AN INDEPENDENT SUPPLEMENT FROM MEDIAPLANET TO THE NATIONAL POST

Decommissioning
Safely removing waste and dismantling

Producing isotopes
Supplying global isotope demand

MEDIA PLANET

May 2013

THE NUCLEAR RENAISSANCE

3 THINGS YOU SHOULD KNOW ABOUT THE NUCLEAR INDUSTRY

CHALLENGES

NUCLEAR GENERATES 12.96% OF GLOBAL ELECTRICITY

EAST COAST NUCLEAR
Commissioned in 1983, the Point Lepreau Generating Station was the first CANDU-6 to begin commercial operation. PHOTO: NB POWER

The nuclear industry plays a **critical role in Canada** — it powers roughly **17 percent** of our country, and provides **$5 billion in economic activity.**

Nuclear in Canada: why we need it

Nuclear technology is an essential part of your daily life, even though you may not realize that it's working for you. Look closely. You'll see nuclear technology making a big difference in safe, reliable energy production, medicine and manufacturing, and even in food safety.

Continuous, clean generation

Nuclear energy has powered the Canadian electrical supply since 1962. Today it provides nearly 17 percent of Canada's daily needs — and 56 percent of the electricity used in Ontario. It's the generator that runs continuously, unlike solar that shuts down at night or wind that sometimes doesn't blow. On a hot summer night when the air doesn't move, nuclear energy will keep your air conditioning humming. Coal and gas plants can also run continuously, but they continuously produce far more greenhouse gases than nuclear energy.

Running your air conditioner on gas-produced electricity means 30 times more carbon dioxide emissions than nuclear electricity. Running it on coal-powered electricity produces 62 times the emissions. You'll breathe better with nuclear power! It's a simple but important fact: by displacing fossil power, nuclear energy has prevented nearly 90 million tonnes of carbon dioxide from entering our environment. That's like getting 80 percent of cars off Canadian roads.

Supplying the world with the high isotope demand

The nuclear technology that delivers these benefits is also helping to improve Canadian health care.

Cancer diagnosis and treatment depend on isotopes — chemical elements produced by nuclear reactors. Canada leads the world by supplying 20 percent to 30 percent of global isotope demand. In fact, we've helped save millions of lives since we invented the cobalt-60 radiation treatment machine in 1951.

There are lots of other areas where you wouldn't expect to find nuclear technology at work, but it's there. It sterilizes food and medical supplies, and detects the tiniest of faults in precision-manufactured parts. Airplanes, cars, pipelines and ships all run better. And we're steadily finding new uses for nuclear technology through seven research reactors in Ontario, Quebec, Saskatchewan and Alberta.

A major part of the economy

Nuclear technology helps to power the Canadian economy, too. Our industry employs 30,000 Canadians directly, and supports a further 30,000 jobs indirectly. It adds up to $5 billion of economic activity.

Heather Kleb
President and CEO,
Canadian Nuclear Association

Those numbers will only rise with new investments in the nuclear industry, such as:

- Growth in northern Saskatchewan's uranium mining capacity.
- Mid-life refurbishment of ten more CANDU nuclear reactors at nuclear power plants over the coming eleven years
- Proceeding with construction of two new CANDU reactors.

These investments are already written into Ontario's Long-Term Energy Plan and elsewhere. They will deliver long-term, affordable, clean-air power — and about 24,000 jobs over five years.

How safe is it?

What about safety? Our nuclear energy facilities have proven that they're exceptionally safe. They use natural-grade uranium rather than enriched uranium, and are cooled with heavy water. Each safety system has three backups, and can be tested while the reactor runs under full power.

The people who operate our facilities are carefully selected, highly trained and qualified, and licenced by an independent federal regulator. Training takes about eight years.

This makes Canadian nuclear energy facilities among the safest in the world. In fact, they're built to withstand the conditions that triggered the failures at Fukushima, Japan.

After the Japanese accident, the Canadian Nuclear Safety Commission inspected all Canadian nuclear energy facilities. It concluded that our reactors operate with adequate emergency preparedness and are safe, just as they have been for over 40 years.

Safe, reliable power with solid economic benefits and leading-edge contributions to Canadian healthcare — these are all reasons why nuclear technology is an indispensable part of Canadian life.

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MEDIA PLANET

THE NUCLEAR RENAISSANCE
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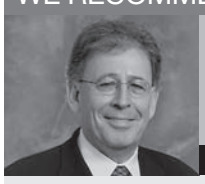

Nuclear waste
Learn about how Canada keeps the public safe from radioactive waste.
PAGE 7

"CNSC regulates the safe storage and monitoring of radioactive waste until it poses no threat."

Panel of experts p. 4
See what the experts have to say about nucler power.

Reactor types p. 5
Discover how multiple types of reactors differ.

Canada's nuclear leadership

From a holistic viewpoint, Canada is one of the world's leading nuclear power countries. Which other countries can boast, today, that they are nearly entirely self-sufficient across the fuel cycle? With its unique heritage Canada is well-placed to take advantage of the many opportunities that exist within the global nuclear market.

Self-sufficiency

High-tech mining operations feed substantial uranium exports, and distinguish Canada as one of the world's largest uranium suppliers. These mines, which include the highest uranium ore-grade deposits in the world, also provide the source material for domestically-based conversion and fuel fabrication facilities which in turn produce fuel bundles for Canada's distinctive, indigenously-developed CANDU Pressurised Heavy Water Reactor (PHWR) technology.

