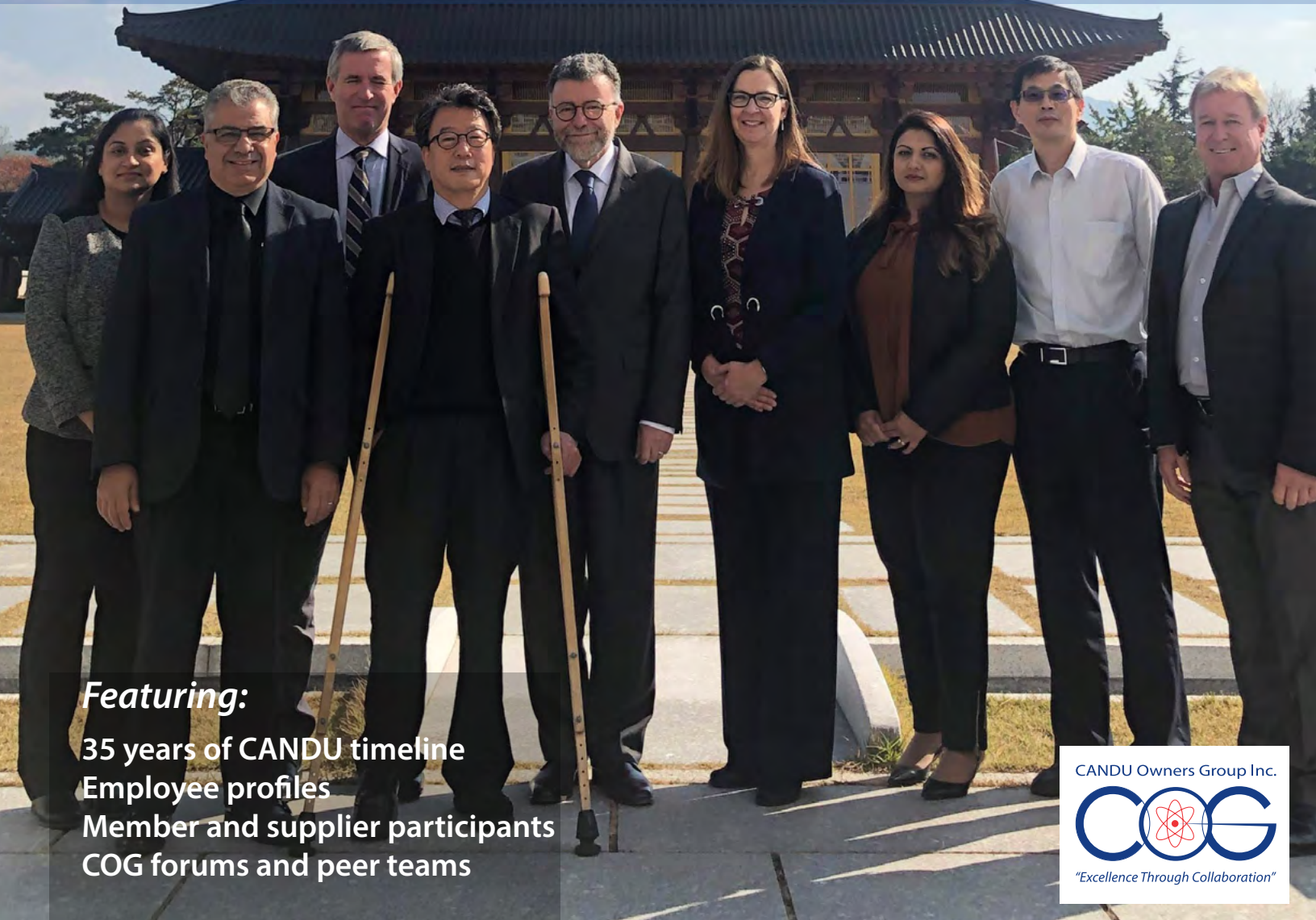


COGNIZANT

A magazine of the CANDU Owners Group

*35th Anniversary
Special Edition*

VOLUME 24
November 2019



Featuring:

- 35 years of CANDU timeline
- Employee profiles
- Member and supplier participants
- COG forums and peer teams

CANDU Owners Group Inc.



"Excellence Through Collaboration"



Clockwise from top left: COG staff in 2000, supplier participants visit the Darlington refurbishment training facility, NB Power accepts EPRI award in 2017, NB Power refurbishment in 2012, a COG meeting in 2001, CCNuclear at the COG AGM in 2019, COG visits China in 2018.

On the cover: In November 2019, members of the COG team attended the 15th COG-IAEA Technical Committee Meeting for the exchange of PHWR safety experience, hosted by KHNP in Gyeongju, Korea.

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Our collective accomplishment

Throughout its 35-year history, COG has helped us bring our very best to the people relying on us for essential life services they can count on

Each of us has our own memories of our time working as part of a COG team or perhaps on many teams.

The time in our career, the role we played, who we worked with and our area of work, all influence the details of our personal experiences. But, common to each of us is the experience of being part of something bigger than ourselves or even our company toward a common goal of achieving excellence.

I have heard people describe their nuclear career as akin to working on an International Space Station based on earth. There are so many opportunities to work with science and technology to progress the agenda of safe, clean, abundant and cost-effective electricity with some equally significant medical contributions through harvesting of Cobalt-60 for medical isotopes. We can achieve great things with the caveat we must always maintain respect for the power within the technology. This drives our pursuit for continuous improvements to achieve excellence in human and plant performance. COG helps us to achieve that.

I have been president and CEO of COG for close to six years. But even before that, COG played an important role in my life. As an engineer at Ontario Power Generation (OPG), it allowed me to contribute in a way my work could be leveraged collectively with the contributions of others to create a sum of the parts significantly beyond the outcomes of a series of individual efforts. It strengthened the knowledge I had to contribute to my work at OPG through information exchange and OPEX from other stations.

The Fukushima response was a defining moment for the industry and for COG. Tom Mitchell, then President and CEO of Ontario Power Generation, was appointed by the World Association of Nuclear Operators (WANO) to chair a special committee to determine what happened at the Daiichi nuclear station, learn from it and advise the world's nuclear industry on how to ensure safe operations everywhere.

COG was the mechanism the CANDU industry chose to apply the direction established by WANO. As an OPG representative, I worked with the COG team, then

led by Bob Morrison, and my industry peers to examine, analyze and develop a plan that would help ensure a similar event, and the resulting loss of public confidence, would never happen again.

The COG team helped the CANDU utilities worldwide to converge on a common, optimal approach through the CANDU Industry Integration Team, or CIIT, and I was honoured to act as the chair of the CIIT. They developed and maintained a database identifying the additional safety features, how each was dispositioned by each station, and the status of implementation. They helped organize the INPO-WANO-COG Fukushima Forum III that was held in Toronto. There were only four Fukushima forums held: Two in the US, one in Toronto and the last one in Tokyo. The choice to include a Toronto meeting, co-hosted by COG, was a reflection on the respect for the CANDU utilities' leadership.

For many years, through the Engineering Managers Peer Group, I was afforded the chance to work with colleagues from across the CANDU-operating nations to solve industry challenges and to create opportunities through



When the CANDU Owners Group was recognized by the Canadian Nuclear Society in 2019, the accolades reflected the work of COG staff and also the thousands of people from member, supplier, partner and academic organizations who contributed to the achievements through the COG collaboration model over the past 35 years.

“As the COG president, I have seen a new, diverse generation continue this tradition through forums, peer groups and the Supplier Participant Program. Their work is strengthening CANDU technology and taking us beyond to other opportunities such as small modular reactors.”

break-through advancements such as the feeder integrity project and the fuel channel life management program.

As the COG president, I have seen a new, diverse generation continue this tradition through forums, peer groups and the Supplier Participant Program. Their work is strengthening CANDU technology and taking us beyond to other opportunities such as small modular reactors.

It was about this time last year, at the second COG Collaboration Week, when a young professional stood up to say that in the 10 years he has been working in the industry, this event was singularly the most impactful he had attended. What will he and his peers do through COG? It is an exciting prospect.

Every meeting I have had with the Pakistan Atomic Energy Commission to review safety cases aimed at supporting

safe operation of KANUPP has been a reminder of the essential role COG plays in facilitating the transfer of technology to a country with which Canada has no nuclear co-operation agreement. It is a powerful example of how a will to collaborate for the common good can overcome even geo-politics.

Yes, it has been my privilege to be part of this community over the past 35 years. And, if you are reading this, chances are, it has been yours, too. As we continue our CANDU journey, and look beyond it to new technologies such as small modular reactors, I anticipate the great things yet to be accomplished together. The world is truly depending upon us to be our collective best.

***Fred Dermarkar
COG president and CEO***

Words about COG

“I want to thank everybody who built COG, who made it what it is today. We are standing on the shoulders of giants. I want to thank the people who are working at COG today for making it the amazing place that it is and for creating a great future going forward.”

Fred Dermarkar, COG president and CEO

“We connect a community of people who truly believe in the technology of CANDU.”

Liette Lemieux, COG director R&D

“COG adapts with the times and stays current. It helps the industry going forward.”

Paul Thompson, NB Power and former COG director

“We are able to facilitate the bringing together of a whole community, all across the globe, with one thing in mind: advancing the CANDU technology.”

Sonia Qureshi, COG director, Joint Projects and Services

“I’m very proud to be part of an organization that brings an invaluable service to the industry and to the CANDU technology, for the future.”

Carla Carmichael, OPG and COG director

35 years of CANDU knowledge management

The CANDU Owners Group was founded 35 years ago in 1984 and incorporated 20 years ago, in 1999. Through industry ups and downs, challenges and opportunities, COG has endured and thrived to provide some of the technology's, and industry's, greatest moments of achievement.

At the heart of COG has been the people whose dedication, expertise and passion for excellence have driven tremendous discoveries that have innovated the very way we make electricity and strengthened the way we operate our plants and execute our projects.

Over the next 20 pages, we take a look back at a timeline of this journey to where we are today: An organization of members and participants that together invested almost \$70 million in joint projects, research and development while helping thousands of workers exchange and grow knowledge that helps them do their job better.

Through the commitment of industry leaders willing to pass down their vast experience and knowledge, we have developed future leaders, who will continue a tradition of learning and development for the nuclear plants of tomorrow, to provide safe, reliable, environmentally-sustainable and cost-effective electricity to meet the growing world demand.

Thank you to all the people, past and present, working at COG, in member, supplier and program participant organizations; thank you to the people in partner organizations in Canada and worldwide; thank you to the strong regulators who make us better; and thank you to the people who use electricity that is generated through nuclear technology, for the confidence to continue to build an industry committed to *excellence through collaboration*.



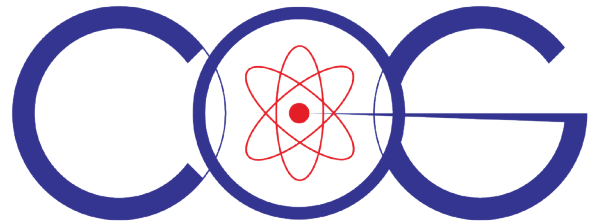
"I remember when I first began my journey at COG in 2007, I was so intimidated by the vast experience and knowledge... everyone was so inviting and encouraging..."

They were willing to take the time to educate and share their knowledge with me; they made me feel a part of COG."

*Amanda Debidyal,
COG project coordinator*



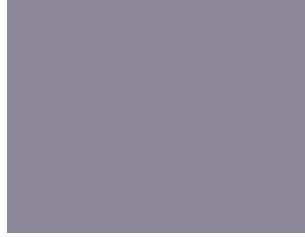
CANDU Owners Group Inc.



"Excellence Through Collaboration"



35 Years of CANDU Collaboration 1984 - 2019

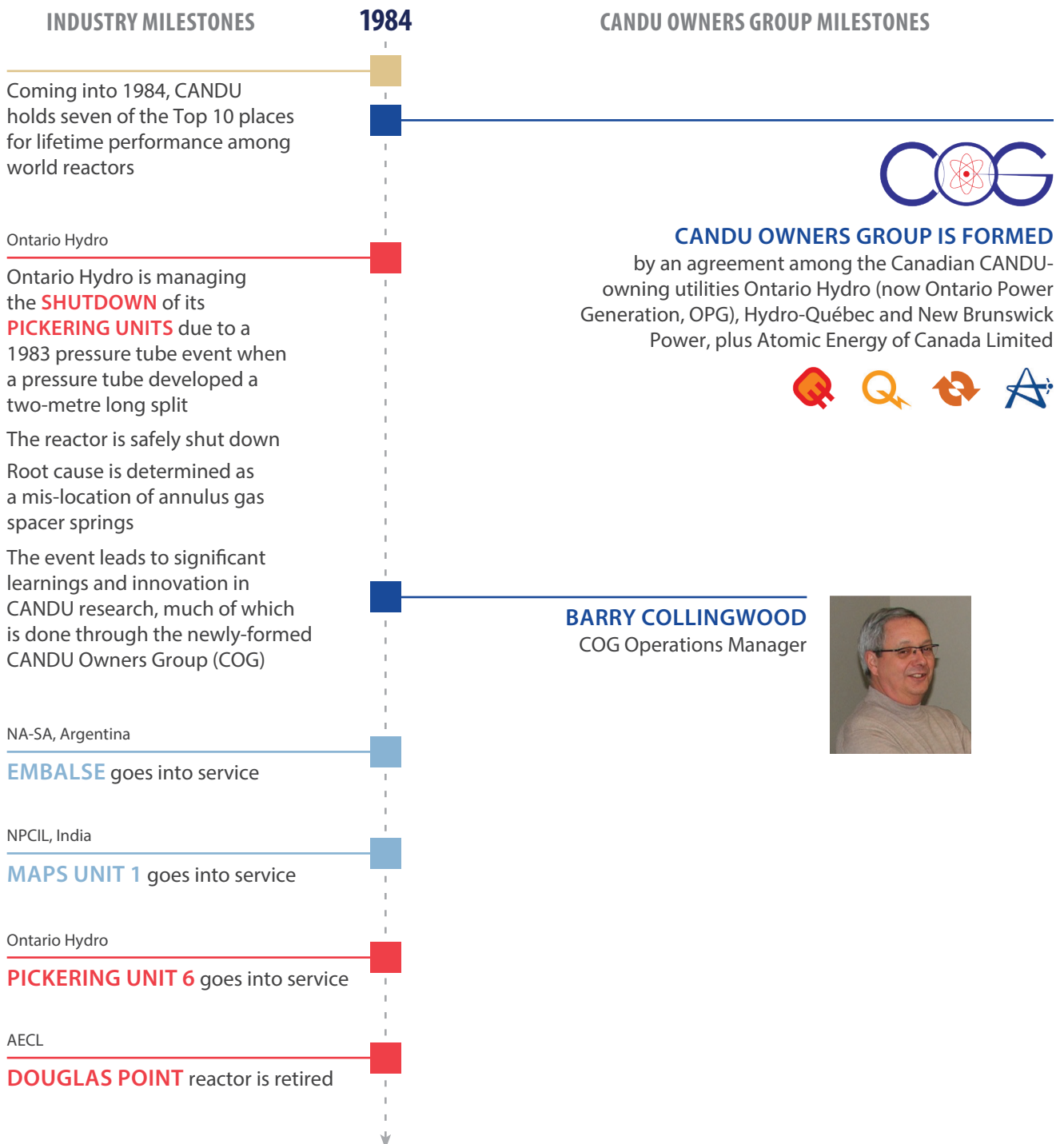


CANDU Owners Group

1984 - 2019

- COG
- CANADIAN MEMBERS
- INTERNATIONAL MEMBERS
- INDUSTRY
- CULTURAL MILESTONES

In 1984, the CANDU Owners Group was formed to help CANDU operators share resources and knowledge to further develop and continuously improve the nuclear plants they operate. Today, 35 years later, COG continues its vital role in helping its members, worldwide, and the broader industry leverage collaboration to create nuclear excellence. What follows is a journey through COG's last 35 years.



