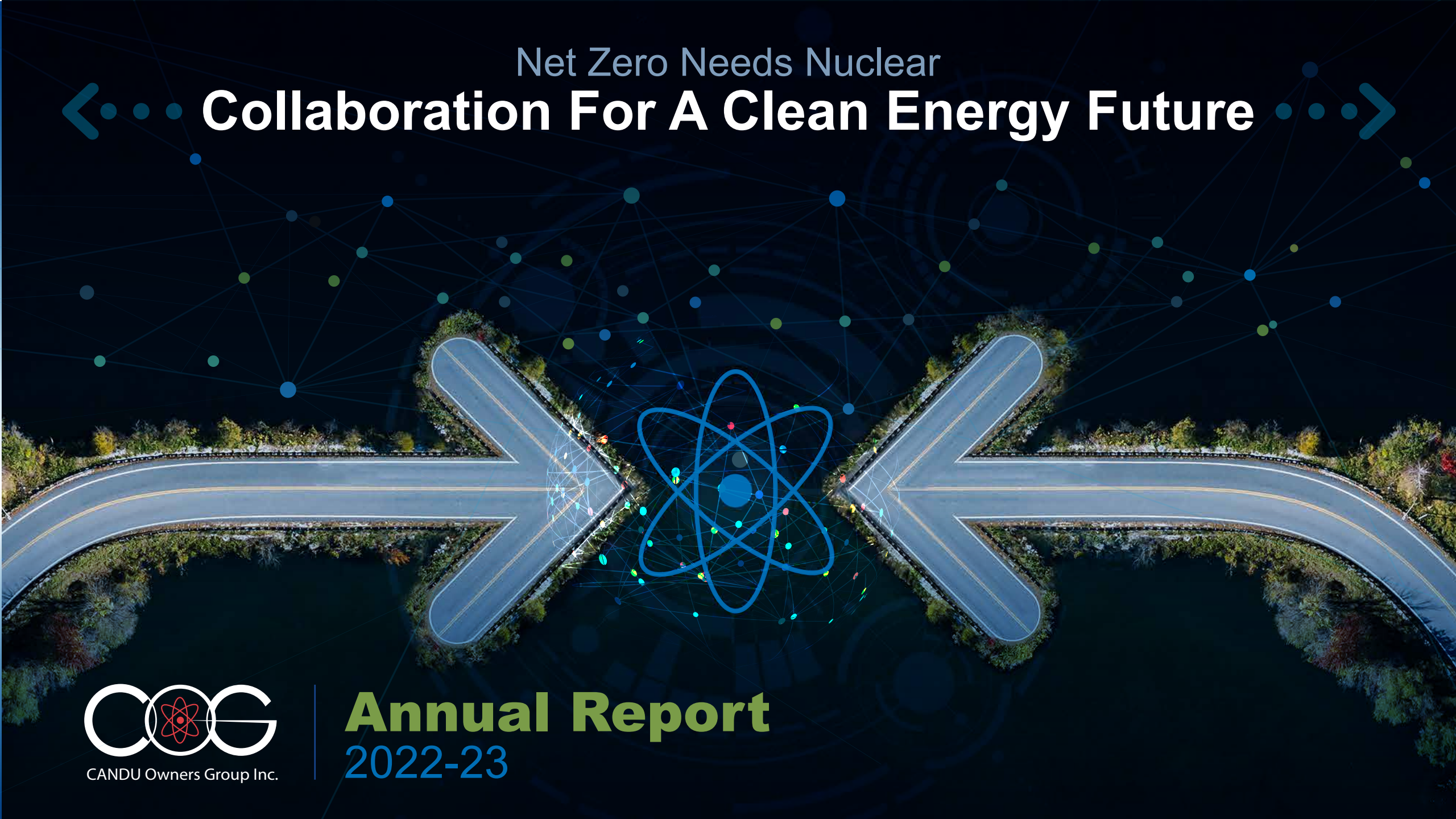


Net Zero Needs Nuclear

# Collaboration For A Clean Energy Future



**Annual Report**  
2022-23



<b>About COG</b> .....	3
Who We Are .....	3
COG's Values .....	3
Generating Exponential Value from the COG Collaboration Model .....	4
Excellence and Innovation Through Collaboration .....	5
Members .....	6
Supplier Participants .....	6
SMR Vendor Participants .....	6
Partners .....	6
Working with Partners and Stakeholders .....	7
COG Lines of Business .....	8
<b>Message from the Chair of the BOD</b> .....	9
COG Board .....	9
<b>Message from the President and CEO</b> .....	10
COG Management Team .....	11
<b>Performance Highlights 2022-23</b> .....	12
Stronger, Together: A Return to In-Person Collaboration .....	12
2022–23 Results .....	13
Fostering Diversity: An Interview with Rachna Clavero .....	14
Global Collaboration for Excellence .....	15
The World at Our Fleet: CANDU 6 Fleet Forum .....	17
Building a Strong Supply Chain: Supplier Participant Program .....	18
Supply Chain Support: CANPAC/CANIAC Program Update .....	19
Fuel Channel Innovation: A Point of CANDU Pride .....	20
Beyond CANDU: Leveraging the COG Collaboration Model for Advanced Technologies .....	22
Exploring New Frontiers: The Innovation Technology Workshop .....	23
<b>COG 2023–24 Priorities:</b> Addressing Today's Challenges and Tomorrow's Opportunities .....	24



## About COG

# Excellence Through Collaboration

### Who We Are

Established in 1984, **CANDU Owners Group (COG)** is the preeminent organization providing collaborative research and development and information sharing, enabling our members in Canada and internationally to achieve operational excellence and bring clean energy to the world.

COG is a private, not-for-profit corporation funded voluntarily by CANDU operating utilities worldwide, Canadian Nuclear Laboratories (CNL) and supplier participants. Together with its members, suppliers, partners and researchers, COG is continuously strengthening nuclear plant equipment and processes to ensure the highest standard of safety, efficiency and environmental performance.

COG's workshops, events, training programs peer groups, and online resources facilitate industry sharing of operating experience and create the conditions for regulatory acceptance and improved human performance.

Through its Collaboration Model, COG helps the industry succeed through creation, retention and transfer of knowledge to achieve continuous improvement and develop the nuclear innovations of tomorrow.

COG is a trusted nuclear industry leader comprised of **highly skilled, diverse employees with extensive experience** in many facets of CANDU nuclear technology and project management.



We are committed to the **principles of equity, diversity, inclusion and collaboration excellence.**

### COG's Values

#### Integrity

- > Be truthful and honest
- > Do the right thing regardless if anyone is watching
- > Accept responsibility for our actions



#### Respect

- > Treat all with dignity
- > Embrace diverse backgrounds, experiences, perspectives, and talents of all
- > Demonstrate fair and equitable treatment to all

#### Commitment

- > Do what we say
- > Our word is our contract

# Generating Exponential Value from the COG Collaboration Model

We generate powerful synergies for our members and nuclear partners to help them create solutions, transform and achieve performance excellence – better, faster, and at a lower cost than they could on their own.