All of the country's 19 operating nuclear power reactors are CANDUs and the technology has also been successfully exported to six countries. Even in an international reactor market dominated by light water reactors, CANDUs remain a competitive option. They offer some unique fuel cycle benefits which countries such as the UK are now actively considering as part of a flexible fuel/waste approach.

Agneta Rising
Director General,
World Nuclear Association

Although no new reactors have been constructed in Canada for a while, nuclear engineering prowess has been maintained through the major refurbishment projects carried out at Bruce, Pickering and Point Lepreau. When the time comes to build new units at home the skills base and the supply chain shall not be found lacking. Skilled workers as well as quality components are of course in demand for overseas projects. All told, the nuclear and uranium industries provide stable well-paid employment to some 71,000 Canadians.

Staying away from pollution

In many ways Canada stands out as a champion of nuclear technology. With new reactor designs under development and supported by the excellent research carried out at the Chalk River Laboratories, you remain true to the spirit of the early nuclear pioneers.

Perhaps even more importantly, Canada also serves as a model to the world on how to successfully transition away from a polluting, coal-based electricity supply. Although much attention is focussed on Germany with its immense program of renewable build, the net result has been only a modest reduction in carbon emissions with coal still the source of some 45 percent of electricity production. However in the province of Ontario, home to some 40 percent of Canadians and where the majority of reactors are located, nuclear power forms the cornerstone of clean electricity generation.

Looking to Canada for answers

With the addition of recently refurbished reactors nuclear now provides over 50 percent of Ontario's electricity. Supported by natural gas and renewables, it has allowed the province to make a near complete transition away from reliance on coal.

The world will look to Canadian nuclear expertise as prospects for new-build continue to recover after the accident at Fukushima Daiichi. The world should look to Ontario and note what an electricity supply is capable of when it includes nuclear as part of a balanced mix.

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NEWS

NUCLEAR REFURBISHING: MAXIMIZING PLANT LIFESPAN

DARLINGTON NUCLEAR GENERATING FACILITY **Darlington, one of the top performing CANDU reactors is up for refurbishment outages in 2016.** PHOTO: ONTARIO POWER GENERATION

Nuclear refurbishment is a **complicated and highly technical undertaking** that requires years of meticulous planning and high-level training delivered to a **workforce of the highest calibre.**

REFURBISHING

Ontario Power Generation's (OPG) nuclear plants use the highly successful CANDU nuclear systems, which, to operate to their fullest potential, and maximize their potential lifespan, require mid-life refurbishment of their most important components after being in operation for between 25 and 30 years.

"The point at which replacement of components needs to happen is impacted by a number of things: the number of hours of operation, the size of the reactor, the number of heat up and cool down cycles," explained Dietmar Reiner, Senior VP of Nuclear Refurbishment at OPG. "During our normal routine inspection programs, we assess the condition of all the major components."

Necessary steps to safely refurbish components

The first step of refurbishment is to power down the reactor and ensure that it's not producing electricity. The next process is to remove and store the reactor's fuel bundles and then transfer its heavy water to a purpose built storage unit. Following that, the reactor's components: the calandria tubes, pressure tubes, end fittings and feeder pipes are removed using specialized robotic tools stationed on platforms at the reactor's face. These components are then safely stored in secure and monitored waste storage containers.

"When that's complete, the new tubes and pipes are inserted. That's less of a robotic process because you're dealing with new components and the radiological hazard at this point is not as significant," said Reiner. "But there's still a significant amount of specialized tooling used to put those components into the reactor. This is the critical part of the job."

Upcoming Darlington refurbishment

Expected to begin its refurbishment outages in 2016, Darlington is one of the top performing CANDU reactors. In 2011, all four of its units achieved a Forced Loss Rate of less than 1 per cent, and its safety record, 12.7 million hours worked with no time lost due to injury, is a first in the nuclear industry.

ESSENTIAL ENERGY

"Nuclear power is a critical part of the Ontario energy mix."

Dietmar Reiner
Senior VP, Nuclear Refurbishment, Ontario Power Generation

"Darlington is the latest generation of CANDU plant, it has systems and design features that other older stations don't have that allow it to operate very reliably," said Reiner. "It is a well-maintained plant and the condition of systems is very good. Also, Darlington was recently recognized by the nuclear industry as a top performing plant in the world. For all of those reasons, it's a very good candidate for refurbishment."

Rehearsing skills on full scale mock-up

As part of the planning for the Darlington refurbishment project, a full-scale mock-up of the Darlington reactor will be built, allowing the workforce to rehearse their tasks in a controlled, realistic environment, before moving onto the reactors in the station. "The full-scale mock up is something that is worth its weight in gold," said Reiner. "It's an important element for tooling because it gives us the opportunity to ensure that the tools perform exactly as designed. All sequences of work on the reactor will be tested on the mock-up."

The mock-up will also allow OPG to create a detailed and accurate schedule of how long it will take to execute the Darlington refurbishment, which will, in turn, allow for more accurate forecasting of budget and costs. "Our plan currently calls for four 36-month outages, and if you were to compare that to prior refurbishments, it's a significant improvement," said Reiner.

Refurbishing to provide energy to Ontario for years to come

Reiner is confident that the Darlington refurbishment will play a significant role in providing Ontario with affordable energy for a further 25 to 30 years once the process is complete. "Nuclear power is a critical part of the Ontario energy mix," he said. "We can produce large volumes of power at low cost at Darlington.

Our goal is to deliver a successfully refurbished Darlington station: safely, to the quality that is required in a nuclear environment, on time, and on a fact-based budget."