Ontario Hydro
BRUCE UNIT 6 goes into service

1985

Ontario Hydro
DARLINGTON UNITS planned for 1985-1988 commissioning are delayed due to changes in political landscape and electricity demand

The project would be pushed over budget and schedule due to accumulating interest rates and changing regulatory requirements during the delay period

COG'S R&D PROGRAM IS FORMED

AECL/Ontario Hydro's jointly-sponsored CANDEV research and development program is expanded to include Hydro-Québec and NB Power
 CANDEV is transferred to COG to become the COG R&D Program

Ontario Hydro
PICKERING UNIT 7 goes into service

COG'S FIRST JOINT PROJECT

Development of Spacer Location and Repositioning (SLAR) tooling becomes the first COG joint project followed by development of Single Fuel Channel Replacement (SFCR) tooling

Ontario Hydro
BRUCE UNIT 5 goes into service



BRIAN MULRONEY

is elected Prime Minister of Canada

1986

Ontario Hydro
PICKERING UNITS return to service following the 1983 event
 COG Joint Projects on SLAR and SFCR contribute to success restart

CNEA (NA-SA) & KHNP JOIN COG

COG membership expanded to include Comisión Nacional de Energía Atómica (now Nucleoeléctrica Argentina Sociedad Anónima, NA-SA) and Korea Hydro & Nuclear Power (KHNP)



CHERNOBYL

The world's worst nuclear accident occurs at Unit 4 Chernobyl, a graphite-moderated reactor

A seven on the INES scale, it occurs due to human error and design flaws during an exercise intended to develop a safety procedure for loss of power events

NPCIL, India

MAPS UNIT 2 goes into service

Ontario Hydro

BRUCE UNIT 7 goes into service

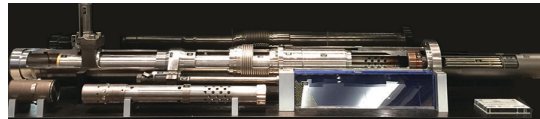
1988

Ontario Hydro

BRUCE UNIT 8 goes into service

THE CANDU REACTOR

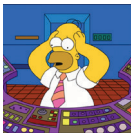
is ranked as one of Canada's Top 10 engineering achievements during the previous 100 years (marking Canada's engineering centennial)



THE SIMPSONS

airs on network TV for the first time, making Homer Simpson

the world's most famously incompetent nuclear power plant employee



1989

Ontario Hydro

DARLINGTON UNIT 2 generates its first electricity

1990

KHNP purchases two additional **CANDU-6 REACTORS** from Canada

Ontario Hydro

DARLINGTON UNIT 2 goes into service

1991

SNN JOINS COG

With the construction of a CANDU reactor at Cernavoda in Romania, Societatea Nationala Nuclearelectrica (SNN) becomes a COG member



NPCIL, India

NAPS UNIT 1 goes into service

1992

NPCIL, India

NAPS UNIT 2 goes into service



Ontario Hydro

DARLINGTON UNIT 1 goes into service

PAEC, Pakistan

ISFoK PROJECT

with Karachi Nuclear Power Plant Expansion (KANUPP) is launched with IAEA and Canadian Government approval

The ISFoK initiative supports the safe operation of KANUPP (SOK) through the IAEA and COG

PAEC & NPCIL JOIN COG

Pakistan Atomic Energy Commission and Nuclear Power Corporation of India, owners/operators of a number of PHWR power reactors of CANDU design, join COG

This followed the accident at Chernobyl and recognition that cooperation and sharing of operating experience among nuclear utilities is essential to ensure the safe operation of all nuclear power plants worldwide



1993

Ontario Hydro

DARLINGTON UNITS 3 & 4

go into service

NPCIL, India

KAPS UNIT 1 goes into service

COG's **R&D PROGRAM** peaks at **\$180 MILLION** per year

1994

Ontario Hydro

19 REACTORS ONLINE

for the first time

Throughout the mid-1990s, several **COG R&D PROJECTS** demonstrated generic safety issues were identified and resolved to the satisfaction of the regulator.

NPCIL, India

RAPS UNIT 1 & 2 shut down for refurbishment

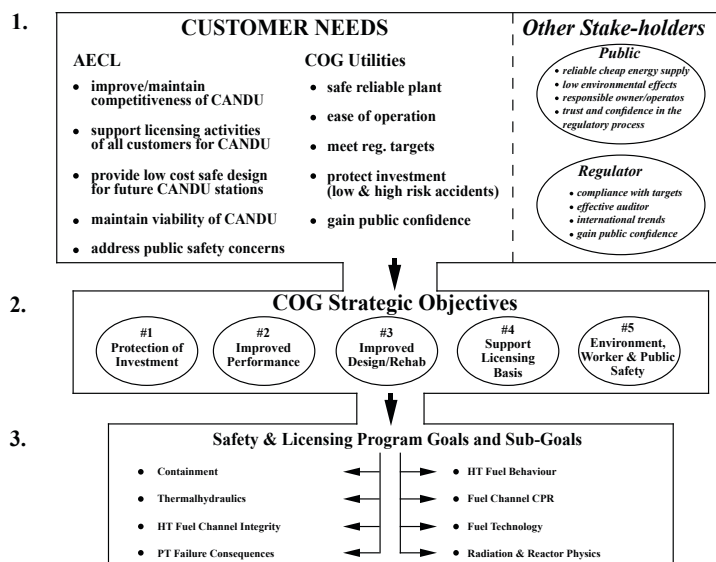
COG'S 1994 STRATEGIC PLANNING HIERARCHY CHART

for CANDU Owners Group

SNN, Romania

FCN NUCLEAR FUEL PLANT

(later known as Cernavoda) is authorized by AECL and Zircatec Precision Industries Inc. (Canada) as a CANDU 6-type nuclear fuel producer



Ontario Hydro

PICKERING UNIT 2 experiences a Loss of Cooling Accident

The Emergency Core Cooling System is successfully used

Public safety is fully maintained

Pickering A remains shut down until all corrective actions are completed in May 1995

R&D3jrw22
* Replica of 1994 chart created November 2019

Strategic Planning Hierarchy

1995

NPCIL, India

KAPS UNIT 2 goes into service

Ontario Hydro

BRUCE UNITS 1-4 are shut down and placed in layup by the former Ontario Hydro until 1998

A COG joint project investigates the susceptibility of **API 371 TRIP METERS TO RADIO-FREQUENCY INTERFERENCE** from portable transceivers and cellular phones helping to prepare CANDU plants for the coming digital transformation

Korea

HANARO RESEARCH REACTOR, based on AECL's MAPLE technology, starts up

1996

AECL and TQNPC, China

AECL signs a **\$4 BILLION** contract for the sale of two CANDU-6 reactors to China

COG completes development of acceptance criteria for evaluation of pressure tube integrity following **SPACER LOCATION AND REPOSITIONING (SLAR)**

“*As a scientist, I would like to note that some of the most interesting work I undertook in my career was under the auspices of COG. It was wonderful to be able to perform novel scientific research, while knowing that there was a customer who needed the results to solve a real problem.*”

Dr. Joanne Ball, CNL

SNN, Romania

CERNAVODA UNIT 1 goes into service

1997

Ontario Hydro

ALL PICKERING A UNITS shut down for an indefinite lay-up as part of Ontario Hydro's Nuclear Asset Optimization Plan (NAOP)

KHNP, Korea

WOLSONG UNIT 2 goes into service

KYOTO PROTOCOL

is signed by 55 countries, including Canada, committing to reduce greenhouse gas emissions

1998

KHNP, Korea

WOLSONG UNIT 3 goes into service

AECL and TQNPC, China

QINSHAN PHASE III construction begins in Haiyan with **AECL** as the general contractor



The Radioiodine Test facility at Whiteshell, which operated from around 1987 to 1998, and which was built for COG R&D

NPCIL, India

RAPS UNIT 1 & 2 return to service following four-year refurbishment project

IAEA releases its report entitled: **ASSESSMENT AND MANAGEMENT OF AGEING OF MAJOR NUCLEAR POWER PLANT COMPONENTS IMPORTANT TO SAFETY: CANDU PRESSURE TUBES**

The report identifies status and challenges as well as several design and operating improvements developed, in part, through research facilitated by COG over the decade prior

1999

COG CELEBRATES 20 YEARS OF INCORPORATION IN 2019

In 1999, COG moved out from Ontario Hydro to become an independent entity

KHNP, Korea

WOLSONG-4 goes into service

ONTARIO POWER GENERATION

is launched as a successor to Ontario Hydro



COG registers as a **NOT-FOR-PROFIT FEDERAL CORPORATION**

Ontario Hydro, AECL, NB Power and Hydro-Québec sign the by-laws
A board of directors is appointed to replace the directing committee

The COG office is moved out of Ontario Hydro to 480 University Avenue in Toronto

JOHN SOMMERVILLE
COG President & CEO



A NEW ERA

In 1999, COG incorporated as a not-for-profit, moving on from a period of uncertainty toward a future fueled by innovation and collaboration

The mid-to-late 1990s marked a period of transition for the Canadian nuclear industry and for COG.

In 1995, the Canadian federal government completed a review of Atomic Energy of Canada Limited's (AECL) funding model, including its R&D expenditures, and the result was a significant reduction in nuclear investment. As one of COG's founding members, AECL's budget reduction had a major impact on COG and its activities. Between 1995 and 1998, COG R&D funding was reduced by approximately \$100 million.

By the end of 1998, changes in the Canadian energy landscape, combined with controversial policy and restructuring decisions in Ontario including layup of several Ontario Hydro (now Ontario Power Generation) reactors, including at the Bruce County site, meant changes for the COG funding and organizational model.

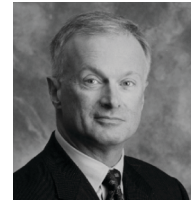
Under the original agreement signed in 1984, then Ontario Hydro served as administrator of COG, reporting to a directing committee comprised of representatives of the four original Canadian members (Ontario Hydro, Hydro-Québec, New Brunswick Power and AECL). In 1999, COG incorporated as a not-for-profit federal corporation, funded voluntarily by CANDU operating utilities, with OPG, AECL, New Brunswick Power and Hydro-Québec signing its new by-laws.

COG's offices moved out of OPG and to a new downtown Toronto location. The COG directing committee was replaced by a board of directors. From 2000 to 2003, grant of membership in the new corporation was provided to all existing COG members.

The new model set the stage for nearly two decades of restructuring, growth and renewal. Today, COG is a trusted nuclear industry leader known for its commitment to excellence through collaboration. In 2018-19, COG invested about \$70 million in R&D through its research and joint project programs.

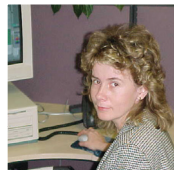
Through collaborative excellence in the creation, retention and transfer of knowledge, COG and its members are making innovative breakthroughs, ensuring continuous improvement in CANDU nuclear plants and helping to set a global nuclear safety and quality culture.

PAT TIGHE
COG President & CEO



“ I have stayed at COG for the people. The bond that my team and I share is amazing. We work very hard but I’m also very lucky because I have such wonderful human beings to work with. ”

Sonia Qureshi, COG Director JP&S



COG STAFF circa 1999

Carmen Trandafir (picture inset), along with Bernice Brooks (second row, third from left) and Mersedeh Safa (first row, third from left) are still with COG today

2000

COG and AECL contribute to industry preparations for **Y2K COMPUTER ISSUES** as 1999 rolls into 2000

All goes well at midnight, Dec. 31 and plants remain online

NPCIL, India

RAJASTHAN UNITS 3 & 4 and **KAIGA UNITS 1 & 2** go into service

SNN joins COG’s **R&D PROGRAM**

KHNP joins COG’s **R&D IST** and **S&L PROGRAMS**

2001

OPG and Bruce Power

LEASE OF OPG’S BRUCE A & B REACTORS to consortium Bruce Power

OPG is directed by the government to reduce its share of Ontario’s electricity to 35% (from 85%) by 2010

LAUNCH OF COGonline

offering digital destination for news, OPEX, events and to serve member groups

Canadian Prime Minister **JEAN CHRÉTIEN** tours **QINSHAN**

BRUCE POWER JOINS COG as an independent Canadian member after signing a lease agreement with Ontario Power Generation to operate the Bruce A and B nuclear generating stations



JOINT PROJECTS WORK VALUE REACHES \$7 MILLION

Following the events of **SEPT. 11, 2001**, the CNSC takes steps to enhance security at major nuclear facilities in Canada

Nuclear operators take significant actions to build, train, and strengthen their security forces

JOHN SOMMERVILLE
returns as COG President & CEO

COG becomes a member of the **CANADIAN STANDARDS ASSOCIATION (CSA)**



COG becomes a member of the **ELECTRIC POWER RESEARCH INSTITUTE (EPRI)** on behalf of COG member organizations



2002

40 YEARS OF NUCLEAR POWER IN CANADA



KHNP, Korea

WOLSONG UNIT 1 attains **100,000,000 MWh** since coming into service

CANADA RATIFIES KYOTO PROTOCOL IN PARLIAMENT

committing to lowering greenhouse gas emissions

PAEC, Pakistan

KANUPP SHUT DOWN for life extension assessment

CNNO, China

QINSHAN UNIT 4 goes into service
It is the first CANDU-6 project to use open-top reactor building construction, and the first project where commercial operation began earlier than projected date

New Brunswick Power

POINT LEPREAU attains **100,000,000 MWh** since coming into service

Formation of **CANPAC**
The procurement audit service provides COG members a cost-effective and efficient quality assurance program for qualifying Tier 1 suppliers

Initiation of **CANTEACH PROGRAM** supporting knowledge transfer and providing high quality information relating to CANDU nuclear technology for use in various aspects of education, training, design and operation

Launch of **COGNIZANT** as an electronic newsletter

BRIAN MACTAVISH
COG President & CEO



LAUNCH OF COG PUBLIC WEBSITE

2003

TQNPC (CNNO) JOINS COG
With the construction of a CANDU reactor at Qinshan, Third Qinshan Nuclear Power Company (now CNNP Nuclear Power Operations Management, CNNO) in China becomes a COG member



CNNO, China

QINSHAN UNIT 5 goes into service

THE BLACKOUT

Grid failure across Ontario and eight U.S. states on August 14

Ontario Power Generation

PICKERING UNIT 4 returns to service following an extensive re-start project including bringing the units up to current safety codes

PAEC, Pakistan

KANUPP returns to service following refurbishment

Bruce Power

BRUCE UNIT 4 returns to service following refurbishment

The newly elected Liberal government reverses some divestiture of assets from OPG

2004

Bruce Power

BRUCE UNIT 3 returns to service following refurbishment

Ontario Power Generation

PICKERING UNIT 1 returns to service following an extensive re-start project including bringing the units up to current safety codes

NPCIL, India

TARAPUR UNIT 4 goes into service

COG develops **'JUST-IN-TIME' BRIEFINGS**

COG launches **INSPECTION QUALIFICATION PROGRAM**

COGonline features more than **17,000** reports and documents

COG introduces **MONTHLY CANDU/PHWR UNIT RANKING** based on 12-month rolling performance indicators

COG launches **EMERGENCY SPARE PARTS ASSISTANCE PROGRAM**

COG launches **NEW SUPPLIER PARTICIPANT PROGRAM**

COG began developing **SEVERE ACCIDENT MANAGEMENT GUIDELINES**

COG completes development of **FEEDER FREEZE TECHNOLOGY**

COG launches the **INTER-STATION ASSISTANCE PROGRAM** to connect operators in a shared spare parts inventory and to facilitate better exchange of information for emergent issue identification and resolution