Through the COG cost-sharing model, members and participants gain a much larger return on investment than they contribute on the most innovative research, continuous improvement programs and access to industry intelligence, best practices, and supply chain development. In addition, COG manages industry IP and a shared pool of information, data and human capacity development.

Through COG, members achieve their individual and collective objectives by developing common approaches to standards and regulations, sharing audit and procurement services, developing best practices and addressing industry technical challenges and opportunities.

COG also serves as a bridge to other organizations so members get the most value and relevance from their memberships.

## Financial Benefits



### Cost Sharing

Customer funding, Strategic Research and Education Development credit, grants, shared audit and procurement services



### IP Portfolio Management and Information Access

Managing shared data for information exchange and retention more effectively and at a fraction of the cost



### More Revenue Streams

COG revenue-generating strategic initiatives contribute to cost centres, thereby ensuring COG remains sustainable, adaptive to member needs and able to retain unique expertise and capabilities

## Other Benefits

- > Pooled resources
- > Shared intelligence
- > **Highly Qualified Persons:** COG peer groups, forums and training programs contribute to greater human capital
- > **Group Support:** COG members and participants benefit from peer support and the ability to “call a friend”
- > Maintains a higher standard of CANDU performance across the fleet
- > Key expertise and support is available to members when and where they need it  
*e.g., quick response in the face of an industry emergent issue or advancing innovation to ensure future sustainability*
- > With significant turnover taking place across the nuclear industry, COG is uniquely positioned to maintain and build industry capability and expertise through its mechanism for information exchange, training and leadership development
- > Common approaches to standards and regulations
- > Proven collaboration model can be applied to additional areas of member interest

# Excellence and Innovation Through Collaboration

Through collaboration of all CANDU operators, worldwide, with supplier participants, small modular reactor vendors, and COG partners and other participants, COG has established a unique and proven mechanism for pooling of funding, resources and knowledge. It also brings together expertise from across the industry and a diversity of perspectives that can lead to exponential results on initiatives and research of common interest to its members.

In addition to its CANDU operating members, COG has a well-established Supplier Participant (SP) program, which provides opportunities for information exchange, training and interaction between operators and SPs to strengthen common understanding of expectations, issues and opportunities.

As well, since 2018, COG has steadily grown its presence as an industry facilitator of industry small modular reactor (SMR) collaboration. Through COG, members, Small Modular Reactor (SMR) vendors and partner organizations are sharing information,

pooling resources, and working together to develop and deploy SMRs in support of climate change goals.

To fully take advantage of COG's collaboration infrastructure, COG has formed several partnership agreements or strong working relationships with industry partners in Canada and around the world.

COG's head office is in Toronto, Canada.

**10** members in 7 countries

**30+** supplier participants

**8** SMR vendor participants

**3** organization participants

And many Canadian and international partners



“ COG has established a unique and proven mechanism for pooling of *funding, resources and knowledge* ”



## Supplier Participants

AECOM  
 Aecon Construction Group  
 Alithya Digital Technology  
 ATS Corporation  
 Babcock Canada-Cavendish Nuclear  
 BWXT Canada Ltd.  
 Calian Nuclear  
 Cameco  
 CCNuclear  
 China Nuclear Power Operations  
 Technology Corp.  
 Curtiss-Wright Nuclear Canada  
 EXO Insights  
 Framatome  
 Hatch Ltd.  
 Isaac Operations Ltd.  
 Jensen Hughes Consulting  
 Canada  
 Kalsi Engineering Inc.  
 KEPCO E&C  
 Kinectrics Inc.  
 L3HARRIS/L3 MAPPS  
 Lakeside Process Controls  
 Laurentis Energy Partners  
 Macdonald, Dettwiler & Associates Inc.  
 NPX Innovation  
 Nuvia Canada Inc.  
 PCL Industrial Constructors  
 Plan Group  
 Promotion  
 SNC-Lavalin Nuclear Inc.  
 Stern Laboratories Inc.  
 Tyne Engineering Inc.  
 Unified Engineering.com Corp.  
 Westinghouse  
 Worley



## Organization Participants

Atomic Energy Canada Ltd. – AECL  
 Hydro-Québec  
 Nuclear Waste Management  
 Organization – NWMO

## Partners

Canadian Nuclear Association – CNA  
 Canadian Standards Association – CSA  
 Electric Power Research Institute – EPRI  
 Institute of Nuclear Power  
 Operations – INPO  
 International Atomic Energy Agency – IAEA  
 OECD Nuclear Energy Agency – NEA  
 Nuclear Energy Institute – NEI  
 Nuclear Generation II and III  
 Association – NUGENIA  
 Organization of Canadian Nuclear  
 Industries – OCNI  
 University Network of Excellence  
 in Nuclear Engineering  
 – UNENE  
 World Association of Nuclear  
 Operators – WANO

## SMR Vendor Participants

ARC Nuclear Canada  
 GE Hitachi Nuclear Energy  
 Moltex Energy  
 NuScale Power  
 Terrestrial Energy  
 Ultra Safe Nuclear Corp.  
 Westinghouse  
 X-energy



# Working with Partners and Stakeholders

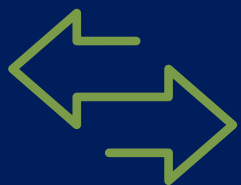
COG holds the membership for the Canadian utilities with the Electric Power Research Institute (EPRI) helping members to contribute and derive knowledge from EPRI membership most effectively.

COG facilitates its Canadian members' interactions with the Canadian Nuclear Safety Commission (CNSC) on some regulatory files and the Canadian Standards Association Group (CSA) on standards development where multiple COG members have common objectives.

As well, COG interacts with government organizations and ministries including Natural Resources Canada, Health Canada and Environment and Climate Change Canada, federally, and the Ministry of Energy, provincially in Ontario, where its members have shared objectives on technical policy development.