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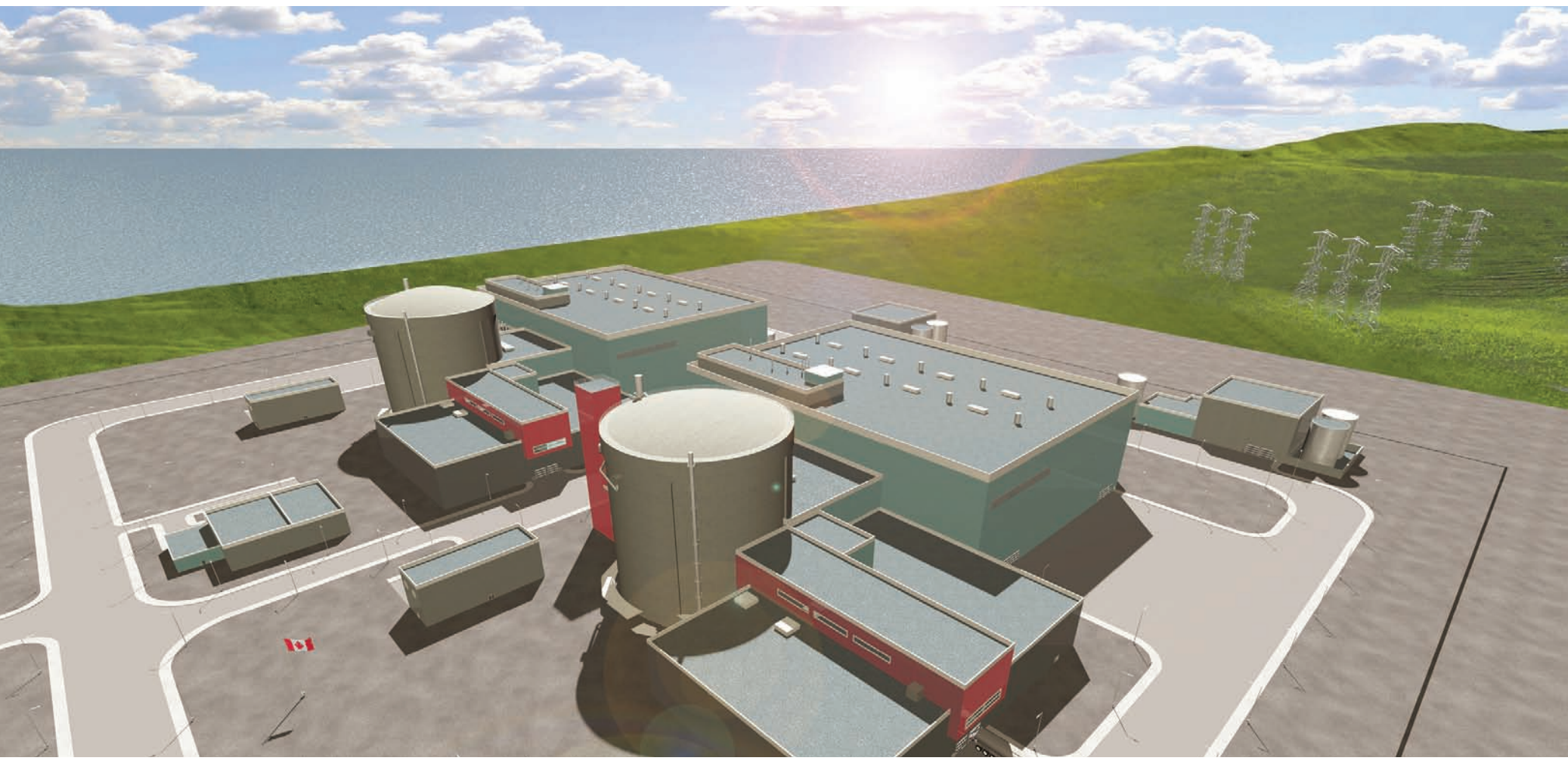
INSIGHT



Decommissioning in Canada's near future

DECOMMISSIONING

The lifespan of a nuclear power plant is usually dictated by one of two factors: its ability to operate safely and in line with current health regulations, or, more commonly, its ability to function with economic feasibility.

Although, a nuclear power plant cannot simply be modified to function for another business purpose, like some industrial buildings. It needs to go through a rigorous process whereby any radioactive material is removed and the plant is dismantled; a process called decommissioning.

Decommissioning in view for the near future

Decommissioning is on the horizon for a selection of Canada's nuclear power plants, which are due to be shutdown in the near future. Although the decision of when to stop operating a plant is taken solely by the plant's licensee, the Canadian Nuclear Safety Commission (CNSC) regulates the decommissioning process.

The CNSC's role is to implement the rules that will safeguard the health of workers, the public, and the environment over the course of a decommissioning project.

Decommissioning strategies

There are three main strategies for decommissioning, and a licensee's choice of strategy is dictated by technical, legal, radiological, political, and economic considerations.

- **Immediate Dismantling**, also known as Early Site Release, is a method in which the dismantling and decontamination of the plant begins in the immediate months, or years, after its shutdown. This option allows the plant to be free from regulatory control relatively soon after shutdown, leaving the site available for regeneration and reuse.
- **The Safe Enclosure strategy** postpones the removal of regulation and controls on the plant for a longer period of time, usually for around 50 years. The nuclear plant is placed into a 'safe storage configuration' until authorities deem it safe to be dismantled and decontaminated. This method ensures that the radioactivity level is reduced by the time decommissioning starts, allowing for a greater amount of materials to be reused.
- **Entombment** is only used under exceptional circumstances, usually when there has been a severe accident. It involves building a concrete structure to encase the plant, preventing the possibility of any radioactive leaks. The Entombment strategy removes the need of ever having to transport the radioactive materials away from the plant, but the site can never be regenerated.