2006

NPCIL, India
TARAPUR UNIT 3 goes into service

Bruce Power
BRUCE UNITS 1 & 4 are shut down for refurbishment

Al Gore's *AN INCONVENIENT TRUTH* debuts

JOHN FROATS
 COG President & CEO



Ontario Power Generation
 The **MINISTRY OF ENERGY** directs OPG to begin the federal approvals process for new nuclear generation at Darlington B site

Ontario Power Generation
 OPG submits Letter of Intent and Project Description to CNSC for **PICKERING-B REFURBISHMENT**

“ I want to thank everybody who built COG, who made it what it is today. We are standing on the shoulders of giants. ”

Fred Dermakar, COG President & CEO

2007

NPCIL, India
KAIGA UNIT 3 goes into service

SNN, Romania
CERNAVODA UNIT 2 goes into service

Bruce Power
BRUCE UNIT 2 installs the first steam generator ever to be replaced in a Canadian nuclear plant

2008

Ontario Power Generation
 OPG makes business decision **NOT TO PROCEED** with **REFURBISHMENT** of **PICKERING-B** despite clearing environmental assessment and integrated safety review

A COG joint project made significant gains on the industry's understanding of **FEEDER THINNING AND CRACKING**

This included significant review of data, including inlet feeder wall thickness from a Cernavoda reactor

The study results demonstrated little sign of thinning at the inlet walls for CANDU reactors

New Brunswick Power
POINT LEPREAU shuts down for mid-life refurbishment project

2009

Ontario Power Generation

OPG begins planning for a **\$12.8-BILLION REFURBISHMENT** of four nuclear reactors at Darlington Nuclear

OPG indicates the project, scheduled for completion in 2026, is anticipated add \$15 billion to Ontario's gross domestic product, create up to 11,800 jobs annually and add up to another 30 years of operation to the plant

KHNP, Korea

WOLSONG UNIT 1 shuts down for refurbishment

COG begins generating a quarterly **EQUIPMENT RELIABILITY INDEX (ERI)** for CANDU stations based on data provided by the stations

COG's **VIDEO CONFERENCING NETWORK** goes live at COG Board Meeting

COG initiates the **FUEL CHANNEL LIFE MANAGEMENT PROGRAM (FCLM)**

First **INTERNATIONAL COG SIMULATOR TRAINING WORKSHOP**

2010

Ontario Power Generation

The government of Ontario announces **DARLINGTON REFURBISHMENT PROJECT**

NPCIL, India

RAJASTHAN UNITS 5 & 6 go into service

BARRY COLLINGWOOD
COG President & CEO (Interim)

The Board of Directors endorses a proposal to fully develop the **KNOWLEDGE MANAGEMENT PROGRAM** with the key objective to capture and retain the experience collectively from a wider CANDU base and to transfer knowledge and experience to members in a cost-effective manner

2011

World population hits **7 BILLION**

NPCIL, India

KAIGA UNIT 4 goes into service

ROBERT C. MORRISON
COG President & CEO



FUKUSHIMA DAICHI

nuclear plant event initiated by a tsunami on March 11

The Canadian government **SOLD THE COMMERCIAL CANDU DESIGN** and marketing business of AECL to Candu Energy for \$15 million and 15 years worth of royalties

POST-FUKUSHIMA SEVERE ACCIDENT MANAGEMENT PROJECT

Following the Fukushima event, COG is requested by senior industry leaders to bring CANDU stations together, coordinate common approaches and responses, share ideas and work together as a team to analyze and create a response

In response, COG launches the Post-Fukushima Severe Accident Management Project, its most rigorous undertaking on the nuclear safety front, delivering technical reports to help meet the requirements of Canadian Nuclear Safety Commission's Fukushima Action Plan

Canada withdraws from
KYOTO PROTOCOL

COG moves their offices to their current home at
655 BAY STREET in **TORONTO**

KHNP, Korea

WOLSONG UNIT 1 returns to service following a 25-month shut-down

2012

This is the first time a CANDU-6 reactor is successfully retubed

COG's R&D program launches **37M FUEL BUNDLE PROJECT** investigating improving heat removal from fuel under certain accident conditions in collaboration with Stern Laboratories

New Brunswick Power

POINT LEPREAU returns to service following four-year refurbishment that extends its operating life to 2039



HYDRO-QUÉBEC

is no longer a COG member following the decision to permanently shut down their CANDU reactor

COG completes the **OUTAGE DURATION OPTIMIZATION PROJECT**

Bruce Power

BRUCE UNITS 1 & 2 return to service following completion of refurbishment projects

The project's objective is to reduce the time CANDU power plants are shutdown for planned maintenance outages

COG establishes a **FUKUSHIMA RESPONSE JOINT PROJECT** to address specific areas identified by the regulator

The goal is to provide guidance that would ensure a systematic and consistent approach for assessing activities of key importance in closing the CNSC Fukushima action items (FAIs), and to support international participant responses

Ontario Power Generation

A **10-YEAR SITE LICENCE** is issued to OPG for preparation of site for new build at

DARLINGTON B

Though the original new build project did not move forward due to government direction, the environmental assessment and licensing work positions OPG for future opportunities on the Darlington site

2013

The planned output includes updated technical basis documents (TBDs) and an updated generic SAMG set, incorporating lessons learned from the Fukushima event

A number of vendors provide deliverables for the project, based on their knowledge and experience in related areas including: Candu Energy Inc., AMEC, Kinectrics/Candesco, ERIN Engineering Inc. and Atomic Energy of Canada Ltd.

SEVERE ACCIDENT JOINT PROJECT

is created, delivering updates to technical basis documents and Severe Accident Management Guidelines through lessons learned and operational experience (OPEX) post-Fukushima

The COG-initiated-and-managed **FCLM** supports the extension of original nominal fuel channel life by four-to-five years

2014

COG'S PRESIDENTS

Barry Collingwood*	1984 - 1999
John Sommerville	1999
Patrick Tighe	1999 - 2001
John Sommerville	2001 - 2002
Brian MacTavish	2002 - 2006
John Froats	2006 - 2010
Barry Collingwood*	2010 - 2011
Robert C. Morrison	2011 - 2014
Fred Dermarkar	2014 - present

* Barry Collingwood served as COG's operations manager until incorporation in 1999; then as interim president in 2010-2011.

FRED DERMARKAR
COG President & CEO



COG implements **DELL APPASSURE** for a comprehensive disaster recovery solution for its IT system

Its new duplicate and compression technology reduces backup time and minimizes the storage footprint. Recovery time and data loss are dramatically reduced by "virtually shadowing" the key servers and running small-time-interval incremental backups

COG RECOGNIZED BY EPRI for Application Material Degradation Matrix to CANDU reactors

OPG and Bruce Power

PICKERING-B and **BRUCE-B UNITS** reach **NOMINAL LIFE** (design-based assumption) of **210,000 EFPH**

COG's in-house band **THE FISSION KATZ** (comprised of staff members past and present) perform at the 30th anniversary celebration



The Fission Katz continued to perform at various charity functions and COG celebration and charity events until 2018

2015

COG creates the **CANDU 6 FLEET** to capitalize on the synergies of C6 utilities

PARIS CLIMATE AGREEMENT

COG launches **STRATEGIC RESEARCH & DEVELOPMENT** focusing on a long-term vision creating research that will help the CANDU industry remain sustainable and strong over the next several decades

COG's **OBSOLESCENCE PEER GROUP** held a first international workshop featuring procurement and engineering experts with participation from 17 vendor companies

Bruce Power

Bruce Power sets a site production record of **47.63 TERAWATT-HOURS** of carbon-free energy

COG member OPG wins

EPRI TECHNOLOGY TRANSFER AWARD

for work on Innovative Applications of the Modular Accident Analysis Program (MAAP) Code



CNL JOINS COG

AECL transfers its COG membership to Canadian Nuclear Laboratories



Bruce Power

BRUCE POWER and the **INDEPENDENT ELECTRICITY SYSTEM OPERATORS (IESO)**

announce an amended, long-term agreement to secure 6,300 megawatts of electricity from the Bruce Power site through a multi-year, \$13-billion investment program

Bruce Power will begin main component replacement on Units 3-8 in 2020, starting in Unit 6

This will generate between 1,500 and 2,500 jobs on site annually – and 18,000 across Ontario directly and indirectly – while injecting up to \$4 billion annually into Ontario's economy

The **CANDU 6 FLEET** signs a six objective agreement including rod-based guaranteed shutdown to save time, dose and money, improved reliability of emergency power diesels and strategies to mitigate aging of the primary heat transport system

COG partners with

ORGANIZATION OF CANADIAN NUCLEAR INDUSTRIES (OCNI)



and its members on a number of initiatives to further strengthen the nuclear supply chain including efforts to strengthen against counterfeit, fraudulent and suspect items (CFSI)

Actions include a workshop of suppliers, utilities and regulators to talk about expectations and strategies



Left to right: OCNI President Ron Oberth and COG President Fred Dermarkar sign a partnership agreement to further strengthen the supplier community engagement

KHNP, Korea

KHNP VISITS NB POWER

for a community session at Point Lepreau as part of a C6 Fleet collaborative initiative on strengthening social licence

KHNP, Korea

WOLSONG UNIT 1

at 100% full power after relicensing

In recognition of COG's contribution, KHNP CEO Seok Cho presented a plaque of thanks to COG President Fred Dermarck who noted the efforts and collaboration of COG members

All COG members benefited significantly by learning from the Wolsong experience



Canadian Nuclear Laboratories

CNL begins full operation under the government-owned, contractor-operated model

Experiments on **HIGH TEMPERATURE FUEL BUNDLE DEFORMATION** are completed

While analysis of the data continues, enough is now available for the development of a deformation model for Anticipated Operational Occurrences (AOO) and some types of Loss of Coolant Accident (LOCA)

A new model to predict the behavior of the overload cracking at flaws implemented into CSA Standard N285.8

The **CANDU INDUSTRY ASSESSMENT COMMITTEE JOINT AUDIT PROGRAM (CANIAC)**

is formed to contribute to enhanced safety, reliability and economics in CANDU plants through a collaborative quality assurance audit service

A COG workshop on **LOW AND INTERMEDIATE LEVEL NUCLEAR WASTE** focuses on source reduction and research opportunities

Topics included waste minimization, characterization and processing; use of reusable protective equipment and laundering; development of communications to change worker behaviour; and formal benchmarking as a means for sharing best practices

The COG **EQUIPMENT RELIABILITY PEER GROUP**

creates five initiatives for equipment reliability:

- Equipment Health Initiative
- Preventative Maintenance (PM) Strategy
- Component Classification and Maintenance Strategy Review
- Required Frequency and Criticality Initiative
- Condition-Based Maintenance (CBM) Strategy

COG actively strengthens its **SUPPLIER PARTICIPANT PROGRAM**

to support refurbishment and Major Component Replacement (MCR)



2015 Supplier Participant program director, Ian Trotman, at a COG supplier workshop

2016

Ontario Power Generation

OPG awards a 50/50 joint venture **\$2.75 BILLION** contract to **AECON** and **SNC-LAVALIN NUCLEAR** for the execution phase of its refurbishment project

Completion of Phase 2 of the **FUEL CHANNEL LIFE MANAGEMENT PROJECT**

The project enabled many stations to benefit from a four-to-five-year extension of operations, improved life cycle management plans, and increased confidence in operation and business plans
The revenue resulting from the extra years of operating multiple units amounts to billions of dollars for the utilities involved

Utility nuclear leaders identify “grand challenges” requiring long-term strategies as part of COG’s **STRATEGIC RESEARCH & DEVELOPMENT (SRD) PROGRAM**

R&D projects to provide tools for **AS LOW AS REASONABLY ACHIEVABLE (ALARA)** and **DOSE REDUCTION DURING OUTAGES & REFURBISHMENT** are completed

Ontario Power Generation

DARLINGTON REFURBISHMENT gets underway starting with work on Unit 2

COG’s **FCLM PROJECT** supports safe operation of Darlington to 210,000 EFPH and Pickering to 240,000 EFPH

HYDRO-QUÉBEC REJOINS COG as a participant in the Information Exchange program



COG member New Brunswick Power wins **EPRI TECHNOLOGY TRANSFER AWARD** for work on Use of Heat Exchanger Guidance to Develop In-house Program

NA-SA, Argentina

EMBALSE shuts down for refurbishment



2017

COG launches the **SMR FORUM** creating a platform for exploration of Small Modular Reactors, in keeping with COG’s role in the Canadian SMR Roadmap

Ontario Power Generation

OPG launches **X-LAB INNOVATION ACCELERATOR**, tapping into the latest technology to improve training and make work processes more efficient with innovative items including virtual reality headsets and smart glasses



Sonia Qureshi, COG director of Joint Projects and Services becomes chair of **WOMEN IN NUCLEAR CANADA** Golden Horseshoe West chapter



COG's strength is its diversity
By 2019, COG was gender balanced and with a broad ethnicity of employees representative of its international membership

NWMO JOINS COG



as a participant in the Nuclear Safety and Environmental Affairs program
The Radioactive Waste Leadership Forum is formed through COG the same year

SNN, Romania

SNN announces plans for **CERNAVODA UNIT 1 REFURBISHMENT** starting in 2026 that will extend plant operations by 30 years

The refurbishment will produce a significant savings compared to new generation and will strengthen the return on the original investment in the plant, making it even more economical for Romania's electricity users

UNENE-initiated and COG-administered **THE ESSENTIAL CANDU TEXTBOOK** is published in partnership with funding participants: OPG, Bruce Power, NB Power, AECL-CRL, SNN, CNNO, CNSC, Kinectrics, AMEC-NSS, SNC-Lavalin and CNS



COG testifies at **CNL LICENCE RENEWAL HEARING** highlighting the importance of CNL research to the CANDU industry

First **COG COLLABORATION WEEK** takes place
The conference featured workshops, an R&D expo and an opening plenary including leaders from across the nuclear industry
More than 200 participants attended



“ COG adapts with the times and stays current. It helps the industry going forward. ”

Paul Thompson, NB Power

COG's **FCLM PROJECT** supports safe life extension of Darlington to 235,000 EFPH and 247,000 EFPH for Pickering and Bruce

By 2021, FCLM is expected to support Pickering up to 295,000 EFPH and Bruce up to 300,000 EFPH

2018

COG's **SUPPLIER PARTICIPANT PROGRAM** membership welcomes its first international supplier, KEPCO E&C

14TH COG/IAEA TECHNICAL COMMITTEE MEETING on the Exchange of Operational Safety Experience of Pressurized Heavy Water Reactors (TCM) in Argentina sees record participation and 56 presentations



Bruce Power

Bruce Power receives **10-YEAR LICENCE RENEWAL** from CNSC

COG testifies at the regulatory hearing

COG industry team's work on whole-site **PROBABILISTIC SAFETY ASSESSMENT (PSA)** helps demonstrate safety at the successful Pickering Nuclear **10-YEAR OPERATING LICENSE RENEWAL**

Ontario Power Generation

Pickering Nuclear receives **10-YEAR LICENCE RENEWAL** from CNSC, including continued operation to 2024

COG testifies at the regulatory hearing

COG forms and progresses the **SUPPLY CHAIN, OBSOLESCENCE AND PROCUREMENT**. This high potential area offers opportunity for joint project development, especially in the areas of strategic sourcing, bulk procurement, obsolescence solutions, emergency spare parts and inventory and vendor management



REGULATORY APPROVAL FOR EXTENDED FUEL CHANNEL LIFE

Both OPG Pickering and Bruce Power receive the green light to extend reactor operation, providing Ontario with years of additional noncarbon electricity

The utilities gain billions of dollars of additional revenue and service from the capital investment while providing a continuity of service through Ontario's nuclear refurbishment period

This is possible through the multi-year COG joint project that demonstrated safety margin and the technical basis for continued operation