# COG Lines of Business



01

## Information Exchange

- > Learning and Development
- > Operating Experience
- > Technical conferences, workshops and meetings
- > Benchmarking and operational effectiveness

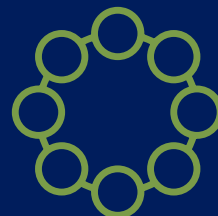
02



## Research and Development

- > Strategic R&D
- > Fuel Channels
- > Safety and Licensing
- > Chemistry, Materials and Components
- > Industry Standard Toolset
- > Health, Safety and Environment

03



## Joint Projects and Services

- > Joint projects (two or more members) including FCLM
- > Supply chain, obsolescence management and procurement
- > Shared supply chain auditing and inspection services
- > CANDU-6 Fleet

04



## Nuclear Safety and Environmental Affairs

- > Nuclear Safety
- > Environmental Affairs
- > Common Standards and Regulatory Approach
- > Emergency Preparedness and Response
- > Decommissioning
- > Nuclear Waste Management
- > Small Modular Reactors

**Learn more** about our Lines of Business on our [public website](#) or [COGonline](#)





## Message from the Board Chair

# Building a clean energy future, together



**Gary Newman**, Board Chair

In 1987, the CANDU reactor was ranked one of Canada's Top 10 engineering achievements of the previous 100 years. Today, more than 35 years later, the technology has proven the test of time, and so has the value of collaboration.

We are seeing this demonstrated through momentum across multiple fronts, including the refurbishments at Ontario Power Generation and Bruce Power being delivered on time and on budget, the growth of medical isotopes programs, the prospective refurbishment of Pickering, a new build on the horizon at Cernavoda, and the potential for life extensions at Wolsong and Qinshan.

Jurisdictions in Canada and internationally are relying on CANDU members to power their economies and meet climate change goals. Domestically, clear support for nuclear by Ontario's provincial government, together with the tax credit system rolled out by the federal government in this year's budget are game changers. Today, there are unprecedented opportunities for new technologies and a newly level playing field between large scale nuclear and other forms of generation, opening the door to all of the benefits of clean, affordable energy, medical isotopes, and meaningful Indigenous partnerships that come with it.

With many new areas of nuclear exploration underway, and new technologies transforming our existing operations, COG's unique collaboration model and infrastructure will continue to be the key mechanism for building and sharing knowledge to address the nuclear industry's most challenging technical problems and enable sustained, quality performance.

For example, analytical modeling, experimental research and surveillance done via COGs Fuel Channel Life Management (FCLM), Spacer Life Management (SLM) and Fuel Channel Research and Development projects have helped secure extended operations of the domestic CANDU fleet, and are now being leveraged in support of refurbishments in COG's international member countries. More recently, COG's agility

and bench strength in this area put CANDU operating facilities in a very strong position to respond quickly to surveillance discovery items, assuring pressure tubes integrity and the ability to meet related regulatory requirements, in line with the industry's high standards and safety culture.

With the potential for CANDU facilities to continue operations for another 40–80 years, and the opportunities for new nuclear technologies and new-build, the Board and Management Team recognize that a deliberate, thoughtful approach is needed to ensure the sustainability of the industry, and of COG. Maintaining and building on the credibility, expertise and social license we have generated collectively over the past several decades is job number one. To that end, COG is undertaking an organizational refresh, including a thorough review of the Research and Development program, to ensure ongoing sustainability and sustained focus on the industry's highest areas of priority, opportunity and risk.

I am very proud of what the industry has achieved over the past 35+ years, and even more excited about all that is ahead. I am thankful for the COG team, and for the leadership and stability that Rachna Clavero has brought to the organization since being appointed as president and CEO in December. Our history of collaboration is the foundation on which we are building our collective clean energy future.

### The COG Board of Directors



**Dumitru Benchea**  
Societatea Nationala  
Nuclearelectrica, Romania



**Jeffrey Griffin**  
Canadian Nuclear Laboratories



**Leslie McWilliams**  
Ontario Power Generation



**Jason Nouwens**  
New Brunswick Power

## Message from the President and CEO

# What a difference a year makes



**Rachna Clavero**, President and CEO

In June, 2022 the International Energy Association (IEA) published a report looking at how nuclear energy could help address two major global crises – energy security and climate change. The report noted that “extending nuclear plants’ lifetimes is an indispensable part of a cost-effective path to net zero by 2050.” It made several other recommendations, including implementing solutions for nuclear waste disposal, promoting efficient and effective safety regulation, and accelerating the development and deployment of small modular reactors.

Governments and utilities around the world responded in kind. Over the course of 2022–23, there has been momentum like I have never seen in my 25 years in the nuclear industry. And our collective success hinges on our ongoing commitment to collaboration.

Since I returned to COG in December, 2022 I have spent a lot of time connecting with COG’s members, suppliers, and partners. From my conversations, COG continues to be the industry go-to for the reason we were first established almost 40 years ago — to maintain CANDU performance excellence. At the same time, we are increasingly being sought out for our unique capability to foster industry collaboration and alignment as momentum grows for advanced technologies and new builds.

To that end, our focus over the past fiscal year has been on ensuring that COG’s collaboration model is robust, sustainable, and scalable, so we can continue to provide support for CANDU operators here in Canada and internationally, while leveraging it for new applications.

COG maintains the CANDU industry’s largest collaborative research and development program. The over \$75 million in work we do annually in support of our members has enabled them to achieve record-breaking operations while improving safety margins and extending plant life. In FY22–23, the COG team delivered value through over 500 R&D work packages completed; one of our strongest years ever.

And as industry seeks solutions to reduce cost and increase energy output, COG has taken a leading role in bringing innovative solutions to our members by working with our supplier partners and launching a series of Innovation and Technology Workshops.

Joint Projects and Services also had a strong year, demonstrating that when the industry needs emergent work done, COG is there to bring the right subject matter experts together.

Phase four of the Fuel Channel Life Management (FCLM) project continues with additional focus on pressure tube high hydrogen equivalent [Heq] predictability, modeling and burst testing. With the need for continued monitoring and understanding of fuel channel behavior, phase five of the program has been approved. In addition to this important work, the joint project portfolio included projects focused on waste management, decommissioning, leak detection, inspections, and obsolescence.

“

Over the course of 2022–23, there has been momentum like I have never seen in my 25 years in the nuclear industry. And ***our collective success hinges on our ongoing commitment to collaboration***

“



Strategically, this team is focused on the potential to support refurbishment work in the C6 fleet, bulk procurement, and continued support for fuel channels to ensure our members reach their long-term operational targets.

As the industry embarks on multiple refurbishments, new builds, and decommissioning planning, the need for qualified vendors is increasing. Through COG's CANPAC, CANIAC and CIQB programs our members and suppliers benefit from shared audit and qualification services, and we anticipate increased demand in the coming year.

With the return to in-person collaboration and training, COG's Learning and Development courses are experiencing renewed interest and demand. This program is helping to build the next generation of nuclear leaders and ensuring high standards of leadership are maintained across the fleet and to non-CANDU leaders. In recent years the program has garnered attention from both WANO and the IAEA.

Over the course of FY 2022-23 we relaunched our Nuclear Professional Development Seminars, featuring refreshed content, instructors, nuclear plant site visits, and a new venue, and resumed our Supplier Participant First Line Supervisor course. We also hosted the COG-International Atomic Energy Association (IAEA) Nuclear Energy Management School in Oshawa.