Massive impact on Canada's future needs

The cost of decommissioning is the sole responsibility of the nuclear plant's operator. The CNSC has the power to request financial guarantees, ensuring that the decommissioning funds are in place, so that future generations are not left with the cost of cleaning up defunct nuclear power plants.

As well as ensuring the health and safety of Canadians through the responsible removal of radioactive materials, decommissioning also benefits the national labour force. The dismantling of plants and the regeneration of land will, over the coming decades, create thousands of jobs, injecting billions of dollars into Canada's economy.

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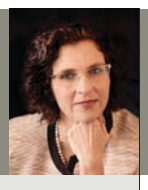

Ala Alizadeh
Senior Vice President,
Marketing and Business Development,
Candu Energy Inc.

1 Why is nuclear power generation an essential step in moving towards a world with more carbon-free electricity?

Nuclear power can produce large volumes of clean electricity. Sources such as wind and solar are also low-carbon, but only produce power intermittently. In order to sustain a reliable electrical supply, we require access to sources with a consistent power output. Coal and natural gas can do so, but produce greenhouse gas emissions that contribute to climate change and smog. Next to hydro — for which further development options are very limited — no other source can produce as much clean, base load electricity as nuclear.

Baseload generation is the backbone of the electricity system that powers the modern Canadian economy. Gravity-safe, emissions-free technologies represented by the AP1000 and the Westinghouse SMR, provide long term levelized cost of baseload generation that utilities need to meet increasingly stringent air quality standards.

Nuclear energy is a key part of that energy mix; it provides safe and reliable electricity, with low carbon emissions and relatively small amounts of waste that can be safely stored and eventually disposed of. CANDU reactors can run for months without interruption, making them a reliable source of baseload power. The global CANDU 6 Fleet has a performance of over 88 percent lifetime; the units are consistently some of the best performing units in the world.

2 In terms of safety, how does nuclear energy compare to alternatives such as hydroelectric and coal?

Safety is our number one priority. Canada's nuclear power operations have a proven track record of being among the safest in the world. They are highly monitored, stringently regulated, and continuously improved through the daily efforts of qualified professionals who are committed to ensuring public and worker safety. Unlike hydro and coal, the nuclear industry has an additional, dedicated regulator — the Canadian Nuclear Safety Commission. The commission oversees the Canadian nuclear industry, protecting the health, safety and security of Canadians and the environment.

The nuclear industry is built on an unmatched safety culture with an outstanding record. Lessons learned in the aftermath of the tsunami in Japan have been incorporated into the design and operational standards for both the large and small modular reactors in the Westinghouse product line. When compared to hydro and coal generating facilities, emissions-free and water-efficient nuclear has a relatively gentle impact on the environment.

The nuclear energy industry is heavily regulated and is monitored by international agencies to ensure worker and public safety. Comprised of technical experts, organizations like the International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO) ensure that industry practices are aligned with their safety and governing principles. The Canadian Nuclear Safety Commission, Canada's nuclear regulator, is charged with regulating the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment.

3 What are the major changes you are expecting to see in Canada's nuclear industry over the next 10-30 years?

Within the decade, a number of our plants will reach a designed stage of their life that will require refurbishment that will allow them to operate for an additional 30 or more years. Additional units are planned to be removed from operation in 2020, which will require the construction of new, more advanced reactors. Additionally, our workforces are seeing the same life cycle. Many senior employees will soon be retiring in large numbers. This creates an enormous opportunity for highly-skilled young professionals to enter and advance in the industry.

Canada is an energy superpower with abundant natural resources including uranium, natural gas, oil and large-scale electricity production from both hydro and nuclear sources. We expect to see Canada adopt the more-dominant light water reactor (LWR) technology as part of its energy portfolio. These LWRs will complement the existing CANDU reactors to help Canada meet its aggressive environmental protection standards.

Nuclear energy will continue to be a key component of Canada's energy mix given its ability to deliver safe, reliable, affordable, and CO2-free energy. We expect to see the fuel-flexible CANDU reactor successfully exported to countries such as China and the UK to burn fuels other than natural uranium. Because of the inherent fuel flexibility in CANDU technology, the Generation III Enhanced CANDU reactor and the Advanced Fuel CANDU reactor are able to burn fuels as diverse as recycled uranium from other reactor technologies, mixed oxides and thorium.

4 What do you believe are the greatest misconceptions that face the Canadian public in terms of the entire nuclear industry?

Safety is a difficult concept to communicate effectively because of misinformed notions of nuclear danger from fictional sources such as The Simpsons. The truth is that radiation exposure is a normal part of life — most of it comes from natural sources such as food and the earth, and less than 0.1 percent of our annual exposure comes from nuclear power. It is a difficult science to communicate in a way that makes sense to the public, and powerful and sometimes inaccurate media messages can be challenging to overcome.

Nuclear power is safer than other forms of baseload generation because it is so tightly regulated. The same high standards for operations apply to the development and management of nuclear fuel. And the volume of fuel waste, when compared to the impacts of coal and gas, and the carbon emissions and waste they produce, is a relatively small footprint on the landscape.