Canadian Nuclear Laboratories

THE NATIONAL RESEARCH UNIVERSAL (NRU) RESEARCH REACTOR

operated by the Canadian Nuclear Laboratories (CNL) at Chalk River was shut down on March 31



Bruce Power

Bruce Power and the Bruce County announce plans to establish the **NUCLEAR INNOVATION INSTITUTE (NII)**

A year later, NII announces their first international partner, the University of Strathclyde's Advanced Nuclear Research Centre

9TH CLEAN ENERGY MINISTERIAL

New nuclear innovation partnership is announced between the United States, Canada and Japan to investigate nuclear energy's role in future clean energy systems

KHNP, Korea

WOLSONG UNIT 1 shuts down, lowering the global number of CANDU reactors to 46

HBO's **CHERNOBYL** series debuts

NA-SA, Argentina

EMBALSE returns to service following three-year refurbishment that extends its operating life for another 30 years



CRITICAL HEAT FLUX RESEARCH (CHF)

demonstrates safety in aging CANDU pressure tubes

Demonstration of critical heat flux to 6.8% creep confirms safe continued operation of existing channels

A significant factor in continued operation of CANDU plants is demonstrated longevity and safety margin of key reactor components

COG research on behalf of its members on critical heat flux in reactors has been instrumental in validating fitness for continued service

COG members OPG and Bruce Power win EPRI TECHNOLOGY TRANSFER AWARD

for work developing Standardized Test Evaluations



2019

COG and the IAEA SIGN A PRACTICAL ARRANGEMENT

building on existing working partnership

Almost **\$70 MILLION INVESTED** in **COG R&D** and **JOINT PROJECTS**

COG begins developing an EXPANDED COLLABORATION MODEL

to include more member-country labs through a work-in-kind program

COG's **OPEX DATABASE** totals about **44,000 ENTRIES** providing members searchable information to help solve problems based on past experience from COG members

10TH CLEAN ENERGY MINISTERIAL

is held in Vancouver
 For the first time, a significant focus is given to the role of nuclear
 The book *Breakthroughs* is released by the Nice Futures partners featuring nuclear innovations

Ontario Power Generation

OPG nears completion of **DARLINGTON UNIT 2 REFURBISHMENT** and prepares to begin work on Unit 3

Several COG members further invest in **MEDICAL ISOTOPE** harvesting and development partnerships for life-saving diagnostics, treatments and medicines

Bruce Power

Bruce Power officially launches the **NUCLEAR INNOVATION INSTITUTE**, a centre of excellence for innovation, talent development and applied research

New Brunswick Power

New Brunswick Power is **RECOGNIZED FOR OPERATING EXCELLENCE** following several years of steadily improving performance following its 2012 return to service following refurbishment

COG's **SUPPLIER PARTICIPANT PROGRAM** experiences significant growth, reaching almost 30 members and launching the **FRONT-LINE SUPERVISOR LEADERSHIP TRAINING PROGRAM**

COG forms an **SMR VENDOR FORUM** further contributing to the industry's SMR development initiatives and increasing collaborative efforts by members and industry participants through COG as part of COG's contribution to the Canadian SMR roadmap



AECL REJOINS COG as a participant in the Nuclear Safety & Environmental Affairs program



“ We tremendously value our relationship with COG and all of the work that we’ve done together over the past many years. Certainly, AECL’s research is better for its cooperation with COG. ”

Shannon Quinn, AECL

COG wins the Canadian Nuclear Society's **JOHN S. HEWITT TEAM ACHIEVEMENT AWARD** for its achievements in advancing technical and leadership knowledge and sharing operating experience across CANDU stations around the world



COG's Bernice Brooks (centre) and other members of the COG team accept the award
 Bernice Brooks has served as assistant to every COG president since the company was incorporated in 1999

COG Members and Program Participants

The members of the CANDU Owners Group are nuclear operators who invest in achieving operational *excellence through collaboration*. Every day, through their employees' contributions to COG, they demonstrate their commitment to this principle, the vision that has made so many achievements possible.

In 1984, the CANDU Owners Group was formed by Atomic Energy Canada Limited (AECL), Ontario Hydro, Hydro-Québec and New Brunswick Power. As CANDU plants were built worldwide, international members joined COG, further strengthening the opportunities to pool resources for innovative research, development and joint projects. This collaborative model also created a diverse pool of shared expertise and operating experience across a global CANDU fleet.

Over time, Hydro-Québec and AECL left the COG membership due to business-model changes, but both returned in recent years as program participants (along with the Nuclear Waste Management Organization) to participate in areas of collaboration still relevant to them today. As well, Canadian Nuclear Laboratories, the company managing AECL's assets and national lab operations, holds the COG board seat previously held by AECL. Through COG, the members invest more than \$60 million annually in R&D and joint project activities, an investment in innovation in line with the spending of Top 20 private-sector organizations in Canada.

Together, through COG and individually, the members have achieved tremendous accomplishments in nuclear science starting with the development of CANDU technology. Today, they continue to meet new challenges and opportunities with innovation solutions while continually improving their operational and project expertise.

COG members timeline

- 1984** • CANDU Owners Group is formed by an agreement between Ontario Hydro (now OPG), Hydro-Québec, NB Power and AECL, making them COG's first members
- 1986** • CNEA (now NA-SA), Argentina & KHNP, Korea become COG members
- 1991** • SNN, Romania becomes a COG member
- 1992** • PAEC, Pakistan and NPCIL, India become COG members
- 2001** • Bruce Power becomes a COG member after signing a lease agreement with OPG to operate the Bruce nuclear generating stations
- 2003** • TQNPC (now CNNO), China becomes a COG member
- 2012** • Hydro-Québec leaves COG membership following the decision to permanently shut down their CANDU reactor
- 2015** • AECL transfers its COG membership to CNL, making CNL a COG member
- 2016** • Hydro-Québec rejoins COG as a participant in the Information Exchange program
- 2017** • NWMO joins COG as a participant in the Nuclear Safety & Environmental Affairs program
- 2019** • AECL rejoins COG as a participant in the Nuclear Safety & Environmental Affairs program

COG MEMBERSHIP

CANADIAN MEMBERS

Bruce Power

Bruce Power joined COG as a member in 2001, the same year it was formed. An electric utility partnership based in Tiverton, Ontario, 250 km northwest of Toronto, Bruce Power is Canada's first private nuclear generator. It provides 30 per cent of Ontario's power from the shores of Lake Huron. Bruce Power is a voting member on COG's Board of Directors, represented by Gary Newman, Senior Vice President, Engineering & Chief Engineer.

The eight-unit plant has more than 4,000 employees, over 90 per cent of whom own a part of the company. Bruce Power is a partnership among TransCanada Corp., Borealis Infrastructure, the Power Workers' Union and The Society of Energy Professionals.

For more than 30 years, the four reactors at Bruce Power's Bruce B Generating Station have produced a steady supply of the world's Cobalt-60 medical isotopes. These are used to sterilize single-use medical devices and for radiation-based treatments of cancer and other diseases.

In 2016, Bruce Power began its Life Extension Program, enabling its units to operate safely to 2064.



Canadian Nuclear Laboratories

Established in 2014, Canadian Nuclear Laboratories (CNL) is a wholly-owned subsidiary of Atomic Energy of Canada Limited. CNL joined COG as a member in 2015. Employing approximately 3,400 people at 12 locations across Canada, CNL's corporate headquarters and core research and development operations are situated at Chalk River Laboratories in the upper Ottawa Valley. CNL is a voting member on COG's Board of Directors represented by Neil Mantifel, Chief Operating Officer, Nuclear Operations.

CNL is a world leader in developing peaceful and innovative applications from nuclear technology through its expertise in physics, metallurgy, chemistry, biology and engineering. Highly-skilled employees deliver a range of nuclear services – ranging from research and development, design and engineering to specialized technology, waste management and decommissioning.



CNL is committed to ensuring that Canadians and the world receive energy, health, and environmental benefits from nuclear science and technology with confidence that nuclear safety and security are assured. In 2019, CNL and TRIUMF announced they had completed the first joint production run of actinium-225, a rare medical isotope that shows great promise as the basis for new, cutting-edge cancer therapies.

It plans to become a global hub for small modular reactor research and technology and intends to have a demonstration unit built on a CNL site by 2026.

COG MEMBERSHIP

CANADIAN MEMBERS

New Brunswick Power

New Brunswick Power (NB Power) is the largest electric utility in Atlantic Canada and a founding member of COG. New Brunswick was Canada's third province to produce electricity using nuclear energy. It operates Atlantic Canada's only nuclear facility, Point Lepreau Generating Station, which went into service in 1983. NB Power is a voting member on COG's Board of Directors represented by Michael Hare, Deputy Chief Nuclear Officer.

Point Lepreau has one nuclear reactor, a CANDU-6 unit and it was the first CANDU-6 to be licensed for operation and to begin commercial operation. The unit supplies about 30% of the energy consumed in the province.

NB Power completed a refurbishment of Point Lepreau in 2012, extending the station's life to 2039. Since returning from refurbishment, the station has been recognized for continually improved performance and excellence in plant operation.

NB Power and the provincial government are partnering in research for potential development of small modular reactors with two private-sector companies.



Ontario Power Generation (previously Ontario Hydro)

Ontario Power Generation (OPG), a successor company of the former Ontario Hydro, is 100 per cent owned by the Province of Ontario. Ontario Hydro was one of the founding members of COG's predecessor, CANDev (CANDU Development) and formation of COG in 1984. OPG is one of the largest and most diverse clean power producers in North America and currently operates Darlington, Pickering A and Pickering B nuclear generating stations in addition to other assets, including a fleet of hydro-electric stations. OPG is a voting member on COG's Board of Directors represented by Carla Carmichael, Vice President, Project Assurance and Contact Management.

Pickering A station went into service in 1971 followed by Pickering B in 1983. Today, it continues to provide up to 20 per cent of the province's electricity on any given day and is experiencing some of its best life-time performance.



Darlington is currently undergoing a refurbishment. One unit has been taken out of service while the other three continue to generate electricity. The refurbishment is expected to create 14,200 jobs per year and extend the life of the plant by 30 years.

OPG previously operated Bruce A and Bruce B nuclear generating stations until May 2001 when they were leased to Bruce Power. OPG's Darlington and Pickering Nuclear stations together are capable of providing about 30 to 35 per cent of Ontario's electricity needs.

INTERNATIONAL MEMBERS

Nucleoeléctrica Argentina Sociedad Anónima

ARGENTINA

Nucleoeléctrica Argentina Sociedad Anónima (NA-SA) are the owners and operators of the single-unit Embalse Nuclear Plant. It is one of two nuclear power stations in Argentina currently operational. NA-SA joined COG in 1986.



Nuclear power provides 28 per cent of energy to houses in Argentina. The energy provided by Embalse is supplied to the national grid. On average, Embalse provides enough energy to support the needs of 3-4 million people.

The energy generated reaches the Argentine Northwest, Cuyo, Center Region, Greater Buenos Aires and Litoral. As well as supplying electricity, Embalse also produces the Cobalt-60 radioisotope used in medical and industrial applications.

In 2019, Embalse returned to service following the completion of a life extension project that will enable the plant to operate for 30 more years.

China National Nuclear Operations Management

CHINA

China National Nuclear Operations Management (CNNO) has been a COG member since 2003. CNNO is the operator of the Qinshan Phase III (Third Qinshan) nuclear power plant situated in China's Zhejiang Province. It is adjacent to Qinshan Phase I (Unit 1) and Qinshan Phase II (Units 2 and 3) nuclear power plants. In 1996, Atomic Energy of Canada Limited (AECL) signed a \$4-billion contract for the sale of two CANDU 6 reactors to China.

Qinshan Phase III (Units 4 and 5) use the CANDU-6 technology and are the first heavy water reactors to operate in China. Construction started in June 1998 with AECL as the general contractor. Qinshan Unit 4 began commercial operation on Dec. 31, 2002 and Qinshan 5 on July 24, 2003. Qinshan is the first CANDU-6 project to use open-top reactor building construction and the first project where commercial operation began earlier than its projected date.

Approximately one-third of all new nuclear power plant construction in the world is currently taking place in China.



COG MEMBERSHIP

INTERNATIONAL MEMBERS

Nuclear Power Corporation of India Limited

INDIA

Nuclear Power Corporation of India Limited (NPCIL) is a public-sector enterprise under the administrative control of India's Department of Atomic Energy. NPCIL joined COG in 1992.

The company operates six nuclear power stations: Tarapur Atomic Power Station in Maharashtra; Rajasthan, Madras in Tamil Nadu, Narora in Uttar Pradesh, Kakrapar in Gujarat and Kaiga in Karnataka. In total, NPCIL operates 22 commercial nuclear power reactors. Its first PHWR unit, Rajasthan-1 came into service in 1973 and its most recent, Kaiga-4, in 2011.

Starting in 2020, COG and NPCIL will collaborate on a leadership training initiative for nuclear professionals in India.

The nuclear industry is rapidly growing in India. In addition to the recent construction of four new reactors, it is estimated that India will invest up to \$50 billion in nuclear technology over the next decade.



Korea Hydro & Nuclear Power

KOREA



Korea Hydro & Nuclear Power Co. Ltd (KHNP) joined COG as a member in 1986 and is Korea's largest electric power utility. In 1976, construction began on the Wolsong Generating Station, the first third-generation CANDU reactor export to Asia. Since then, three more CANDU units were added to KHNP's Wolsong facility.

KHNP is owned by Korea Electric Power Corporation (KEPCO), an arm's length government corporation. KHNP operates 23 nuclear power units with five new units currently under construction. Out of the 23 operational units in Korea, three are CANDU-6 reactors located at the Wolsong plant. Nuclear provides about 32 per cent of total power generation in Korea.

A critical example of COG-KHNP collaboration has been in the implementation of the utility's decade-long safety improvement plan for which COG has served as a training partner.

INTERNATIONAL MEMBERS

Pakistan Atomic Energy Commission

PAKISTAN

Pakistan Atomic Energy Commission (PAEC) owns and operates the Karachi Nuclear Power Complex (KANUPP), Pakistan's first nuclear power plant, inaugurated on November 28, 1972. PAEC joined COG as a member in 1992.

KANUPP is one of two nuclear power stations in Pakistan. KANUPP is the oldest CANDU power reactor currently operating. It completed its 30 years design life on Dec. 5, 2002 and was shut down to meet re-licensing requirements. During the shutdown, important plant modifications and retrofits were carried out. KANUPP was brought back in operation in November 2003.

Nuclear power provides about three per cent of total electric power production in Pakistan.



Societatea Nationala Nuclearelectrica

ROMANIA

Societatea Nationala Nuclearelectrica (SNN) operates Cernavoda Nuclear Power Plant, the only nuclear power station in Romania featuring the only CANDU reactors operating in Europe. SNN joined COG as a member in 1991.

SNN is a state-owned company that reports directly to Romania's Ministry of Energy. Cernavoda Unit 1 came into service in 1996 while Cernavoda Unit 2 came online in 2007.



In 2014, SNN became sole owner of Energonuclear, the project company responsible for development of the Cernavoda Units 3 and 4 project implementations.

The electricity annually generated by Cernavoda represents approximately 18 per cent of Romania's electricity production. In 2018, SNN celebrated 20 years of safe, clean and reliable operation at Cernavoda.

Building on its strong performance, a planned refurbishment of Cernavoda Unit 1 is scheduled to move forward in 2026. This will allow the safe operation of the unit for another 30 years.

PROGRAM PARTICIPANTS

Atomic Energy of Canada Limited

Atomic Energy of Canada Limited (AECL) founded COG's predecessor, CANDev (CANDU Development) in 1979. With Ontario Hydro, Hydro Québec and New Brunswick Power, it was one of COG's founding members in 1984. AECL transferred its COG membership to Canadian Nuclear Laboratories (CNL) in 2015 after CNL became accountable for management of AECL's sites, facilities and assets.