We resumed our overseas training programs, delivering four in-person Leadership and Safety Culture courses for Korea Hydro & Nuclear Power (KHNP) leaders.

International requests for COG training programs continue to grow in the current fiscal year. Following fiscal year end, in April and May, 2023 we delivered the first two of eight Leadership Training classes for over 160 staff at Cernavoda NPP in Romania, and the first-ever Senior Leadership course for NPCIL in India.

Our Nuclear Safety and Environmental Affairs (NSEA) program continues to drive common industry approaches and best practices to CANDU regulation in Canada and worldwide, with recent areas of focus such as IAEA's Equipment-Based Approach to Safeguards and modernization of the regulatory framework. After expansion of the COG mandate in 2018 to include advanced technologies, this program also supports key areas of collaboration for SMRs in Canada, ensuring that our industry is ready to integrate and manage new technologies. These discussions are bringing new faces to the COG table with participation from SaskPower and Pathways Alliance.

Developments over the past year have made it clear that net zero needs nuclear. In addition to supporting our members' current needs, our team remains focused on advancing the critical work being undertaken to evolve COG as an organization in response to developing challenges and opportunities. Just as we have been for the past 39 years, we are committed to supporting the industry in knowledge development and transfer and capability maintenance, both today and long into the future.

I am excited to be back at COG, leading an incredible team and working with our members, whose commitment to excellence through collaboration is the key to unlocking our clean energy future.

## Lines of Business



**Carlos Lorencez**

Director, Nuclear Safety & Environmental Affairs Program



**Usha Menon**

Director, Research & Development Program



**Sonia Qureshi**

Director, Joint Projects & Services Program



**John Sowagi**

Director, Information Exchange Program

## Corporate Functions



**Sarah Charuk**

Senior Manager, Communications



**Mark Jeffers**

Director, Corporate Services



**Ann Palen**

Treasurer and Chief Financial Officer



**Carmen Trandafir**

Manager Information Technology and CIO

# Performance Highlights 2022–23

## Stronger, Together

**In-person collaboration is an essential component of excellence through collaboration.**

After pivoting to remote operations in 2020 as a result of restrictions from the global pandemic, the COG team was delighted to resume in-person collaboration in 2022. This involved welcoming COG staff back into the office, organizing and participating in conferences, international trips for collaboration with members, and providing development opportunities.

In August 2022, COG welcomed employees back to the office, implementing a hybrid work model that prioritizes focus, collaboration and information sharing across the COG team.

From May 9–20, COG hosted the COG-International Atomic Energy Association (IAEA) Nuclear Energy Management School in Oshawa at Ontario Tech University. In attendance were 13 international students from 10 countries, as well as eight participants from Canada, with several presentation topics delivered by Canadian subject matter experts.

We relaunched our Nuclear Professional Development Seminars in June and November, featuring refreshed content, instructors, nuclear plant site visits, and a new venue. This program helps to foster the next generation of nuclear leaders, with participants from

COG members and suppliers including Ontario Power Generation, Bruce Power, New Brunswick Power, Canadian Nuclear Laboratories, SNN and BWXT. Our overseas training programs also resumed, allowing us to deliver four in-person Leadership and Safety Culture courses in Korea for KHNP leaders. These courses have addressed a key area of focus for KHNP leaders through opportunities to enhance their knowledge of Safety Culture and apply it directly to their respective roles.

From September 12–16, COG and the IAEA facilitated the 16th Technical Committee Meeting (TCM) in cooperation with our host-member, SNN in Romania. Additionally, we were able to relaunch the Supplier Participant First Line Supervisor course in December. The course empowers nuclear industry suppliers to strengthen their understanding of nuclear culture and develop their leadership skills. Participants represented six organizations including Cameco, Calian Nuclear, BWXT, MDA, Alithya and SNC Lavalin.

COG also seized the opportunity to participate in-person at industry meetings and events, including the annual Canadian Nuclear Association conference, as a sponsor of the Women in Nuclear (WiN) Canada Conference, attendance at NWMO's industry day, EPRI Advisory Meetings and in February of 2023 at the Nuclear Power Council meetings in Nashville, TN where EPRI experienced the largest in-person crowd ever.





# 2022–23 Results

The 2022–23 R&D program had one of its strongest years ever, with 96% of budget spent at year-end, delivering over 500 work packages to COG members and publishing 341 reports.

COG's JP&S portfolio includes 37 active projects with a portfolio value of over \$100 million. COG continues to work on projects covering many different areas such as: enhancements to gain margin/mitigate derating; fuel channel and spacer life management; strategic decommissioning waste management; bulk procurement; equipment reliability and system improvements.

The NSEA program continued to move ahead on key work in many areas throughout 2022–23, including facilitation of the SMR Technology and CEO Forums and several peer groups including Nuclear Safety; Regulatory Affairs Managers; Nuclear Environmental Affairs; Waste Management; and Decommissioning.

For the 12-month period ending 31 March, 2023, COG's Q&A Forum logged 117 questions asked with a response rate of 91%.

We are enhancing our strategic management capabilities through a Balanced Scorecard and refreshed KPIs, with a pilot in process.

COG Integrated COGonline Newsgroups and Q&A Forums into a single application that allows for faster searches and an improved interface. To further streamline and enhance access to real-time information, we've integrated a single-sign on for access to OPEX Records and Forums and enhanced Newsgroups access.

“ **Strengthened cyber security systems, training and IP management.** ”

With a return to in-person collaboration in 2022, we are seeing increased interest and demand for COG's Learning and Development programs from both domestic and international members, including delivery of our first leadership training courses to NPCIL in Mumbai, India.

**500+** Work Packages

**341** Published Reports

**37** Active Joint Projects

**\$100+ M** Portfolio Value

87% 36%

# Fostering Diversity: An Interview with Rachna Clavero

President and CEO Rachna Clavero discusses her approach to fostering diversity at COG, and how the organization is enabling excellence through a broad range of perspectives and application of COG's collaboration model.

**Q** How has COG advanced the principles of diversity?

**A** Traditionally, COG was known for its technical expertise, primarily related to the utilities; but, over the past five years, **we have experienced a transformation, assisting companies with succession planning and knowledge transfer.**

As a cross-industry workplace, we're bringing in people with distinct skill sets – from backgrounds in utilities, supply chain, regulation, academia, and even beyond nuclear – who want to build meaningful careers. Their extensive insights **offer our members diversity of thought**, making the connections that support progress.

**Q** What is the current status?

**A** We have gender parity on our management team and across our staff, and we're getting a lot of interest from people of all ages. **By simply hiring the best talent, we're attracting a diverse demographic;** we'll continue to align our approach with the industry's rising demand for human resources.