One thing the public is generally unaware of is the fuel flexibility of the CANDU reactor. Along with natural uranium, CANDU reactors can be configured to use recycled fuel from other reactors, mixed oxide fuels and advanced fuels such as thorium. The industry is heavily regulated and monitored by international agencies to ensure worker and public safety. The many safety systems built into CANDU nuclear reactors — which produce all the nuclear energy in Canada — take into account human error, equipment failure, and external risks such as earthquakes.

INSIGHT

PRESSURIZED WATER REACTORS IN CHINA
1. This plant, located in Qinshan, China is the first nuclear power plant of the country to use Canada's CANDU reactors. PHOTO: CANDU ENERGY INC.
2. Westinghouse AP1000 ® Pressurized Water Reactor under construction in Haiyang, China.

NUCLEAR POWER PROVIDES ROUGHLY 17.08% OF CANADA'S ELECTRICITY AS OF FEBRUARY 2013

The many types of nuclear reactors

■ **Question:** What are some of the different types of nuclear technology used to generate electricity, and why might a nuclear developer or licensee opt for one of these?

■ **Answer:** There are many types of nuclear reactor technology, two of which are pressurized water reactors and boiling water reactors. Different types of nuclear technology suit different energy requirements.

Pressurized heavy water reactor

A pressurized heavy water nuclear reactor is so called because it uses heavy water (deuterium oxide) as its coolant and moderator. The heavy water contained in the reactor is continuously being pumped through the fuel channels, transporting the heat generated by the fission process to the boilers, where it then heats up ordinary water, which then creates steam. This steam is then piped to the turbines where it drives the generators that produce electricity.

One of the great advantages of a heavy water reactor is its low neutron absorption, which means that it can create chain reactions using naturally occurring, un-enriched uranium. This significantly reduces fuelling costs and takes away the need for a costly uranium enrichment facility. Also, in Canada, heavy water is produced in various locations and is, therefore, readily available. The projected lifespan in which heavy water can function effectively as a coolant or moderator is significantly longer than that of a nuclear reactor itself, making its reusability all the more practical.

Pressurized light water reactor

Another type of pressurized reactor is a light water reactor, which uses standard water as its neutron moderator and coolant. The light water reactor's design is used in the majority of civil nuclear reactors and naval ships, which are powered by propulsion reactors.

Light water reactors are a popular choice because of their safety appeal: using light water as a coolant and moderator means that if a catastrophic event occurs and the reactor is damaged, the release of the light water moderator will immediately stop the nuclear reaction and shut the reactor down, avoiding any harm to the public or local community. Another advantage of using light water reactors is the chemical make-up of their spent fuel, which does not have to go to waste: some recently designed reactors can function on the used uranium from light water reactors.

Boiling water reactor

A boiling water reactor, which uses de-mineralized water as its moderator and coolant, is another type of nuclear reactor technology. In the core of the boiling water reactor, heat produced by nuclear fission causes the cooling water to boil, not simply be heated as in a pressurized water reactor. Steam then drives the turbine that it's routed to, after which it's placed into a condenser and cooled. This water is then routed back to the reactor's core, completing the cycle.

The power vessel located in a boiling water reactor suffers a relatively low amount of irradiation, which allows it to function effectively for many years. Also, this type of generator can function at a low core power density level, using natural circulation, and not a forced flow.

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INSPIRATION

FAST FACTS

Canada leads the world by supplying **20-30%** of global medical *ISOTOPE DEMAND*

THE **CANADIAN** nuclear industry *—EMPLOYS—* **60,000** Canadians **DIRECTLY** *— and —* **indirectly**

NUCLEAR ·produces· **30 X** less CO_2 emissions than **NATURAL GAS** *and* **62 X** less THAN COAL

SOURCE: 2013 CANADIAN NUCLEAR FACTBOOK WWW.CNA.CA/FACTBOOK

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RADIOISOTOPES ARE PRODUCED IN NUCLEAR REACTORS, AS WELL AS BY OTHER DEVICES CALLED CYCLOTRONS

PET SCAN
This PET scanner is a modern form of medical imaging used for diagnosing cancer and neurological diseases.
PHOTO: TRIUMF

FROM MEDICINE TO SMOKE ALARMS

The industry's impact on our daily lives

Isotopes are varying forms of a single chemical element that have the same atomic number (amount of protons), but a different amount of neutrons. The isotopes of any given element do, generally, behave in a similar way, but isotopes that are lighter or heavier than the norm — dictated by the amount of neutrons — can have an unstable nucleus and, therefore, emit radiation during their decay to a stable form.

Supplying the global demand

These chemical elements, known as radioisotopes, are both naturally occurring and artificially produced. Canada is the world's biggest producer of radioisotopes, which have, overtime, been used to aid scientific and technological advances in industrial smoke alarms, oil drilling research, and, most importantly, medical diagnostics and imaging.