As a federal Crown corporation, AECL receives government funding to enable nuclear science and technology and to protect the environment by fulfilling the government of Canada's radioactive waste and decommissioning responsibilities.

AECL's history and past achievements in nuclear science and technology have had impacts on human health, low-carbon energy production, safety, security and the protection of the environment. Starting in 1957, the National Research Universal (NRU) reactor was at the centre of many of these breakthroughs. The NRU was shut down on March 31, 2018.

A fully integrated nuclear technology company, AECL provides services to nuclear facilities worldwide. Its employees are dedicated to delivering leading edge nuclear services, research and development support, design and engineering, construction management, specialized technology, waste management and decommissioning in support of CANDU reactors and technology.

Hydro-Québec

A founding COG member, Hydro-Québec is a world-renowned power utility, leading technological innovator and the largest power utility in Canada. For nearly 30 years, it safely operated the Gentilly-2 nuclear plant before ending operations in 2012. Following the shutdown, it briefly left COG but rejoined in 2013, as a program participant in the Information Exchange program. Though no longer operating a nuclear generating station, Hydro-Québec has and continues to be a contributor to COG-led knowledge management, safety culture, OPEX and continuous improvement. Hydro-Québec operates a vast high-voltage transmission system and its sole shareholder is the Québec government.

Hydro-Québec is now focused on developing a clean energy future while also creating value. It also plays a pivotal role in the transition to renewables and the decarbonization of electrical generation.

Nuclear Waste Management Organization

The Nuclear Waste Management Organization (NWMO) is responsible for designing and implementing Canada's plan for the safe, long-term management of used nuclear fuel. It joined COG as a participant in the Nuclear Safety & Environmental Affairs program in 2017.

The NWMO is a not-for profit organization established in 2002 by Canada's nuclear electricity producers in accordance with the Nuclear Fuel Waste Act (NFWA). The founding members of the NWMO are Ontario Power Generation (OPG), New Brunswick Power and Hydro-Québec. These organizations, along with Atomic Energy of Canada Limited (AECL), are mandated to fund its operations.

NWMO oversees the Adaptive Phased Management Plan which requires used fuel to be contained and isolated in a deep geological repository. It also calls for a comprehensive process to select a site with informed and willing hosts for the project.

The organization is made up of some of Canada's leading experts in fields related to nuclear waste management and it collaborates with experts from across Canada and around the world.

COG'S EMPLOYEES & BOARD

People: The engine of the collaboration model

COG's team of staff and board members are a diverse group of people from many walks of life, across a spectrum of age and gender. Together they represent a depth and breadth of expertise with thousands of combined years of industry and project management expertise.



Top of page: The COG Board and employees gather to capture the 35th Anniversary on the COG Bay Street office patio.

Top right: COG Board of Directors, 2019.

Remainder of photos: COG employees share a close bond through their work and other shared efforts including fundraising and professional development through years.

The COG Team

As of November 27, 2019

President's Office

Fred Dermarkar
Bernice Brooks

Information Technology

Carmen Trandafir, Manager
Kelly Curtis
Chil Kwon
Thomas Noirot
Mersedeh Safa

Human Resources

Denise Bilsland*

Special Projects

Frank Doyle*

Communications

Querencia Partners*

Information Exchange

John Sowagi, Director
Paul Bigley*
Tony Bucci*
Kerry Clemen
Macit Cobanoglu*
Jilliane De La Cruz
Laurie Fraser
Ron Hamann*
Shang Junmin
Rick Manners*
Anjana Mistry
Corina Mocanu
Stephen Prigge
Kelsey Rodger
Mark Skuce
Esther Sun-Lee
Donna Tuck
Nalini Valliere*
George Williams*

Joint Projects & Services

Sonia Qureshi, Director
Nancy Boraso
Kathy Charette*
Ian Cruchley*
Nidhi Gaudani
Fenia Ignat
Dev Jain*
Thanuja Janathasing
Kisang Jang*
Zafar Kalim
Paul Lafreniere*
Taruna Matharu
Amanda Nascimento*
Saloumeh Rasouli*
Gord Rife*
Tania Rose
Sergio Russomanno*
Deny See Hoye*
Harry Sherwood
Olena Shtyrkalo
Tony Tenev
Jeff Weed*

Corporate Services

John Moore, Director & CFO
Arshad Awan
Ryan Cao
Steve Choi
Nicole Kost
Ann Palen
Ivan Petirs

Research & Development

Liette Lemieux, Director
Holly Anderson
Jennifer Benjamin
John de Grosbois
Peter Ernst*
Brian Gihm
Jullaine Hardinge
John Krasznai*
Yevgeniya Le
Tessa Martines
Steve McGee*
Usha Menon
Glenn Pringle
Wei Shen
John Skears*
Prince St. Kitts

Nuclear Safety & Environmental Affairs

Nahil Rahman, Director
Rachna Clavero, Director**
Natalie Alderson
Cindy Cornejo
Amanda Debidual
Krish Krishnan*
Keith Garell*
Ron Maruska*
Phil Smith*
Paul Spekkens*

COG Board of Directors

Gary Newman, Chair
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We're all in this together

Over a 41-year career, Strategic R&D Program Manager Holly Anderson has been instrumental in advancing significant research benefiting COG members and the nuclear industry – now, she is focused on its future

"If we help one utility, we help all," says Holly Anderson of the unique role of COG's collaborative R&D program in the nuclear industry.

Holly joined COG in 2008, after 20 years with Ontario Hydro's (later OPG's) research division and 10 years in OPG Nuclear Engineering Services. For a decade, Holly managed COG R&D's Safety and Licensing program playing an integral role in advancing the 37-element (37M) fuel bundle research project. The research helped to improve heat removal in fuel under accident conditions, thereby increasing safety margin in CANDU plants.

"The COG model is a good one in that it ensures members come together and think beyond themselves."

"37M was very important for the utilities," says Holly. "Experimental work is always fraught with uncertainties and that project was no different. But it did demonstrate to our members the benefits of a collaborative research program and served as a reminder in the nuclear community that we're all in this together."

In 2018, Holly began a new role at COG, focusing on Strategic R&D (SRD). This area of research will help the CANDU industry remain sustainable and strong for future operations over the next several decades. Holly says what's unique about SRD is how it tries to proactively address the issues that will impact the industry over the next 20-50 years.

"We're looking at entirely new fields of research and

creating forums where our members can discuss emerging issues. From societal acceptance of low dose radiation to public acceptance of where you put waste, COG is trying more and more to anticipate the needs of its members."

Holly believes that similarly to the way individual COG members pulled together on the 37M project to address the needs of the industry, the same collaborative approach can benefit them in finding solutions to future challenges.

"The COG model is a good one in that it ensures members come together and think beyond themselves. We work very hard to support members, give them what they ask for and achieve consensus. The model works so well because in serving our members in the way that we do, they all benefit."



Holly Anderson (front row, second from right) celebrated International Women's Day, 2015 by sharing her own career memories as a women entering a then-predominantly male field, as well as the rewarding work that followed.



A bright future in nuclear

Jilliane De La Cruz, a training coordinator with COG's Information Exchange line of business never expected to be working in the nuclear industry – now, she is helping to shape its future

A lot can change in three years.

That is how long Jilliane De La Cruz has worked with COG. In that short time, she has been promoted, has supported the training of the industry's future leaders and had her first child, a new baby boy, who arrived this past July. Since that promotion in 2017, Jilliane has served as a training coordinator within COG's Information Exchange (IE) team.

“COG has helped me to shape my future and I have played a role, through the work of our team, in helping nuclear professionals to take the next steps in their careers.”

Jilliane joined COG fresh out of school and while she never thought she would pursue a career in the nuclear industry, she believes it has been a good choice for her professional growth.

“COG believes in me,” says Jilliane. “When I first got the job, it was a special moment for me. Since then, COG has helped me to shape my future and I have played a role, through the work of our team, in helping nuclear professionals to take the next steps in their careers.”

Jilliane's work on the IE team offers her the opportunity to make an impact through the development and coordination of training programs for COG members and suppliers. She says that this work contributes to helping

advance the next generation of nuclear industry leaders.

“COG has a global presence and I've witnessed how individuals, after attending our training programs, apply the things they've learned back at their organizations around the world.”

Jilliane credits much of her own professional development and growth, over the last three years, to her IE colleagues as well as the wider COG team.

“I have stayed at COG for the people,” says Jilliane. “The bond that my team and I share is amazing. We work very hard but I'm also very lucky because I have such wonderful human beings to work with.”



Jilliane De La Cruz is a member of COG's charity committee, which organizes several events each year in support of charities like the Red Cross.



Collaboration: Then and now

COG Senior Advisor Strategic R&D Frank Doyle has spent 51 years in the nuclear industry, one-third of those with COG. He credits its growth to the collaboration that was one of its founding principles

Frank Doyle fondly recalls COG's earliest days and still can't believe that 2019 marks 35 years of collaboration.

"It seems like only yesterday, we were celebrating COG's 25th anniversary," Frank says.

In thinking back on the very beginnings of COG, he can't help but be reminded of his long-time friend and colleague, the late Barry Collingwood, who along with Henry Chan, served as COG's first employees.

"The focus then, similar to now, is using collaboration to reduce costs for members, strengthen operational safety and continue to ensure that the nuclear industry is viable."

"Everything was very small and compact, originally. Barry was COG's manager while Henry Chan handled OPEX and offshore contacts in those early days."

Frank joined COG in 2002 after holding senior management positions at Atomic Energy of Canada Limited and Ontario Power Generation. He is also the past President and Fellow of the Canadian Nuclear Society. At COG, Frank has previously served as Program Manager, Safety & Licensing and later, Director of COG's R&D program, from 2003 to 2014, when he became Senior Advisor.

While many things have changed at COG, and within the nuclear industry in the time since its formation, Frank believes the constant that has fueled its growth has been a commitment to excellence through collaboration.

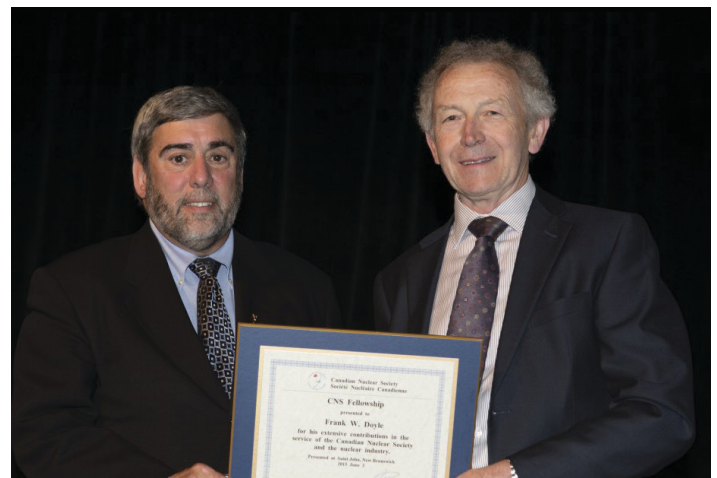
"The focus then, similar to now, is using collaboration to reduce costs for members, strengthen operational safety and continue to ensure that the nuclear industry is

viable. As we move forward, there will only be a bigger focus on collaboration with offshore plants and suppliers, as we look at new ways of extending the life of units an additional 50-60 years."

The spirit of collaboration and the interesting challenges presented by his work are among the reasons why Frank has stayed with COG longer than any other stop through the course of his career.

"COG has been a great place to work," says Frank. "In 2002, I made a one-year commitment and 17 years later I'm still here. The fact is that I get to work in an environment collaborating with great people and there is always a different challenge. Even rebuilding old plants is an interesting challenge. And who knows? We may still be building new plants."

"For people who are motivated to solve problems, there are few places like COG."



Frank Doyle (right) receiving the 2015 CNS Achievement Award from Jacques Plourde.



Leading by example

Sonia Qureshi, COG's Director, Joint Projects & Services takes pride in working for an organization with gender-balanced leadership and which serves as a model for the nuclear industry

COG's leadership team was very different when Sonia Qureshi joined the organization in 2016, after almost 20 years at Atomic Energy of Canada Limited / Candu Energy.

"The management team was all-male, at that time," says Sonia. "But there has been gradual change since then."

Sonia believes that change, namely, a leadership group that is now equally male and female, has benefited women at COG and across the nuclear industry.

"Having COG at the forefront of the movement toward

"Having COG at the forefront of the movement toward gender parity is really exciting and powerful."

gender parity is really exciting and powerful," says Sonia. "It provides an example to women, working with our members utilities and suppliers, and demonstrates that if we work hard, there are no barriers to what can be achieved."

In addition to Sonia's role as Director, Joint Projects & Services (JP&S), and a member of COG's senior leadership group, she is also chapter lead for the Golden Horseshoe West branch of Women in Nuclear Canada (WiN Canada).

WiN promotes the role of women in the Canadian nuclear industry. COG's support of professional development opportunities for women, including WiN events and initiatives, has created a working environment where professional growth at COG is more accessible than ever before.

"I believe that women at COG feel supported by the organization and its leadership. Before, in nuclear, like

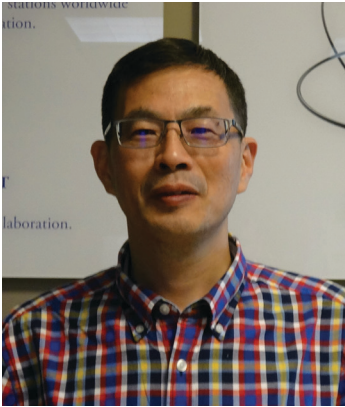
in so many industries, there was a lingering feeling, as a woman, of 'Will I get there?' or 'Will I have the opportunity to succeed?'. Now, we have COG leadership, the head of the Canadian nuclear regulator, CNSC's Rumina Velshi, OPG's [and COG board member] Carla Carmichael, among others, and these individuals help to facilitate expectations and aspirations for women in the nuclear industry."

Sonia sees COG's move toward gender-balanced leadership as well as the diversity of its staff as key ingredients strengthening COG collaboration, moving forward.

"We're special at COG because we really are a collaboration of so many different kinds of people from all over the world. It's like we're CANDU experts without borders...Our differences help to make it welcoming for any person to come to COG. We each play an important role in helping to move the CANDU industry forward."



Sonia Qureshi (left) with COG colleagues, Thanuja Janathasing and Taruna Matharu at the WiN Canada annual conference. Sonia is the WiN Golden Horseshoe West chapter chair.



Innovation built on trust

COG R&D's Safety and Licensing Program Manager Wei Shen says even as CANDU technology evolves, COG's cornerstone remains the same

Wei Shen has seen COG from afar and up close.

With almost 30 years in the CANDU and PWR industry, Wei joined COG in 2017, after stints with the Canadian Nuclear Safety Commission, in academia at Royal Military College as well as AECL. At COG, Wei holds a dual role that sees him managing R&D's Safety and Licensing program while also serving as the member relationship manager for China Nuclear Power Operations Management (CNNO). His diverse career and experiences provide him with a unique perspective on COG's R&D line of business and COG's evolving role in the nuclear industry.

"A foundational principle I have witnessed and worked to deliver at COG is ensuring the member knows that we care about their business, that we are honest and transparent."

Wei believes that in a time of rapid technological change, COG's R&D plays a critical role in enabling members to adapt and meet priorities for safety, regulatory commitments, improved reliability, added revenue and improved human capability.

"COG is no longer just a CANDU organization. Small Modular Reactor (SMR) technology will present more opportunities for COG to support innovation and growth. And COG's role in knowledge management and training will only become more important," says Wei.