As a global company, COG represents seven different countries. **Our member relations managers act as points of contact, resolving language barriers and helping us to understand the international utilities' needs.** And, with COVID elevating people's comfort level in video conferencing, participation in peer groups and meetings has expanded.

**Q** Could you describe COG's international relationships?

**A** Our secondment program, which has been in place for at least 10 years, invites international representatives to join us in our offices for a period of 6–12 months. **We benefit from an overseas viewpoint, and they take our domestic lessons learned and best practices to their sites.** This year we welcomed a member from South Korea, and we are expecting a representative from Romania to join this summer.

**The rate of growth for the international members is phenomenal.** China, South Korea and Romania are refurbishing their CANDU reactors, and Romania is finalizing the acquisition of two new units. Most of the global members are also interested in SMRs, and partnerships are a clear advantage in the development of this new technology.

**Q** How is COG's collaboration model fostering a more diverse industry?

**A** The length and methodology of the certification training program for operators has created barriers. Without the capacity to pause the training, it was prohibitive for those on parental or maternity leave, for instance. We are working with our utility members and the regulator to optimize the program, including the introduction of online delivery, **which will open the doors to include more women and young people in plant control rooms.**

**Our industry is entering a true renaissance; workplace diversity leads to faster and better solutions in our shared commitment to building a clean-energy future.**



# Global Collaboration for Excellence

Global engagement benefits all of us, in mutual support, collaboration, and breadth of perspectives. Our international members report on their status and achievements throughout the past year.

## **Korea Hydro & Nuclear Power Co. Ltd. – KHNP**

This year, KHNP completed outages on Units 3 and 4 at the Wolsong Generating Station, with Unit 1 shut down for decommissioning. Three 1400 Mwe pressurized water reactors are now under construction, with two more in the planning stage. Currently, KHNP is developing SMR technology, with a 2025 target for vendor design submission. COG’s CANDU Inspection Qualification Bureau (CIQB) qualified two feeder thickness measurement procedures and five inspection personnel. In 2022–2023, KHNP joined the Nuclear Safety and Environment Affairs Program and completed four one-week courses through our Safety Culture Training platform.

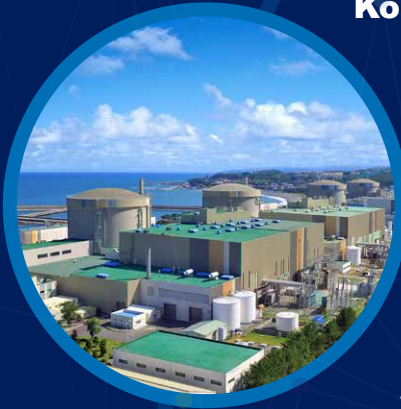
## **Pakistan Atomic Energy Commission – PAEC**

The Karachi Nuclear Power Plant (KANUPP) Unit 1 was one of the first international exports of Canadian CANDU technology, achieving its first criticality on August 1, 1971. After 50 years of operation, as the longest continuous run of CANDU operation without major refurbishment, it was permanently shut down. PAEC is currently involved with COG in decommissioning and waste management activities.

## **China National Nuclear Operations Management – CNNO**

In 2022, CNNO’s two CANDU 6 units at Qinshan achieved non-stop year-round operation, hitting a power-generation record exceeding 53.5 billion kWh. Power generation has increased eight times in a row, with capacity and load factors achieving “Double 90%” performance for six consecutive years. On April 24, 2023, CNNO’s CANDU Unit 1 was successfully connected to the grid after completion of its 112th outage, lasting less than 27 days – another performance record for CANDU units.

Through participation of COG’s S&L and IST R&D programs, CNNO has successfully applied related reports to CANDU units to carry out major projects such as 37M fuel application, pressure-tube re-tubing preparation, and plant simulator system development. To date, the 37M fuels have been successfully fabricated and loaded at the Qinshan site with increased safety margin to avoid the risk of power de-rating. CNNO’s personnel took part in 20 peer groups in 2022; and, in February 2023, shared their principles in spare-parts quality assistance classification at the C6 Fleet Technical Support meeting.



## Nuclear Power Corporation of India Limited – NPCIL

NPCIL operates 22 commercial nuclear reactors with a combined capacity of 6,780 Mwe. In 2022, ground was broken for the Kaiga 5 and 6 reactors, the first set of 10 indigenous 700Mwe Pressurized Heavy Water Reactors (PHWR) to be built and set up in fleet mode. As of May 2023, seven PHWRs have undergone successful En Mass Coolant Channel Replacement (EMCCR) campaigns, and one unit at the Rajasthan Atomic Power Station (RAPS 3) is undergoing EMCCR. In March 2023, Rachna Clavero, Sonia Qureshi and Usha Menon met with NPCIL executives at their headquarters to discuss further opportunities to engage with COG; and COG conducted NPCIL's first Senior Leadership Course in May 2023 in Mumbai, India, which received very good feedback. A secondment of NPCIL staff at the COG office in Toronto is being pursued for participation in COG Peer Group and OPEX meetings.



## Societatea Nationala Nuclearelectrica – SNN

Romania's SNN participates in a number of peer groups through Nuclear Safety and Environmental Affairs, helping to prepare reports documenting industry challenges, opportunities and best practices, as well as the Human and Organizational Factors Peer Group. Recently, SNN, Bruce Power, Canadian Nuclear Laboratories, New Brunswick Power and Ontario Power Generation developed a Nuclear Safety and Security Culture Assessment Tool. A project to build two new CANDU 6 units is in progress, doubling the number of CANDU units in Romania; and SNN is partnering with American company NuScale Power to build a first-of-a-kind small modular reactor. In September, SNN hosted the 16th Technical Committee Meeting, including a site visit to its Cernavoda plant.



## Nucleoeléctrica Argentina Sociedad Anónima – NA-SA

NA-SA currently awaits the conclusion of negotiations between the governments of Argentina and China for the financing of a new build (Atucha III). The life extension of Atucha I is ongoing, with a scheduled shutdown in September 2024. The spent fuel dry storage Project I was completed in August 2022, and preliminary tasks for Project II started in May 2023. In August 2022, a COG team visited plants and head office to help NA-SA optimize their operations. NA-SA continues to collaborate with Argentina's National Atomic Energy Commission (CNEA) to complete civil construction of the CAREM SMR.