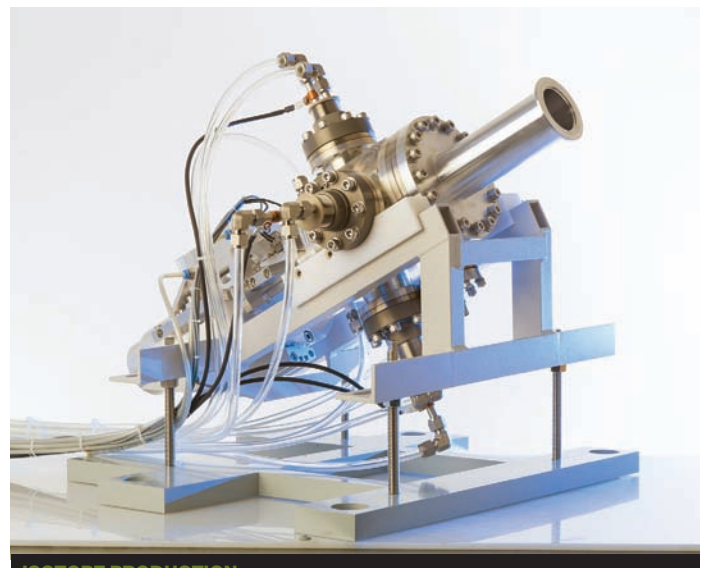
"Nuclear medicine uses cameras that detect gamma rays, which are emitted from isotopes injected into the body," explained Nigel Lockyer, Director of TRIUMF.

"It's been used for over 50 years to look at cancerous tumours, and in the last 20 years for looking at Parkinson's and other neurological diseases. If you have a heart attack, your doctor will inject you with a medical isotope that allows him or her to see the blood flow in the heart's muscle, and tell you where there is damage."

No more need for reactors

Recent breakthroughs have made it possible for scientists to produce the technetium-99m isotope, which is used in the majority of diagnostic procedures, without the need of a nuclear reactor.

"It can be produced using small machines called cyclotron accelerators," said Lockyer. "Historically, technetium-99m has been produced using highly-enriched, weapons-grade uranium, but the International Atomic Energy Agency (IAEA) is saying that we need to go away from uranium, and everyone is agreed. There are no safety concerns or proliferation issues with the cyclotron approach."



ISOTOPE PRODUCTION
New Technology such as this transfer system allows scientists to make new isotopes on a cyclotron. PHOTO: TRIUMF

Nigel Lockyer
Director, TRIUMF,
Professor of Physics
and Astronomy, UBC

"If you have a heart attack, your doctor will inject you with a medical isotope that allows him or her to see the blood flow in the heart's muscle, and tell you where there is damage."

Isotopes for therapeutic purposes

Typically, medical isotopes have been used for detection and diagnosis, but, as Lockyer explained, they are now being utilized to develop medical therapies that are considerably more sophisticated and effective than the ones currently used.

"There are designer molecules that can target specific areas of the body. Suppose you have a breast tumour that has an estrogen receptor, a chemist will design a molecule that attaches itself to that cell," said Lockyer. "Instead of putting an isotope on it that emits a gamma ray for imaging, you can put an isotope that emits an alpha particle - a highly damaging particle that will break both strands of the DNA. The cell can't repair itself and is destroyed."

For a cancer patient, this method of targeted treatment has significantly less damaging side effects than the commonly used radiotherapy. "It never attacks the healthy tissue, which is the issue with external radiation," said Lockyer. "The new method targets the cells in your body that are mutated and cancerous, so you can pick them off. The world is not quite there yet, but, as chemistry gets better, we're hoping to start medical trials."