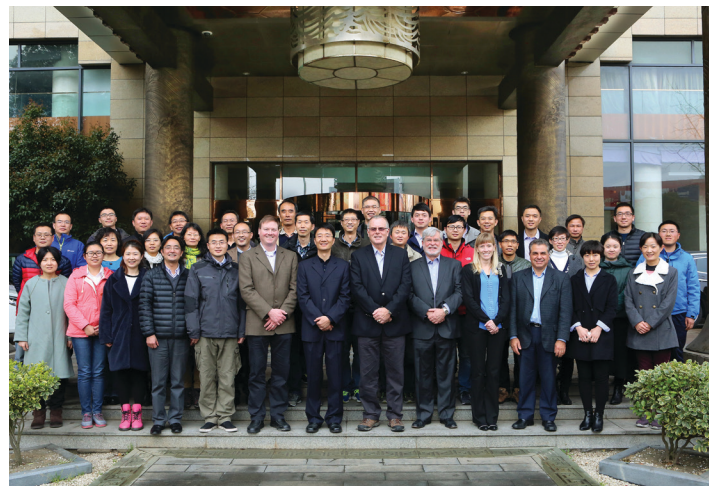
Wei has contributed to and witnessed COG's role in advancing developments in CANDU technology, from

researching advanced CANDU fuel to supporting the adoption of new fuel bundle design with higher dryout powers through COG's 37M Fuel Bundle Project.

He has also experienced first-hand, through the relationship he manages with CNNO, how COG's commitment to building trust with members is a critical ingredient to its successful collaboration model.

"A foundational principle I have witnessed and worked to deliver at COG is ensuring the member, in this case, CNNO, knows that we care about their business, that we are honest and transparent...I want them to trust COG and understand that ours is a platform built on trust."

With one-third of new nuclear builds happening in China, Wei says COG's strong and trusted global reputation will benefit members well as they look to CANDU and beyond.



Wei Shen was among attendees of COG and CNNO's Training Systems Development benchmarking event held in China in March 2017.



Sharing information, strengthening connections

Carmen Trandafir started on a one-month contract in 1999. Today, she is one of COG's longest serving employees. It's an uncommon story in IT to stay at a single organization so long but the challenges and collaboration have kept her coming back.

"It's been a long journey but a happy one," says Carmen Trandafir, who serves as COG's Manager, Information Technology and CIO as well as Member Relationship Manager for Romania's Societatea Nationala Nuclearelectrica (SNN).

As one of COG's most tenured staff members, Carmen has seen a great deal of change in her nearly 20 years with the organization.

"These were extremely challenging but also extremely rewarding initiatives because we were able to provide great service to our members."

Particularly, when it comes to the rapidly evolving technology she and her IT team have implemented in order to ensure safe, secure and enhanced access to COG's OPEX and knowledge management systems, for members and suppliers.

"I feel a great sense of pride in the big projects our team has contributed to over the last 20 years," says Carmen. "From the launch of the OPEX database and making that available to all members, to the evolution of COGonline, and our work during Fukushima to bring all our members together using video conferencing technology. These were extremely challenging but also extremely rewarding initiatives because we were able to provide great service to our members."

Carmen says that the evolution of web-based technologies marked the beginning of a new period in COG's existence. SNN, as an example, has benefited

greatly from the connectivity that COG technology offers to its international members.

"When we look at Romania, as the only CANDU plant in Europe, they would be more isolated without the engagement COG offers, both technologically and in terms of the regular meetings through which we collaborate. SNN has expressed appreciation for COG's engagement."

Carmen, who is of Romanian heritage, began serving as COG's SNN relationship manager in 2013. Thanks to her dual roles, she has witnessed how COG collaboration been strengthened by advances in technology and by its committed people.

"As COG has grown, we have shown that good collaboration makes everyone's lives easier. I am one of the lucky ones because I have been able to make a difference alongside amazing people."



Carmen Trandafir (far right) at a site visit to Cernavoda Nuclear Plant in Oct. 2012. Also pictured: Bob Morrison, former COG President and CEO, Alexandra Tudor and Sorin Ghelberu of SNN Romania, and the late Barry Collingwood, former COG Operations Manager and JP&S Program Director.

COG'S SUPPLIER PARTICIPANT PROGRAM

Supplier participants, key industry partners

Through the CANDU Owners Group (COG) Supplier Participant Program (SPP), suppliers have collaboratively developed an internationally-recognized approach to achieve an increasingly strong safety and quality culture.

COG's Supplier Participant Program (SPP) provides suppliers opportunities for information exchange, training and interaction between operators and suppliers.

Today, there are almost 30 suppliers in the program, with objectives to:

- Share supplier perspectives, OPEX, and lessons learned
- Identify, communicate and resolve common challenges in execution of services for customers
- Obtain an understanding from customers of the top issues that suppliers should address
- Engage with customers and remove impediments for the benefit of the nuclear industry

The SP program also provides an opportunity for shared programs that strengthen and secure the entire CANDU supply chain. This is accomplished through collaboration in developing best practices and shared experience for preventing and identifying counterfeit parts and other supply chain management activities.

The program has helped the industry manage a transition to increased partnership and leadership by supply organizations in nuclear projects and operations. SPP participants have developed similar training, OPEX (operating experience) and information exchange mechanisms as nuclear operators have relied on for decades.



From far left: SNC-Lavalin's Pam Tume (standing), is a key member of the Supplier Participant Program (SPP). Top, Dave Dennier, then with Amec, was chair of the SPP during a period of growth and development. Inset, left, Macit Cobanoglu, SPP manager and close left, Bruce Power CNO Len Clewitt, a proponent for supplier development.

COG'S SUPPLIER PARTICIPANT PROGRAM

Acuren

Acuren's services include conventional and advanced non-destructive testing and examination, inspection, engineering, rope access enabled services and condition-based monitoring services through more than 80 locations and 4,000 employees across North America and the United Kingdom. It serves many of the largest and most sophisticated industrial firms in the world – with clients in the refinery, chemical, pipeline, storage tank, power generation (fossil, nuclear and wind), pulp and paper, aerospace, automotive, and pharmaceutical industries. Its formula for success is straightforward: be highly capable locally, with certified, well-trained and well-equipped personnel supported by trained, experienced leaders. Acuren's commitment to safety, quality and professionalism spans four decades. Continuous improvement is core to its culture. It strives for incident-free work environments and continuous service improvement. Its safety and quality assurance are evidenced through its industry certifications and its strict adherence to industry standards.

<https://www.acuren.com/industries/nuclear-power/>

AECOM

For more than 60 years, AECOM has provided nuclear power customers with a wide range of operating plant technical services. It has been the engineer or constructor of record for 49 nuclear power plants, totalling 39,000 megawatts of nuclear power. Its work has included the first nuclear units in Spain, Italy, Brazil, Mexico and Taiwan, as well as the U.S. nuclear plant most recently placed online, Watts Bar Unit 1. Its staff has helped maintain the reliability of the nuclear operating fleet by accomplishing thousands of technical services tasks and life-extension modifications at more than 100 operating units. It has established a comprehensive and responsive maintenance capability and has managed dozens of refueling, modification and maintenance outages. Operating through its SGT joint venture, it provides construction-support services for large component replacements, such as steam generators and reactor vessel heads, including under the most aggressive outage schedules.

<https://www.aecom.com/markets/power/nuclear-generation/>

Aecon

Spanning five decades and more than 400 nuclear energy projects, Aecon Nuclear's portfolio of building, refurbishing, maintaining and decommissioning nuclear power facilities reflects a record of project success that ranges from small but essential maintenance contracts to major construction endeavours. Aecon supports clients with expert project management and tradespeople. Aecon has successfully executed a broad range of projects, including construction of the Bruce 'B' Heavy Water Plant, Bruce Unit 1 & 2 Balance of Plant Refurbishment and the Darlington Used Fuel Dry Storage Project. This kind of experience and track record has made Aecon a trusted supplier. The Darlington Retube and Feeder Replacement Project (RFR) – Ontario Power Generation's largest nuclear project – and the fabrication, assembly, inspection, examination and testing of 24 American Society of Mechanical Engineers (ASME) Mechanical Process Modules for two new build nuclear power plants in the U.S. are key examples of Aecon Nuclear's flagship projects.

https://www.aecon.com/What_We_Do/Aecon_Industrial/Nuclear

Alithya

Alithya is a respected industry expert in energy solutions. It provides expertise that spans nuclear, oil and gas, and utilities, and has a sterling track record for project. Alithya has a combination of domain expertise, stellar project delivery record, and high staff retention in addition to knowledge of nuclear standards and engineering change control processes, making it an ideal long-term delivery partner. Alithya's energy engineering team is a key contributor to the Canadian nuclear industry, providing comprehensive consulting, software engineering, and hardware engineering services for decades. Its work spans design and development of safety-critical shutdown systems (Category I) and reactor control and regulating systems (Category II), to monitoring and display systems (Category III), and to plant data historians (e.g., PI). It has 2,000 professionals in Canada, the United States and Europe that share the same passion: to understand every client's background, current reality and challenges in order to find the technology best suited to help them achieve their goals.

<https://www.alithya.com/en/industries/energy>

COG'S SUPPLIER PARTICIPANT PROGRAM

ATS Automation

ATS has been involved in providing manufacturing automation for a variety of customers whose primary focus is producing the devices that generate electricity for society. Nuclear customers have benefitted from its application of technology to solve their most pressing production challenges. It believes that by leveraging insights and best practices between all markets it serves, it creates a unique multi-industry synergy. It applies knowledge gained from other sectors to projects in the nuclear industry. It creates the perfect synergy of nuclear experience and automation technology. For more than 15 years, the nuclear industry has relied on ATS to be a trusted key solution supplier. It has worked with Atomic Energy of Canada Limited and others on more than 100 nuclear projects, providing 360,000 labour hours, including 40,000 engineering hours, and the invaluable expertise of more than 200 skilled engineers and technicians.

<https://www.atsautomation.com/en/Energy/Nuclear.aspx>

BWXT Canada

For CANDU nuclear reactor operators looking to better manage their fuel handling, BWX Technologies, Inc. has a full-scope solution. As the original designer and manufacturer of CANDU fuel handling systems at Bruce Power Generating Station, Darlington Generating Station and others internationally, BWXT has a legacy of excellence in fuel services. Its services range from the fuel handling system design to manufacture, delivery, installation and commissioning. In addition to meeting its customers' equipment needs, it provides timely and responsive on-site engineering support for fuel handling systems. It also supplies remote on-line fuel handling systems, both new and spent fuel transfer systems, as well as specialized maintenance and recovery tooling. The BWXT team can design or modify nuclear plant electro-mechanical equipment and any associated software. Partnered with its field services department, it can provide a full engineering, procurement, construction turnkey solution. BWXT also offers maintenance and engineering services.

<https://www.bwxt.com/bwxt-nec>

Cameco

Cameco is one of the world's largest providers of the uranium needed to generate clean, reliable baseload electricity around the globe. Its tier-one operations in Canada and Kazakhstan have the licensed capacity to produce more than 53 million pounds (100% basis) each year. It holds about 467 million pounds of proven and probable reserves and extensive resources on three continents. Its exploration program spans about 1.7 million acres of land, most of it near its existing operations. It is also a leading provider of nuclear fuel processing services, supplying much of the world's reactor fleet with the fuel to generate one of the cleanest sources of electricity available today.

<https://www.cameco.com/businesses/fuel-services/port-hope-cobourg>

CCNuclear

CCNuclear is recognized as a specialized service provider in the nuclear industry. Its team of experts has extensive experience in the design, development, manufacturing and proof testing of global solutions for the management of low-, intermediate-, and high-level radioactive waste. It provides clients with integrated expert services, from idea to implementation, dry safe storage and decommissioning of equipment, systems, and facilities. Its expertise spans a large spectrum of waste management activities such as spent fuel handling, packaging and storage both under water and in dry conditions, extraction packaging and dry storage of dry powder or wet bead spent ion exchange resins, and other low-, intermediate- and high-level radioactive waste extraction, handling and storage. It provides sample collection and characterization services for wet or dry spent ion exchange resins, and other ILLW radioactive material.

<https://www.ccnuclear.ca/en/home/>

COG'S SUPPLIER PARTICIPANT PROGRAM

CNPO

China Nuclear Power Operations Technology Corporation (CNPO) is a global nuclear industry supplier dedicated to providing full scope field, engineering, training and simulation services required throughout the lifecycles of nuclear power plants. Formed in 2007, CNPO has ensured the safe, reliable and cost-effective operation of nuclear power plants across China. That year, it also became a subsidiary of China National Nuclear Power Operations Management (CNNO), which operates 18 of the country's 45 nuclear plants including two CANDU-6 units at the Qinshan Plant in Zhejiang Province. CNPO offers operations and maintenance services to CNNO plants, owned by state-run China National Nuclear Corporation. CNPO has become a global leader and partner in the development and implementation of emerging technologies, including virtual reality and artificial intelligence, for training, simulation and inspection purposes. Its work on full-scope CANDU and severe accident simulators and its role in the development of more than 100 special maintenance tools have also benefited the wider nuclear industry.

Curtiss-Wright

Curtiss-Wright Nuclear, which includes the product brands of AP Services, Enertech, Nova, QualTech NP, Curtiss-Wright Nuclear Canada (CWNC) and Scientech, offers a comprehensive range of products and services that support the global nuclear power industry. Its advanced technologies and innovative solutions have been used in operating reactors for more than 55 years, sustaining the safe and reliable operation of nuclear plants throughout the world. It continuously provides technologies and experience in support of Plant Life Extension and Extended Power Uprate programs and offers proactive solutions to critical plant obsolescence issues. Curtiss-Wright Nuclear has proven its long-term commitment to serve the nuclear power industry. It will be there in the future to provide next-generation technology, equipment, services and experience, and it stands ready to support the industry's complex and evolving requirements.

<https://www.cwnuclear.com/home/default.aspx>

E.S. Fox

E.S. Fox provides a fully-integrated, single source of engineering, fabrication, construction and maintenance for all nuclear markets. It provides fabrication services to the international nuclear market, having manufactured numerous nuclear components for projects in Canada, China, Korea and Romania. E.S. Fox's nuclear fabrication capabilities include pressure vessels and piping, feeder tube fabrication, custom steel fabricated nuclear waste containers, feeder cabinets, spent fuel modules, and resin liners. Its nuclear field capabilities consist of pressure boundary, environmental qualification field installation, valve maintenance, feeder tube installation, nuclear waste container installation and handling, and radioactive waste management. E.S. Fox is recognized as an industry leader for industrial fabrication and construction by integrating safety and quality assurance practices into everything it does. With a strong commitment to health, safety, and the protection of the environment, it has earned a reputation as a people-first, environmentally-conscious, socially-responsible constructor.

<http://esfox.com/services/power-generation/>

Framatome

Framatome is an international leader in nuclear energy recognized for its innovative solutions and value-added technologies for the global nuclear fleet. It is a designer and supplier of nuclear steam supply system and nuclear equipment, services and fuel for high levels of safety and performance. With worldwide expertise and a proven track record for reliability and performance, the company designs, services and installs components, fuel, and instrumentation and control systems for nuclear power plants. Its more than 14,000 employees work every day to help Framatome's customers supply ever cleaner, safer and more economical low-carbon energy.

<http://www.framatome.com/EN/businessnews-94/framatome-designer-and-supplier-of-nuclear-steam-supply-system-and-nuclear-equipment-services-and-fuel-for-high-levels-of-safety-and-performance.html>

COG'S SUPPLIER PARTICIPANT PROGRAM

Hatch

Hatch has participated in the nuclear industry for many years, both in Canada and abroad. Its clients benefit from its extensive experience with a wide array of new nuclear construction and refurbishments projects, particularly in the CANDU space. It goes beyond design basis to ensure safe and efficient projects that consider fire protection, seismicity, security design, and human factor or radiation safety. It offers smarter and more efficient solutions to operating issues, and supports delivery strategies by improving operating business. These include support for obsolescence issues and minimizing outage durations and impacts. It's partnered with clients to develop tools and methods for the management of low-, intermediate-, and high-level waste products from nuclear energy production and used fuel dry storage. Working together with owners, regulators, and industry associations, it has contributed substantially to the nuclear operating experience and body of knowledge. Hatch also has direct project execution experience in uranium mining.