## Technical Committee Meeting 2022

SNN hosted the 16th Technical Committee Meeting (TCM) in September 2022, to develop solutions and exchange best practices on key topics such as outage optimization, fuel handling operations, equipment reliability enhancement and condition-based maintenance. Participants included our Canadian and international utilities members, as well as the Canadian Ambassador to Romania, the International Atomic Energy Agency, the Electric Power Research Institute, the Atomic Energy Regulatory Board of India, BHABHA Atomic Research Centre, Westinghouse, Kinectrics and SNC-Lavalin. Focused interactive workshops followed by discussion sessions created synergies and optimized opportunities for continuous improvement of the CANDU fleet. Some specific solutions were realized with respect to the Fuel Handling Equipment Reliability Index, analyzing performance, reviewing events and sharing lessons learned; as well as Condition-Based Maintenance insights including financial and operational benefits derived from on-line monitoring. The informal workshops, networking dinners and site visits to Cernavoda were well received, setting the style for future TCM events.



# The World at Our Fleet: CANDU 6 Fleet Forum

In 2015, the CANDU 6 Fleet was formed with the idea of exchanging designs, safety analysis basis, equipment lifecycles and to discover what else could come of gathering operators with common technology and common issues together. A Steering Committee (SC) with senior representatives from the C6 utilities provides leadership and direction to the Forum.

In the years since, the group has leveraged individual experience into the benefits that accrue from a global fleet.

Supported by the Joint Projects & Services group, COG enables collaboration among C6 utilities in different geographic regions. Facilitation plays a crucial role in enabling collaboration across geographical boundaries, languages and time zones.

Technical Subject Matter Experts (SMEs) from SNN, CNNO, KHNP, NBP and NA-SA meet to share their expertise and experience on the topics of common interests as advised by the SC. In 2023, technical meetings were held to discuss fuel handling, quality level assignment, preventive maintenance deferrals and outage interval extension.

Technical meeting discussions provide opportunities for C6 stations to learn from the success of their peers and develop strategies to address specific challenges. These

“

Discussions provide opportunities for C6 stations to **learn from the success of their peers** and develop strategies to address specific challenges.

“

technical meetings, in addition to monthly C6 steering committee meetings, help C6 utilities to build a network of subject matter experts that they can rely on to seek support and guidance on urgent issues. With high staff turn-over in recent years at all utilities, the collaboration framework through the C6 Fleet plays an even more important role in sustaining critical CANDU 6 knowledge.

## In 2022-23, the group demonstrated strong collaboration through:



**A 100% response rate** to 12 urgent questions and 56 non-urgent questions posted by C6 utilities.



**Support to Pt. Lepreau and readiness to share** out of stock items such as PHT filters.



**Timely support** on Cernavoda 2's fueling machine challenges from NB Power, including participation in a Quality Review Board meeting within 24 hours of the request by SNN, and ongoing discussions on support for FM simulator training. Other C6s also supported by providing information via e-mail.

The group's ongoing collaboration success is the result of their collective commitment, led by Steering Committee Chair, Dumitru Benchea from SNN and Deputy Chair, Yongxiang Zheng of CNNO. Mr. Benchea demonstrated leadership through the establishment of fleet collaboration metrics and quarterly reviews to increase visibility

of action adherence, meeting attendance, response rate to questions etc., which drove member engagement up throughout the year.

Thanks also to Jason Nouwens from NBP, Jaebum Kim from KHNP and Ricardo Tibaldi from NA-SA for their participation in monthly meetings.

# Building a Strong Supply Chain: Supplier Participant Program

The members of COG's Supplier Participant Program (SPP) collaborate to provide the best services to their utility customers, ensuring a robust supplier network to support the CANDU nuclear industry.

In 2022–2023, the SPP welcomed two new members. NPX Innovations, a consulting engineering company, specializes in developing and managing nuclear solutions such as digital twins and online monitoring, AI and machine learning, and modern design engineering. Exo Insights offers unique training tools to help energy companies in high-risk, mission-critical environments with advanced AR/VR systems.

The program's new post-COVID hybrid format maintained a high level of participation. Efforts are underway to increase in-person participation in order to enhance face-to-face interactions with utility representatives and other SPs, and promote better collaboration. Bi-monthly SP meetings provide a platform for OPEX sharing, averaging five pieces of OPEX topics discussed. The scope of 'Dialogue with Utility Executives' presentations expanded with the addition of international utilities; and the agenda was further enhanced through a 'Dialogue with SMR Vendors' session, featuring senior representatives from X-Energy, GE-Hitachi, Terrestrial Energy, Arc Clean Energy and USNC.

The vitality of the nuclear industry depends on cutting-edge research capabilities. In September 2022, COG member, Canadian Nuclear Laboratories, broke ground for their Advanced Nuclear Materials Research Centre (ANMRC) to study clean energy and production capabilities, radioactive materials, advanced reactor fuels, existing fuels, nuclear medicine, environmental stewardship and global security.

In March 2023, supplier participant, Kinectrics, and SMR vendor participant X-energy announced their partnership to design, construct and operate the new Helium Test Facility, projected to be operational in 2025, to test and verify the performance of the Xe-100 advanced SMR, bringing progressive nuclear technologies into the marketplace.

Ongoing and future refurbishments, CANDU new builds and domestic and international demand for SMRs and MMRs present significant prospects for Canada's suppliers. By sharing best practices and lessons learned in safety and performance, the SPP is strengthening the supply chain to meet nuclear challenges and optimize opportunities.





# Supply Chain Support: CANPAC/CANIAC Program Update

COG's CANDU Procurement Audit Committee (CANPAC) and CANDU Industry Assessment Committee (CANIAC) programs enable effectiveness and cost efficiencies for the nuclear supply chain by conducting Supplier Audits on behalf of CANDU members.

## CANPAC

CANPAC is a Suppliers Audit Program designed for CANDU Utility-Members to perform Quality Management System audits on their Tier 1 Suppliers, to applicable Quality Assurance standards as mandated by the members partaking in the requested audits. Current members are BP, OPG, NBP, KHNP, SNN and CNNO.

The program provides numerous benefits including reduced costs, with the audit cost divided equally by number of utilities involved; the elimination of redundant audits of the same supplier by multiple utilities; and improved consistency from using the same pool of seasoned auditors, allowing for a consistent level of rigor and methodology in the audit execution and deliverables.

All CANPAC audits are performed by qualified auditors in accordance with NQA-1 and ISO 19011 (i.e., education, experience, training, and maintenance of competency).

## CANIAC

CANIAC is a Supplier Audit Program designed for Tier-1 Nuclear Suppliers (i.e., direct suppliers to Nuclear Power Plants, compliant with CSA N286-12, N286.7 and/or N299 series of standards), including SMR Vendors, to perform quality management system and nuclear pressure boundary audits on their nuclear supply chain.

The program provides assurance to Nuclear Utilities that the audits conducted by their direct suppliers were performed using a consistent, well known and widely accepted audit approach, by auditors qualified through a standard qualification process also utilized by the utilities and CANPAC, as well as documenting sufficient objective evidence to support audit conclusions. The program benefits all organizations, including those who may not have sufficient resources for an in-house supplier audit program, and provides a credible, collaborative, and cost-effective supplier auditing model.