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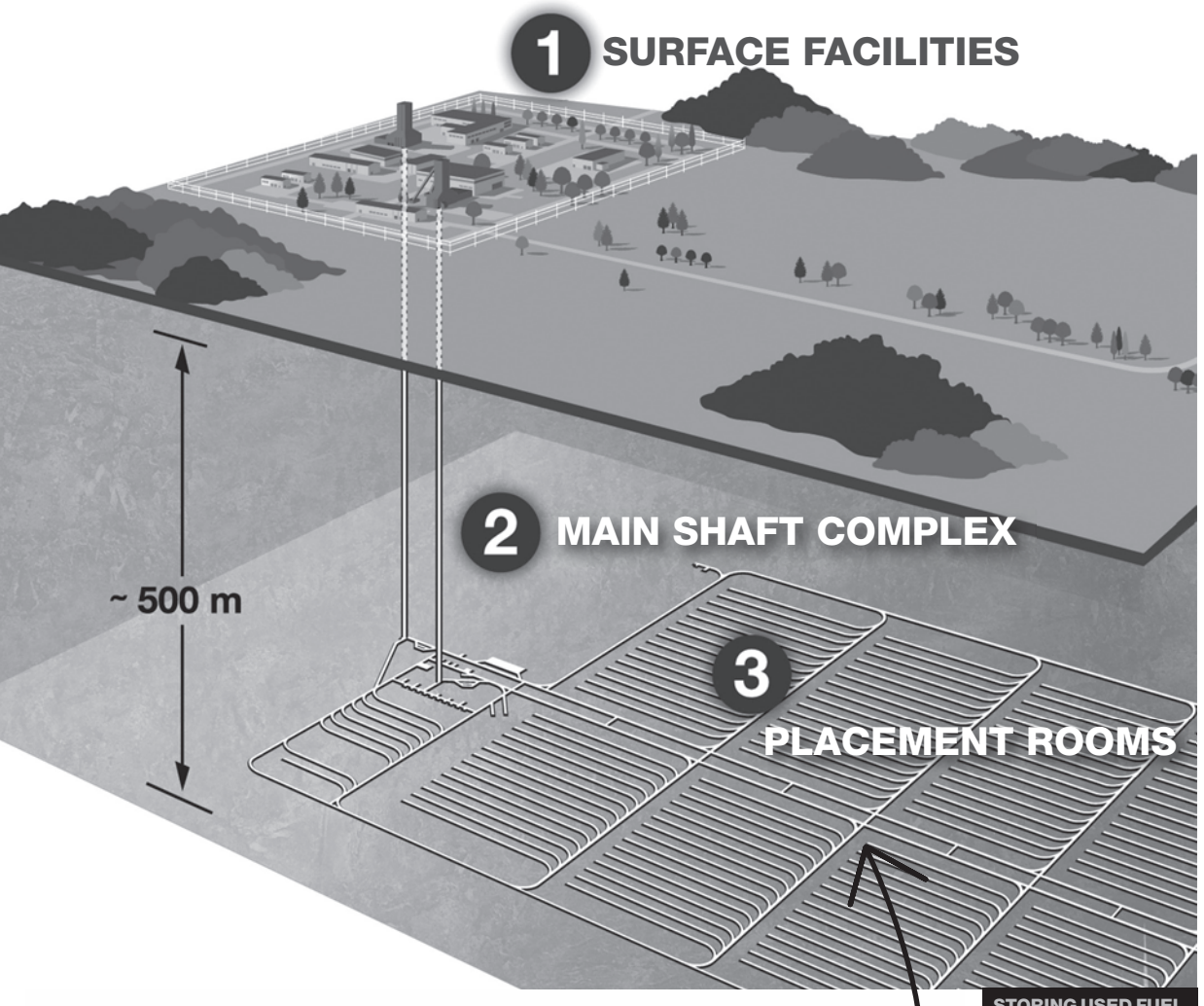
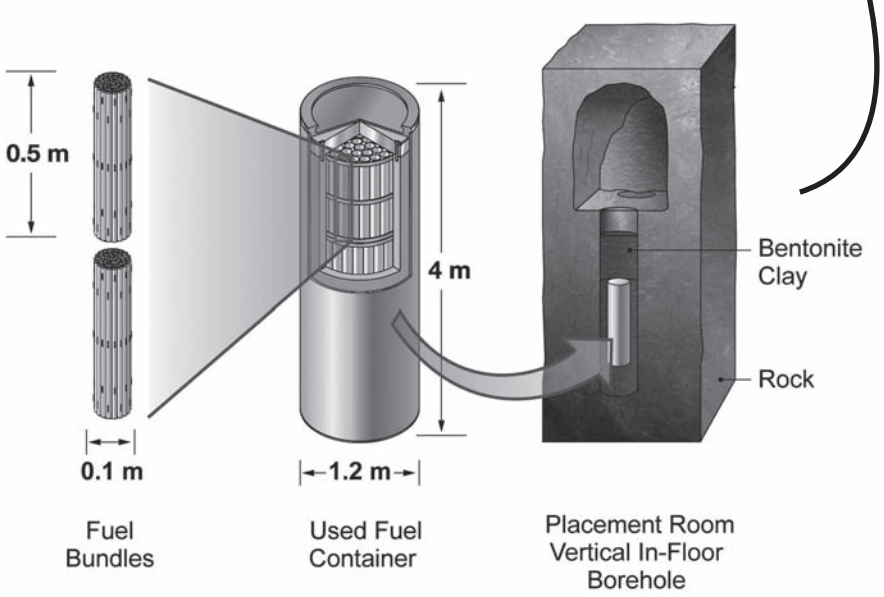
NEWS





STORING USED FUEL **Nuclear waste is produced throughout the entire nuclear fuel cycle. The CNSC regulates nuclear waste in Canada to ensure that it poses no threat to the public or the environment.** PHOTO: NUCLEAR WASTE MANAGEMENT ORGANIZATION

RADIOACTIVE WASTE: STRICTLY REGULATED BY THE CNSC

Radioactive waste in Canada is strictly regulated by the Canadian Nuclear Safety Commission (CNSC) to ensure it is safe and poses no undue risks to people or the environment.

Keeping Canadians safe from waste

Radioactive waste is produced at all stages of the nuclear fuel cycle, from uranium mining and nuclear power generation to nuclear medicine and other industrial uses.

Because of the wide variety of applications, the amounts, types and even physical forms of radioactive wastes vary considerably. Some wastes can remain radioactive for thousands of years, while others may require storage for only a short period before it is disposed of by conventional means. In all cases, the CNSC regulates the safe storage and monitoring of radioactive waste until it poses no threat.

FACTS

- **The three Rs** apply to the management of radioactive waste: reduce, reuse and recycle.
- **The Government of Canada and the nuclear industry** are developing solutions for long-term radioactive waste management that protects the health, safety and security of persons and the environment.
- **CNSC's policy** on managing radioactive waste requires waste owners to put in place design measures, operating procedures and decommissioning practices to minimize radioactive waste.
- **The CNSC** ensures that proper security measures are in place for nuclear facilities and that nuclear sector workers' health is protected.

"Currently, all radioactive waste from Canadian nuclear power plants is stored in safe, engineered facilities."

Michael Binder
President,
Canadian Nuclear Safety Commission

In Canada, waste producers and owners are responsible - also known as the "polluter pays principle" - for the funding, management and operation of waste management facilities. Like any other nuclear facility, the CNSC imposes rigorous reporting requirements on the operators of nuclear waste management facilities and monitors waste management facilities' overall compliance with safety requirements through facility inspections and audits.

Managing nuclear waste

One of projects currently underway is Ontario Power Generation's Deep Geologic Repository for the long-term management of low- and intermediate-level radioactive waste from the Bruce, Pickering and Darlington nuclear generating stations. In January 2012, a Joint Review Panel was appointed to conduct the environmental assessment and the first stage of licensing for the project. Public hearings for the project are to be held this fall in the Bruce area.