<https://www.hatch.com/en/Expertise/Energy/NuclearPower>

Jensen Hughes

Jensen Hughes uses risk insights to improve overall efficiency and increase safety to protect surrounding communities and the environment. It is actively involved with industry policy and research and can offer a range of solutions using risk-informed decision-making, experience-based engineering and innovative software solutions. It provides these services to the entire U.S. nuclear fleet and plants in Asia, Europe and the Middle East.

Since 1939, it has been at the leading edge of safety, security and risk-based engineering and consulting, serving the most complex global projects. In addition, it drives code and standard development and adoption throughout the world and across industries. It has planted roots with a commitment to earning trust and protecting lives, property and reputation in the constantly-evolving nuclear industry focused on increasing reliability and maintaining safety while eliminating unnecessary costs.

<https://www.jensenhughes.com/industries/nuclear-power>

KEPCO E&C

KEPCO E&C has nuclear engineering technology that fulfills various demands from customers. OPR1000 is the Korean Standard Nuclear Power Plant (KSNP) developed by KEPCO E&C through the self-reliance in nuclear technology and standardization plan. All 12 OPR1000s, which are 1000MW class pressurized water reactors, were built by KEPCO E&C. APR1400 is a 1400MW class next-generation nuclear power plant, which marks the first overseas entry of Korea's nuclear technology. Four plants are being constructed in the UAE, and it plans to operate eight plants. KEPCO E&C is constructing small- and medium-sized 100MW class SMART nuclear power plants in Saudi Arabia, and is competitive in the overseas market, responding to demands from many countries for small- and medium-sized nuclear power plants. In addition, it has exported the engineering technology for research reactors to Greece, Jordan, and other countries. KEPCO E&C's nuclear business is divided into two major services: A/E (Architect Engineering) and NSSS (Nuclear Steam Supply System) Design.

<https://www.kepco-enc.com/eng/contents.do?key=1531>

Kinectrics

Kinectrics has a history of more than 100 years of technical excellence and innovation while at the same time, an entrepreneurial spirit. The company continues to grow, with staff who thrive on challenges that others find daunting, and succeeds where investment in the future—in facilities, capability, and people—provides a touchstone for its vision. From initial design and type testing to operational deployment and maintenance services, Kinectrics collaborates closely with customers to ensure that utility assists perform safely, reliably, and efficiently throughout their entire life cycle. Kinectrics takes a proactive, practical approach to obsolescence management, which has been recognized as an ever-growing problem for the operating fleet. Kinectrics has the reliable, qualified staff, and flexibility to devote to unique and time-sensitive customer needs to ensure the highest quality and timely delivery of critical nuclear safety-related services and components.

<http://www.kinectrics.com/Solutions/Pages/Delivering-the-Nuclear-Promise.aspx>

COG'S SUPPLIER PARTICIPANT PROGRAM

Lakeside Controls

Lakeside is an employee-owned Canadian company with more than 70 years as a process automation industry leader. It provides innovative solutions, local accessibility and consistent engineering practices and support customers' process automation challenges. Recognized as a market leader, it provides complete automation solutions to a wide range of industries, optimizing process efficiency, ensuring reliability and up-time, while maintaining and prioritizing a high standard of safety and customer satisfaction. Its capabilities in process management, industrial automation, utilities expertise and digital transformation enable it to solve customers' challenges, keep their operations running safely and deliver improved and measurable business results. Lakeside is a member of the Emerson Impact Partner Network with integrated solutions, technology and expertise in Ontario (excluding the Ottawa Valley), Manitoba, and the Kivalliq region of Nunavut.

https://www.lakesidecontrols.ca/downloads/documents/Lakeside_Line_Card.pdf

MDA Systems

MDA System's automation and system engineering solutions for the nuclear power industry serve a diverse range of mission-critical inspection, maintenance, and remediation requirements within high-radiation environments common to nuclear power plants. Its nuclear capabilities include complete system design, development, and deployment of automated inspection and maintenance equipment, sensor development and integration, control system upgrades, and system operations support. The company offers nuclear power utility operators a supplementary range of specialized engineering support and consultancy services for system engineering, operations planning, safety, reliability, design methodology, and failure assessment. Relying on proven methodologies, it reduces the risk of project overruns and delays.

<https://mdacorporation.com/isg/robotics-automation/commercial-systems/nuclear>

Nuvia Canada

Nuvia Canada is part of the international Nuvia Group, specializing in nuclear products and services in support of Canada's most complex civil nuclear projects. Nuvia Canada Inc. is a specialist nuclear services organization working across the complete nuclear facility lifecycle. It assists Canadian customers to safely, economically, and successfully plan and undertake nuclear material handling, waste management, facility decommissioning and site remediation projects. Its services include strategic and technical consultancy, operational health physics, and management of field operations. Nuvia Group is a worldwide nuclear specialist company with more than 2,700 staff and is an independent supplier of advice, engineering resource and specialist products. These products and services have been provided to many of the world's nuclear power plants and their associated infrastructures, giving Nuvia a global perspective. Nuvia, via its immediate parent Soletanche Freyssinet, is the nuclear entity of the VINCI Group, the world's largest integrated concessions and construction group.

<http://www.nuvia-canada.com/>

PCL Construction

The PCL family of construction companies is a group of independent construction companies that carry out diverse operations in the civil infrastructure, heavy industrial, and buildings markets. Within these markets, PCL has a wide range of construction expertise. PCL offers substantial construction knowledge, competitive pricing, financial strength, integrity, and a commitment to projects that is supported by a foundation of quality and workplace safety. It has a consistent track record of coming through for first-time and repeat clients, no matter the project size or complexity. PCL's industrial construction companies respond to the unique needs of clients in the petrochemical, oil and gas, pulp and paper, mining, and power and cogeneration industries. In addition to offering construction management services, PCL offers a full range of general contracting services, specializing in mechanical, civil, and electrical construction, as well as piping and plant shutdowns/turnarounds.

<https://www.pcl.com/Services-that-Deliver/Market-Expertise/Pages/default.aspx>

COG'S SUPPLIER PARTICIPANT PROGRAM

Promation

Promation Nuclear delivers engineered turnkey tooling solutions to support nuclear utilities for both plant operations and refurbishment projects. It provides the full scope of services necessary to research, develop, engineer, test and build custom solutions. Promation Nuclear's engineering, consulting services and advanced technologies are designed to support and improve station operation. Using innovation and advanced manufacturing technologies, it provides cost-effective virtual insight into tool operability prior to investment in physical hardware. Promation Nuclear's continuous development of leading-edge technologies is essential to its clients' optimum operation and support of the long-term success of the nuclear industry. Its scope of supply includes all prerequisite requirements to support the customer's engineering change processes and it extends its support to site commissioning and outage support. Founded in 1995, Promation is a privately owned Canadian Corporation and a leading automation manufacturer in Oakville.

<https://www.promation.com/nuclear/>

RCM Technologies

RCM Technologies Canada Corp. is a premier provider of business and technology solutions. For more than 30 years, industry leaders and technology companies have repeatedly relied on RCMTCC for engineering design, project management and technical support services. It is recognized for its accomplishments with large engineering-procurement-construction projects as well as smaller but equally detailed partial- to full-service projects.

It has experienced numerous waves of technological and business process advances. It has been successful in understanding the nuances of these advances and delivering value-added solutions based on what its clients' needs demand. RCMTCC provides a comprehensive range of engineering services available to the power generation sector, supplying solutions to both OEMs and operating stations.

<https://www.rcmt.ca/about-rcm-canada/>

Rolls Royce Civil Nuclear

Rolls Royce Civil Nuclear offers intelligent nuclear power. It combines cutting edge data analytics, engineering and support services to give its customers a new, intelligent competitive edge. Its expertise ranges from instrumentation and control systems to inspections, testing, and site services to plant automation and monitoring systems to digital services.

<https://www.rolls-royce.com/products-and-services/nuclear.aspx>

SNC-Lavalin

SNC-Lavalin offers end-to-end project solutions and support, from concept, design and technology development to new-build programs, and from asset management through to end of life and waste management options. It has the combined expertise of more than 3,000 highly skilled experts across its business. It integrates advanced digital technologies - including state-of-the-art computer-aided engineering (CAE) at the design and analysis stages - to enhance the safety and cost-effectiveness of its work. These cutting-edge tools also help clients manage day-to-day activities and operations after the build is complete. SNC-Lavalin has a range of services for decommissioning and remediation: from site management and management of spent nuclear fuel, to transportation of nuclear material and environmental clean-up of legacy sites. As the steward of CANDU technology, it has developed and licensed nuclear technology for more than 60 years.

<http://www.snclavalin.com/en/nuclear>

COG'S SUPPLIER PARTICIPANT PROGRAM

Stern Laboratories

Stern Laboratories Inc. is a Canadian-owned private corporation that conducts reliability and safety experiments for utilities, nuclear reactor and fuel vendors, government agencies and nuclear equipment suppliers. The laboratory has modern computer data acquisition systems, a 16MW DC power supply with 13 individually controlled zones, and is one of the highest power and most versatile heat transfer facilities in the world. It also manufactures specialized equipment, such as electrically heated nuclear fuel simulators and devices for inspection and handling of spent nuclear fuel. It has a highly-skilled and experienced staff of professional engineers and engineering technologists and has served the nuclear industry in Canada and many other countries since 1962. Stern specializes in the design and construction of complex experimental facilities and devices to simulate CANDU, BWR and PWR heat transport systems, safety systems, reactor fuel and fuel channel components. Specialized computing hardware and software are available.

<http://sternlab.com/>

Tyne Engineering

Tyne Engineering has more than 25 years' experience in the design and manufacture of complex engineering systems in the fields of process engineering, mechanical engineering, and instrumentation and controls for nuclear and tritium-handling industries. Its techniques employed in commercial grade dedication and reverse engineering include all manner of design, drafting, and documentation, including those applicable to the nuclear industry. It has a complete series of documents prepared in-house. It has undertaken design work that includes conceptual and developmental designs as well as detailed implementation of known process designs and mechanical equipment designs. It has developed its own QA procedures and manuals, certified to ISO 9001:2000, which meet the needs of an extensive work scope of design through manufacturing and operation. It has been successfully audited by COG (through CANPAC) to CSA Z299.2, and by AECL to the same level.

<http://www.tyne-engineering.com/#Nuclear+Project+Experience>

Westinghouse

Westinghouse provides utility customers around the world with reliable, dependable nuclear power plants, nuclear fuel, plant automation and operating plant products and services. It is driven by its powerful history and experience, ground-breaking ideas, focus on safety and sustainability, and its strong team of 10,000 employees around the world. Westinghouse Nuclear's goal is to provide solutions that keep their customers' plants safe, reliable and efficient. It is committed to quality, safety, and innovation at every turn: advanced nuclear plant designs, nuclear fuel, service and maintenance, and instrumentation and control systems. It is focused on helping utilities around the world improve their plant technology, reduce outage times, reduce maintenance costs, and have access to the highest quality nuclear fuel.

<http://www.westinghousenuclear.com/>

Worley

Worley is a trusted provider of professional consulting, technical, construction, engineering, and project management services to the nuclear industry worldwide. Its global teams of experts are supported from nuclear hubs in the USA (Reading), Canada (Toronto), and Europe/FSU (Sofia and Moscow). Its customized services cover all phases of the nuclear power programs' development and execution. It guides and supports customers through all phases of a nuclear plant lifecycle. Technology and vendor neutral, with extensive expertise in all commercial nuclear technologies currently in operation, under construction or in development, it provides unbiased and fully informed assistance to its customers. It is currently engaged in the implementation of Generation III/III+ nuclear new-build projects in different political, cultural, and regulatory environments across Europe, Middle East and Africa, and provides support and upgrade/uprates services to operating units in US, Canada, and Europe.

<https://www.worleyparsons.com/markets/power/nuclear>

COG TEAMS

COG's team approach

Throughout its history, the heart of the COG program has been the collaborative sharing of ideas, experience and aspirations for new approaches and borrowed ones already working well, to strengthen CANDU performance at every member plant, worldwide.

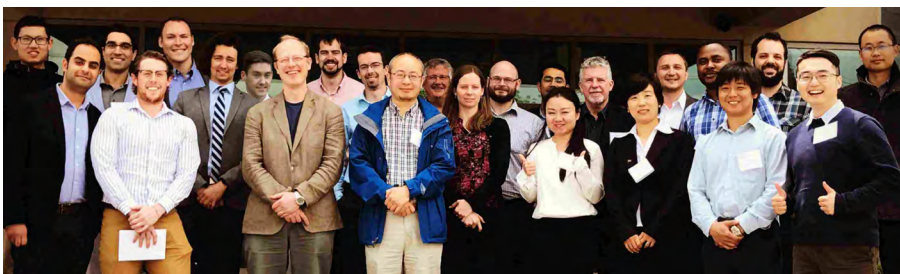
Through the creation of new technologies and processes in R&D and joint projects; the retention of experience through databases and textbooks; and the transfer of knowledge to other stations and new generations, COG and its members have significantly contributed to safer, cleaner, more reliable and cost effective, carbon-free electricity.

In doing so, COG members, suppliers and industry partners have given the world a powerful tool in the fight against climate change and an abundant supply of electricity to address a continually-increasing global demand.

The pages to follow provide a list of the forums, peer teams and working groups that contribute to the success we collectively share under the COG banner. Below, a small collection of photos from some of the thousands of teams who have worked together over the past 35 years.



From CANPAC (top) to C6 Fleet (second and third row, left side), a fuel channel seminar (bottom, left), maintenance managers (bottom right), equipment reliability (second row, right) and at COG Collaboration Week (second row, centre) plus hundreds of other events each year, COG members gather for forums, peer group, working group and task team meetings to achieve excellence through collaboration.



COG TEAMS

Forums	Peer Groups & Technical Committees	Working Groups & Task Teams
<p>C6 Fleet Forum</p> <p>Chief Nuclear Officers Forum</p>	<p>Fuel Handling PG, Radiation Protection PG, Maintenance Managers PG, Training PG, Cyber Security PG, Human Performance PG, Decommissioning and Waste PG, Safety Culture & Human and Organizational Factors PG</p>	<p>Supplier Participant WG, Operations Manager WG, Outage Managers WG, Work Management WG</p> <p>Maintenance Managers: Fix-It-Now TT</p> <p>Safety Culture & Human and Organizational Factors: Management System TT</p>
<p>Chief Nuclear Engineers Forum</p>	<p>Engineering PG, Asset Management PG, Non Destructive Examination PG, Chemistry Managers PG, Equipment Reliability PG, Nuclear Safety PG</p>	<p>Pressure Boundary WG</p> <p>Equipment Reliability: Single Point of Vulnerability TT, Value Based Maintenance TT, Equipment Reliability TT</p> <p>Nuclear Safety: Safe Operating Envelope TT, Risk and Reliability TT, Beyond Design Basis Accident Management TT, CANDU Safety Issues TT, Fuel Integrity TT, Safety Analysis Improvement TT</p>
<p>R&D Technology Forum</p>	<p>Chemistry, Materials & Components TC, Fuel Channels TC, Health, Safety & Environment TC, Industry Standard Toolset TC, Safety & Licensing TC, Strategic R&D TC</p>	<p>CM&C: SG Non-Destructive Examination WG; SG Material Integrity WG; Concrete WG; Steels WG; Chemistry WG; Valve WG</p> <p>FC: PT Crack Initiation WG, Deformation WG, Corrosion & Deuterium Ingress WG</p> <p>IST: Physics Codes WG, Containment and Severe Accident Codes WG, Thermalhydraulics Codes WG, Fuel and Fuel Channels WG</p> <p>S&L: Physics WG, Containment and Severe Accident WG, Thermalhydraulics WG, Fuel Normal Operating Conditions WG, Fuel and Fuel Channels WG, Probabilistic Risk Assessment WG</p> <p>Strategic R&D: Reduced Outages WG, Materials Properties WG, Low Dose Impact WG, Climate Change WG, Environmental Monitoring WG, Decommissioning & LT Waste Management WG</p>
<p>Radioactive Waste Leadership Forum</p>		
<p>Refurbishment Forum</p>		
<p>Regulatory Affairs VPs Forum</p>	<p>Regulatory Affairs PG, Emergency Preparedness & Response PG, Nuclear Environmental Affairs PG</p>	<p>Regulatory Affairs: CILLP</p> <p>Nuclear Environmental Affairs: Environmental Management Systems TT, Environmental Impacts TT</p>
<p>Small Modular Reactor Technology Forum</p>	<p>SMR Vendor Participant Program</p>	
<p>Supply Chain, Obsolescence & Procurement Forum</p>	<p>Supply Chain, Obsolescence and Procurement PG</p>	

Chief Nuclear Officers Forum

Chief Nuclear Officers Forum

Identifies strategic challenges and opportunities that may influence the nuclear power industry and the regulatory bodies. Enables the industry to develop and share consistent industry licensing positions and pool resources for resolution of issues that are of high strategic or operational impact to the utilities.