For both programs, the majority of audits are shared between two or more participants, reducing costs while ensuring a consistent, effective outcome.

## By the numbers

In 2023/23  
Fiscal Year

- ✓ CANPAC successfully completed **54 Tier 1 Supplier Audits**
- ✓ CANIAC successfully completed **23 audits**
- ✓ Were able to share an **additional 25 audit reports** between CANIAC participants

“

The program benefits all organizations, including those who may not have sufficient resources for an in-house supplier audit program, and

***provides a credible, collaborative, and cost-effective supplier auditing model.***

”



# Fuel Channel Innovation: A Point of CANDU Pride

COG's JP&S and R&D Fuel Channel programs were built on a foundation dating back to COG's earliest days and exemplify the value of the collaboration model in achieving both innovation and cost efficiency.

The program provides confidence to CANDU utilities, such as Ontario Power Generation (OPG) and Bruce Power (Bruce A and B), and the industry regulator, that the province's three nuclear plants can safely operate for years to come by demonstrating safety margin and technical basis for continued operation.

Fuel Channel Life Management (FCLM) research has supported the fitness-for-service of CANDU pressure tubes and led to improvements in industry standards used worldwide to confirm pressure tube integrity.

The work currently includes accelerated aging and subsequent testing of actual CANDU reactor components that were removed to evaluate late life material properties. This validation phase under FC R&D has seen COG supporting CANDU utilities with model development, CSA (Group) standard updates as well as data and test results about the expected behaviour of CANDU fuel channels.

In addition, these predictive models benefit post-refurbishment reactors and may do the same for new-builds. They could also be applied to support cost reductions in future reactor maintenance, operations and surveillance procedures.

Innovations in research analysis equipment and software have also contributed to the success of the fuel channel safety case. New instruments such as the Fixed Focused Ion Beam (FIB) Spectrometer have allowed scientists to analyze materials at a much more detailed, microscopic level, as well as test small samples.

Similarly, CNL's Transmission Electron Microscopy (TEM) facility, which houses the JOEL JEM-F200 Multipurpose Analytical S/Philips CM30, a computer-controlled, intermediate voltage electron microscope TEM (Scanning TEM), is used for the analysis of microstructures down to the nanometre level. Combined with FIB, the equipment has become critical to effective materials research and development.

Fuel channel successes reflect a commitment to collaboration across the industry including ongoing program involvement from COG members, academia and contributions from suppliers such as Kinectrics and SNC-Lavalin.

“

Fuel Channel Life Management (FCLM) research has shown the fitness-for-service of CANDU pressure tubes **led to improvements in industry standards used worldwide** and to confirm pressure tube integrity.

”



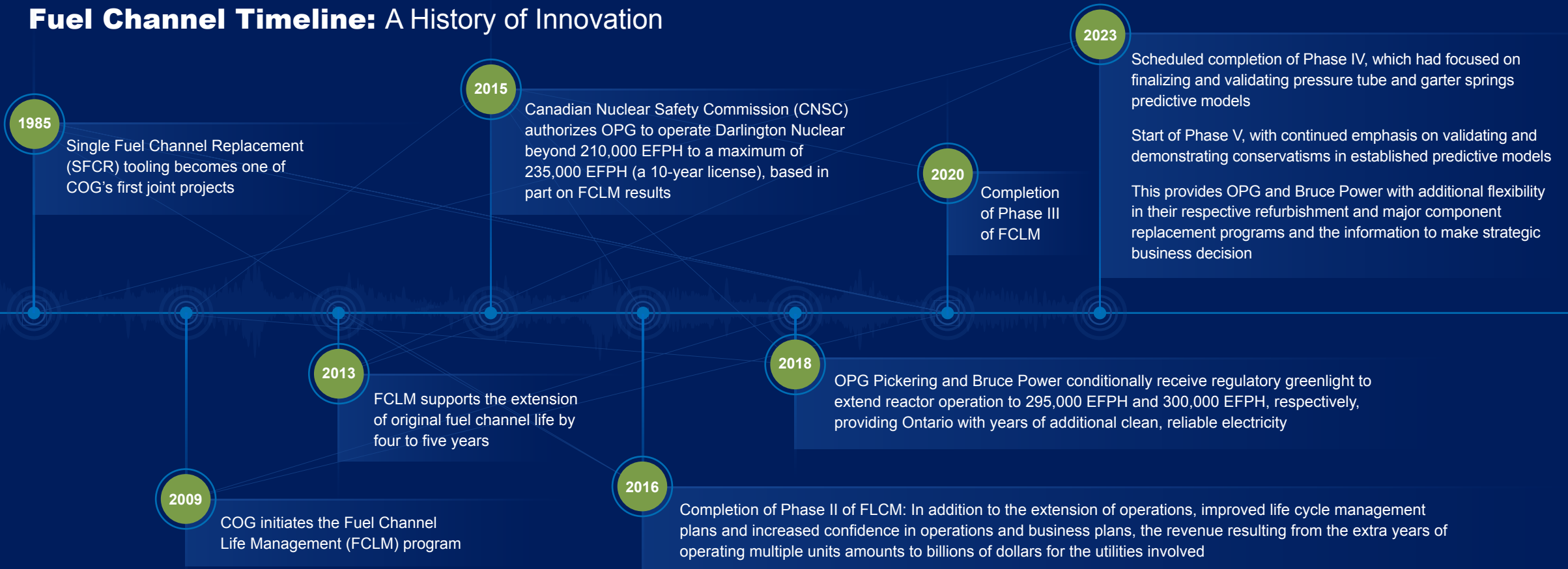
Historically, COG's FC program has focused on improving plant performance and supporting life cycle management, including life extension and refurbishment planning. The Ontario electricity sector is a prime example of the exponential value received from COG's multi-year FC project efforts.

OPG's Pickering and Darlington Nuclear Plants as well as Bruce Power have all benefitted from demonstrating fitness-for-service through the results of this work.

The plants were relicensed in 2018 for operating beyond initial design-based estimates and, as a result, gained thousands of additional hours of generation.

The result has been billions of dollars of additional revenue from the publicly owned assets and a continued supply of low-carbon electricity even as refurbishment projects are underway.

## Fuel Channel Timeline: A History of Innovation



# Beyond CANDU: Leveraging the COG Collaboration Model for Advanced Reactor Technologies and Small Modular Reactors

The nuclear industry lives on the forefront of innovative evolutions that address the pressing issues of today and promise a bright future for tomorrow. Our proven collaboration model supports progressive industry initiatives, including advanced reactor technologies and small modular reactor (SMR) development.

Sharing diverse regional and organizational perspectives reduces risk and promotes cost savings through partnerships between industry stakeholders on common key focus areas', while global harmonization initiatives strengthen the potential of international deployment of Canadian SMR designs.