Fuel Handling PG

Identifies and solves generic issues, develops common improvement strategies, and promotes awareness of regulatory issues. Aims to identify areas where common process may be optimized, establish industry sub-committees to address and prioritize generic issues, initiate joint projects for the common benefit of the participants, and work collaboratively to improve safety, efficiency and overall performance.

Radiation Protection PG

Identifies and addresses generic issues related to radiation protection within CANDU nuclear power plants and related facilities.

Maintenance Managers PG

Evaluates maintenance- and production-related issues affecting member plants. Enhances the sharing of knowledge, experience and lessons learned among member plants. Raises awareness and develops unified positions and guidance related to maintenance issues. Exchanges information on effective maintenance-related processes that will help improve safety, efficiency and reduce cost.

Training PG

Evaluates training-related issues affecting member utilities for training authorized nuclear operators and shift managers, and non-authorization training for the major work groups of operators, maintenance and engineering. Promotes awareness of regulatory issues affecting training programs and to develops joint response strategies; helps improve the quality and cost of utility training.

Cyber Security PG

Ensures consistent implementation of the N290.7 CSA Standard Cyber Security for Nuclear Power Plants and Small Reactor Facilities, across the Canadian utilities.

Human Performance PG

Identifies and addresses generic issues related to human performance at power plants. Promotes awareness of regulatory issues and develops common response strategies. Ensures valuable experience and lessons learned in the human performance areas are shared.

Decommissioning and Waste Management PG

Ensures a consistent approach to decommissioning and waste management and to the exchange of technical information. Provides overall guidance on how to achieve success in decommissioning and resolve waste management issues.

Safety Culture and Human & Organizational Factors PG

Collaborates on industry HOF initiatives and educates members about HOF considerations. Shares best practices, and monitoring and assessment practices. Coordinates mutual assistance between member companies and develops common approaches, methodologies, training, etc. for culture assessments. Collaborates on common approaches, methodologies, and training for management system implementation.

Working Groups and Task Teams

Supplier Participant WG, Operations Manager WG, Outage Managers WG, Work Management WG , Fix-It-Now TT, Management System TT

Chief Nuclear Engineers Forum

Chief Nuclear Engineers Forum

Provides a forum for senior management to identify and oversee resolution of issues of high safety and economic importance to the Canadian nuclear industry, in order to align direction, determine common solutions, consolidate positions and pool resources.

Engineering PG

Provides industry senior management with a forum to identify and address generic issues related to engineering activities at CANDU nuclear power plants. Provides an environment for promoting awareness of regulatory issues and for developing common response strategies.

Asset Management PG

Provides a forum for development of a common CANDU industry approach to addressing asset management issues. Enables the sharing of OPEX, methodologies and consistent approaches to asset management issues.

Nondestructive Examination PG

Provides a forum to share experiences, identify improvement initiatives and learn from the best practices of others with respect to NDE training, capability development, and qualification. Manages NDE activities for the purpose of producing effective common procedures and training preparation for qualification.

Chemistry Managers PG

Provides a forum to improve communication and share OPEX and best practices for chemistry control. Also provides a forum to share new developments and technologies to improve chemistry performance and highlight key results from the COG R&D program. Identifies key issues and takeaways for the CANDU chemistry community and identifies areas for further action.

Equipment Reliability PG

Provides CANDU station owners with a forum to identify and address generic issues related to plant equipment reliability process implementation. Promotes the exchange of information and development of common strategies to deal with plant equipment reliability issues.

Nuclear Safety PG

Allows Canadian members to share information on regulatory interactions, strategies and approaches to resolve common issues, and identify safety and licensing issues for industry collaboration. Authorizes industry task teams to establish common approaches, undertake assessments, monitor progress on issue resolution and address barriers, and co-ordinate interaction between the industry and the CNSC.

Working Groups and Task Teams

Pressure Boundary WG

Equipment Reliability: Single Point of Vulnerability TT, Value Based Maintenance TT, Equipment Reliability TT

Nuclear Safety: Safe Operating Envelope TT, Risk and Reliability TT, Beyond Design Basis Accident Management TT, CANDU Safety Issues TT, Fuel Integrity TT, Safety Analysis Improvement TT

R&D Technology Forum

R&D Technology Forum

Acts as the voting members' primary point of contact for all R&D activities. Ensures the members' R&D issues and needs are addressed. Maintains member organizations' contacts for operations and maintenance, safety and licensing, engineering, and supply chain.

Chemistry, Materials & Components TC

Oversees the CM&C program, which addresses a diverse range of CANDU reactor operating and maintenance issues, with its main focus on the major CANDU systems and their auxiliaries, such as the primary heat transport system, steam generators, emergency core cooling and containment.

Fuel Channels TC

Oversees the FC program, which addresses the current operation need to improve confidence in the fitness-for-service of CANDU pressure tubes and develop industry standards for pressure tube integrity. The program also focuses on susceptibility of pressure tubes to delayed hydride crack initiation at flaws and improved understanding of deuterium ingress, pressure tube deformation and mitigation of hydride blister formation.

Health, Safety & Environment TC

Oversees the HS&E program, which addresses issues related to radiation monitoring and dosimetry, including the establishment of the risks of radiation exposure. Ensures compliance with the dosimetry requirements defined in CNSC Consultative Document C-115. Addresses regulatory aspects of ecological impact, emission reduction and techniques for monitoring emissions and the environment.

Industry Standard Toolset TC

Oversees the IST program, which validates, develops and maintains different computer codes used for design, safety analysis and operational support of CANDU reactors, as well as providing baseline support of IST codes.

Safety & Licensing TC

Oversees the S&L program, which addresses issues relating to the safety design basis and safe operating envelope of CANDU power reactors, with focus on supporting the resolution of outstanding CNSC Generic Action Items, safety assessments of new plant designs, assistance in the maintenance of core capabilities, scientific expertise, and R&D infrastructure to support long-term safe operation of CANDU power reactors.

Strategic R&D TC

Oversees the SRD program, which aligns with and supports federal initiatives, and invokes collaboration between industry, government and academia. The program also develops the technologies and other solutions needed for the current and refurbished fleet of CANDU reactors to keep units operating safely, reliably and competitively for an extended plant life.

Working Groups and Task Teams

CM&C: SG Non-Destructive Examination WG; SG Material Integrity WG; Concrete WG; Steels WG; Chemistry WG; Valve WG

FC: PT Crack Initiation WG, Deformation WG, Corrosion & Deuterium Ingress WG

IST: Physics Codes WG, Containment and Severe Accident Codes WG, Thermalhydraulics Codes WG, Fuel and Fuel Channels WG

S&L: Physics WG, Containment and Severe Accident WG, Thermalhydraulics WG, Fuel Normal Operating Conditions WG, Fuel and Fuel Channels WG, Probabilistic Risk Assessment WG

Strategic R&D: Reduced Outages WG, Materials Properties WG, Low Dose Impact WG, Climate Change WG, Environmental Monitoring WG, Decommissioning & LT Waste Management WG

Regulatory Affairs VPs Forum

Regulatory Affairs VPs Forum

Discusses regulatory issues and provides strategic direction to the regulatory affairs, emergency preparedness and response and nuclear environmental affairs peer groups.

Regulatory Affairs PG

Provides a forum to share regulatory affairs issues, create working groups to resolve license issues, and co-ordinate regulatory assessments. Co-ordinates work between the industry and regulator to discuss, resolve and develop criteria for regulatory issues. Provides training workshops.

Emergency Preparedness and Response PG

Provides a forum to discuss common areas related to planning, exercises, alignment of regulatory responses, review of governance and processes.

Nuclear Environmental Affairs PG

Allows for the exchange of information about process issues and regulatory and government interactions and strategies. Authorizes task teams to address common issues and approves and monitors joint initiatives and issue resolution plans. Communications with NEAC sponsors, regulators and other industry organizations.

Working Groups and Task Teams

Regulatory Affairs: CILLP

Nuclear Environmental Affairs: Environmental Management Systems TT, Environmental Impacts TT

Supply Chain, Obsolescence & Procurement Forum

Supply Chain, Obsolescence & Procurement Forum

Provides oversight and control over ongoing work and develops a framework to facilitate better collaboration to mitigate and resolve common high-risk procurement and obsolescence issues. Supports members in moving towards more proactive and planned approaches in addressing identified procurement and obsolescence issues.

Supply Chain, Obsolescence & Procurement PG

Allows for the sharing of OPEX and issues in the area of obsolescence and supply chain. Reduces risks associated with obtaining parts that can impact station safety and lowers supply chain costs through collaboration and shared resources.

Other COG Leadership Forums

C6 Fleet Forum	Facilitates and supports relationships of the C6 fleet and allows for the exchange of information between fleet members. Allows fleet members to work together to anticipate and resolve common problems to yield significant commercial benefits, cost savings, improved reliability and synergy.
Radioactive Waste Leadership Forum	Identifies strategies and solutions for management of the waste streams from nuclear power generating stations as well as medical and laboratory facilities with due considerations for worker and public safety, protection of the environment and cost effectiveness.
Refurbishment Forum	Provides a forum for sharing knowledge, experience, procedures and lessons learned to improve the effectiveness and efficiency of all refurbishment activities. Identifies and prioritizes refurbishment issues, best practices, areas of strength for review and analysis. Works with the utilities and the industry to develop innovative solutions leading to schedule, dose and cost savings.
Small Modular Reactor Technology Forum	Identifies key issues and establishes technical positions and requirements supporting the development of harmonized policies, including technical positions concerning the regulatory framework, fuel cycle, siting and supply chain of SMRs, for both on-grid and off-grid applications.
<i>SMR Vendor Participant Program</i>	Addresses common challenges of SMR deployment and assists vendors to understand operator challenges in Canada and internationally. Ensures a strong network supporting future infrastructure needs for SMRs.

COG'S COLLABORATION MODEL

COG Partners

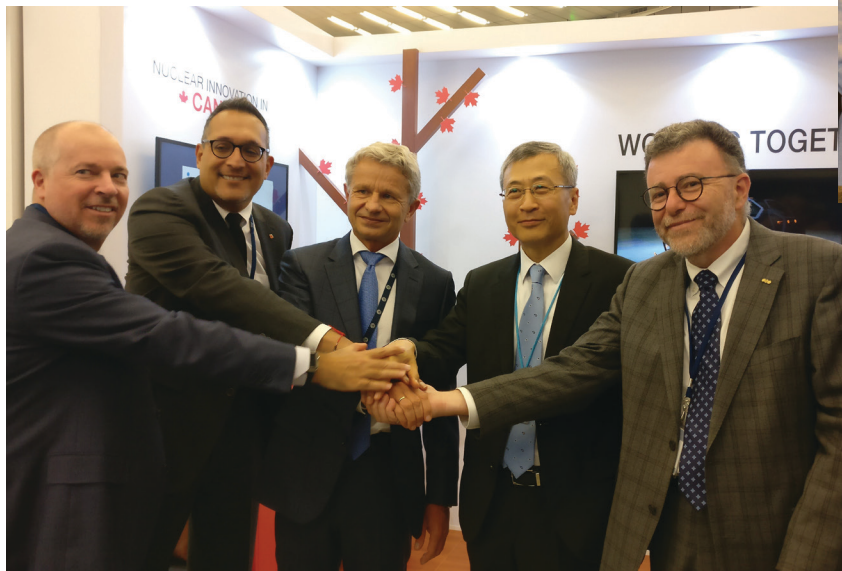
The COG collaboration model would not be complete without the thousands of people in organizations across Canada and worldwide in partner organizations who work jointly with COG members and our supplier and program participants.

Through these partnerships, we connect people and ideas to *create, retain* and *transfer* knowledge throughout the nuclear industry and across generations of nuclear workers. We build on each other's strengths and learn from each other's challenges and successes. COG has partnership agreements and strong working relationships with several organizations, worldwide.

Together, we strive for excellence in CANDU operations and projects and look beyond to development of new technologies and waste management solutions. Hand-in-hand, we are moving the industry forward for excellence today and for tomorrow.

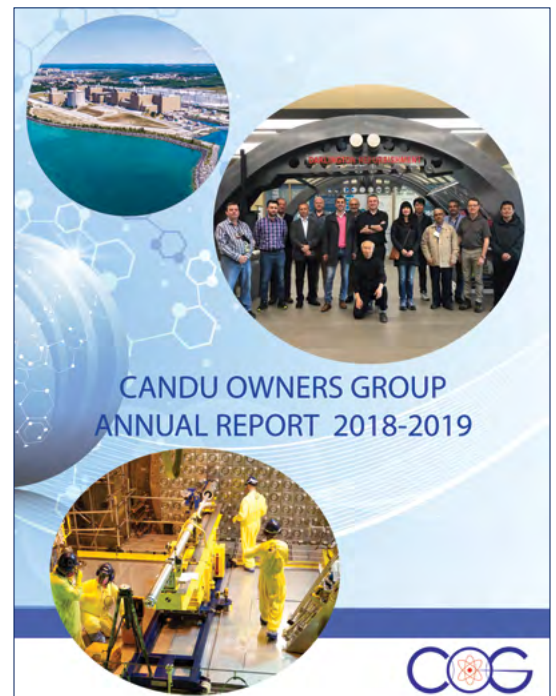
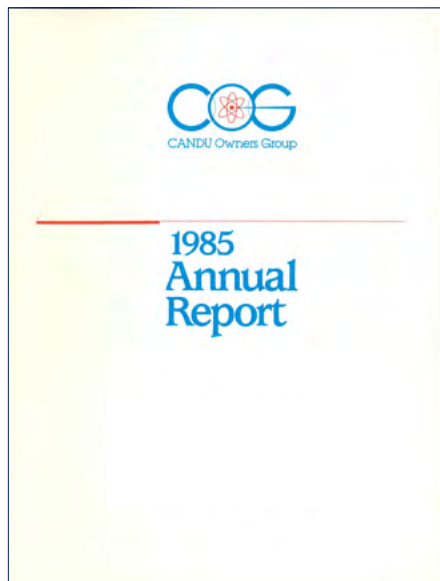
Partners:

- 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)



Above: The University Network of Excellence in Nuclear Engineering partnered with COG on a printed and digital textbook *The Essential CANDU* to ensure historic knowledge on dozens of facets of nuclear expertise were retained and transferred to the next generation.

At left: COG and the International Atomic Energy Agency (IAEA) signed a practical arrangement, furthering an existing working relationship, in September 2019 at the IAEA's General Conference in Vienna at the Canada booth, hosted by the Canadian Nuclear Association.





For more information, visit us at
www.CANDU.org

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