COG's SMR program includes the Small and Medium Sized Reactor Technology Forum (SMRTF) and its related task teams; the Small Modular Reactor Vendor Participant Program (SMR VPP); and the CEO SMR Forum.

Members of the SMR VPP and the SMRTF meet quarterly to receive updates from the task teams, review domestic and international SMR-related initiatives, and identify key priorities. Task teams meet virtually on a bi-weekly or monthly basis to share insights and plan action items: Highlights from the last year are outlined below.

## Task team current highlights:

- ✓ The Fuel Supply Task Team conducted its inaugural quarterly workshop with the Federal Fuel Supply Working Group to **discuss fuel supply and enrichment. In response to actions raised at this workshop the task team worked collaboratively to develop** enriched fuel supply projections.
- ✓ The Nuclear Liability Task Team met with Natural Resources Canada to elevate their understanding of the low risk/SMR liability analysis **being performed by the government and how they can provide support with respect to the collection of data.**
- ✓ The Recycling/Reprocessing Task Team **developed high-level principles for reprocessing** to discuss with the Federal Fuel Supply Working Group.
- ✓ The Radioactive Waste Task Team continued to develop a white paper assessing progress on the Waste Working Group recommendations, with a **focus on assisting SMR deployment in Canada.** They also helped the industry and NWMO with key messaging on SMR waste.
- ✓ The Fuel Enrichment Task Team, in consultation with key industry stakeholders, continued to develop a white paper to **provide a landscape analysis of the benefits, challenges and issues** around introducing enrichment into Canada.
- ✓ The recently established Regulatory Task Team met regularly with CNSC staff to **discuss common and high priority licensing issues.**

SMR deployment for hybrid and alternate applications (including service to remote areas and heavy industry) will be important in the fight against climate change and for Canada to meet its net-zero goals. COG members, participants and partners are collaborating to transform preliminary concepts into active implementation.



# Exploring New Frontiers: The Innovation Technology Workshop

The tremendous amount of interest among our utility members in emerging technologies is driving innovation and technology in COG's Research and Development Portfolio, and CANDU owners are keen to explore the opportunities to apply them in their plants.

COG recently established the Innovation Peer Group (IPG) as a community of practice for sharing ideas, insights progress on initiatives, challenges and lessons learned. Its success has resulted in the recognition of an industry-wide need for a series of technology-oriented workshops, based on topics such as virtual reality, robotics, electronic procedures, machine learning, and cybersecurity. These technologies can be applied to both new builds and existing plants and promise improvements in outages, maintenance, operations, equipment reliability and in general improved plant safety and economics.

At an industry level, there are changing strategic drivers such as climate change mitigation, electrification of transportation, decarbonization of industry, and the evaluation of micro-grids. These factors are altering the way we look at nuclear plants and changing the role they will play in the longer term.

In the future, nuclear energy will extend beyond electricity production to thermal energy applications such as bulk hydrogen production and grid level energy storage. The workshops are a way of sharing and building knowledge and best practices, and creating technical communities of practice, while helping the industry form common strategies and approaches behind the deployment of these technologies for more sustainable plants.

Our first Innovation Technology Workshop (ITW), to be launched at the June 2023 Collaboration Week, presents a magnitude of possibilities, both short and long term. Industry participation is expected from our utility members, leading R&D suppliers, SMR vendors, university researchers, and international collaborators.

## Innovation Peer Group Program



With the looming threat of climate change, the nuclear industry needs both to boost current plant viability and build infrastructure to leverage these new technologies and realize new opportunities. For example:

✓ **Augmented and virtual reality** can integrate data and workflow, enhancing work planning and worker safety.

✓ **Automated scanning** can upgrade predictive maintenance and anomaly detection, saving outage time and worker exposure.

✓ **Advanced robotics** can significantly reduce manual labour.

✓ **Additive manufacturing and advanced welding** can improve component design and reliability.

The ITW Program is an exciting addition to our COG platform, opening up a range of perspectives and creating synergies within a focused strategic technology framework to continue our industry's progress in the evolving nuclear technology landscape.

## COG 2023–24 Priorities

# Addressing Today's Challenges and Tomorrow's Opportunities

The work we are doing together through COG will continue to be of great importance as the world works to address the increasingly pressing impacts of climate change while ensuring a safe, secure energy supply.

The past few years have made it clear that net zero needs nuclear, and in addition to supporting our members' current needs, our team remains focused on advancing the critical work being undertaken to evolve COG as an organization in response to changing member needs. Working together towards our collective clean-energy future is the essence of excellence through collaboration.

In the 2023–24 fiscal year, COG's goal is to continue to deliver high-value collaboration for continuous improvement and innovation in CANDU and advanced nuclear technologies by leveraging expertise and cost-sharing aligned to its members' interests.

We will do this by taking the necessary steps to ensure sustainability of COG and the collaboration model by implementing our refreshed cost model and completing the review of our funding model shares, assessing programs and services to ensure the best value areas are prioritized, and seeking and validating areas for potential new collaboration.



COG has identified three primary business objectives, and are driving organizational focus through our Balanced Scorecard and strategy map.

## COG Business Objectives

### CANDU Performance Excellence

Focus and deliver on the greatest value items for the existing reactor fleet.

### Collaboration Beyond CANDU

Add new areas of collaboration where there are high-value opportunities to deliver value beyond CANDU operations and to generate additional revenue that will contribute to COG's sustainability.

### Strengthen COG Organizational Effectiveness

Optimize COG's internal processes and capabilities to deliver the most effective and efficient collaboration model for its members.



## Strengthen COG's Viability

Focus Areas to Drive Achievement of Business Objectives



### Stakeholders

**Better understanding markets and members**

- Stakeholders value us more
- Stakeholders expand investment
- Deliver highly valued offerings



### Operations

**Strengthen our brand**

Innovate programs and services

**Improve operational efficiencies**



### Enablers

**Strengthen staff capabilities**

Create a proactive member-centric culture

Improve efficiency through technology



### Financial

**Implement new cost model and review funding model shares**

Generate new sustainable revenue



**We are undertaking 2023–24 strategic initiatives in these areas**





## CANDU Owners Group (COG)

Follow us for news and updates



<https://www.linkedin.com/company/candu-owners-group>



[@CANDUOwnersGrp](https://twitter.com/CANDUOwnersGrp)

Visit us online: member site: [COGonline.org](http://COGonline.org) or our public site: [CANDU.org](http://CANDU.org)

655 Bay Street, 17th Floor  
Toronto, ON M5G 2K4 Canada  
Phone: 1-416-595-1888  
Fax: 1-416-595-1022  
[COG@CANDU.org](mailto:COG@CANDU.org)



CANDU Owners Group Inc.