A different project, being led by the Nuclear Waste Management Organization (NWMO), is investigating approaches for managing Canada's used nuclear fuel, a by-product of the generation of electricity in a nuclear power plant. The NWMO, established by Ontario Power Generation Inc., Hydro-Québec and New Brunswick Power Corporation, assumes responsibility for the long-term management of Canada's used nuclear fuel and the necessary financing to pay for the long-term care of used nuclear fuel. Should the project move forward — it is still considered in its very early stages — the NWMO would need a licence from the CNSC to ensure the project meets all safety and regulatory requirements.

Protecting our health, safety and the environment

Currently, all radioactive waste from Canadian nuclear power plants is stored in safe, engineered facilities. Whether the CNSC is dealing with used nuclear fuel or low- and intermediate level radioactive waste, it monitors and inspects all radioactive waste management facilities on a regular basis to ensure compliance with nuclear safety regulations.

In a few words, the CNSC's mandate is very simple — to ensure that nuclear activities are carried out safely to protect the health, safety and security of Canadians and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy.

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QUESTIONNAIRE

Applications of Gamma rays in science and technology

Food safety
Irradiating food with gamma rays can eliminate dangerous pathogens, including bacteria, viruses, fungi, and insects. This helps reduce cases of food poisoning and reduce economic losses from spoilage.

Agriculture
Gamma rays used to induce genetic changes in crops enabled the "Green Revolution," the international effort that started in the 1940s to increase the yield and pest-resistance of staple foods, particularly in developing countries. This has saved hundreds of millions of lives throughout South America, Asia, and Africa.

Medical supplies
Gamma-ray irradiation is an important step in sterilizing surgical tools and single-use supplies such as syringes, gloves, and sutures. Cobalt-60 sterilizes about 40 percent of these products worldwide.

Cancer treatment
Since cancer cells are more sensitive to radiation than healthy cells, gamma rays from cobalt-60 are used to treat cancer. Cobalt-60 treatment units are among the most common technologies for external beam radiation therapy worldwide.

Health and beauty products
Gamma rays are routinely used to sterilize a range of cosmetics, as well as contact lenses and other personal supplies for the general population.

Uses of neutron scattering

Aeorospace
Neutron scattering is used to study the structural integrity of critical components in aircrafts, including rotors, wings, and landing gear, to reduce their chances of in-flight failure.

Automotive
Neutron scattering makes it possible to examinevthe molecular structure of entire engines. By detecting tiny flaws, the manufacturing process can be improved to reduce defects and improve engine reliability.

Natural resources
Neutron scattering improves the analysis of pipes and other components used in the oil and gas industry. This helps decrease defects and improves the industry's environmental and human health performance.

Medical implants
The surface of medical implants impacts their compatibility with the human body. Neutron scattering makes it possible to detect and improve the surface structure of these devices prior to implantation.

Advanced pharmaceuticals
Neutron scattering makes it possible to develop sophisticated delivery systems for pharmaceuticals that can reduce side effects and improve effectiveness.

SOURCE: 2013 CANADIAN NUCLEAR FACTBOOK, WWW.CNA.CA/FACTBOOK
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TIMELINE

The history of nuclear in Canada

1945 — **ZEEP (Zero Energy Experimental Pile)** at Chalk River makes Canada the second country to control nuclear fission in a reactor. The first controlled reaction took place in 1942 in the United States under the leadership of Enrico Fermi.

1962 — The Nuclear Power Demonstration (NPD) reactor — **Canada's first electricity-producing reactor,** and the prototype for the CANDU reactor design — comes online, at a capacity of 22 MWe.

1973 — All four units at Pickering A completed, for a total capacity of 2060 MWe, becoming **the largest nuclear power generating station in the world** at the time.

1983 — CANDU reactors are **7 of the top 10 best-performing reactors** worldwide.

1994 — Bertram N. Brockhouse was awarded **Nobel Prize in Physics** for his research on neutron scattering at Chalk River.

2002 — **Nuclear Fuel Waste Act** passed, mandating the creation of the Nuclear Waste Management Organization (NWMO). Later, in 2007, the federal government approved the NWMO's "Adaptive Phased Management" approach for the long- term storage of spent nuclear fuel.

2010 — Nuclear energy generates over **58 percent of Ontario's total electricity,** Ontario Power Generation (OPG) plans to proceed with the detailed planning for the mid-life refurbishment of Darlington NGS.

2012 — **The nuclear-powered Curiosity rover lands on Mars** carrying Canadian analytical equipment and sends photos back to Earth.

SOURCE: 2013 CANADIAN NUCLEAR FACTBOOK WWW.CNA.CA/FACTBOOK
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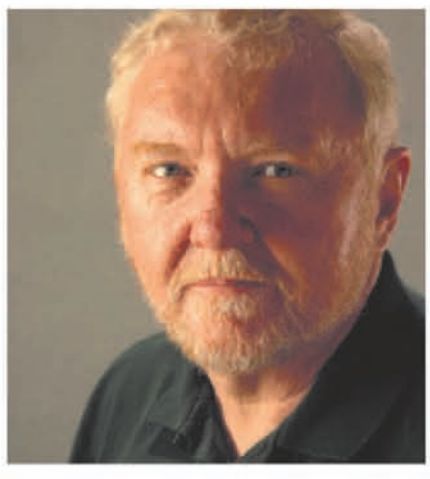
Enhanced CANDU 6 Reactors – Proven Technology for a Better Environment and Economic Prosperity



By Don MacKinnon
President
Power Workers' Union

Canadians expect our leadership to create economic growth while responding to a global recession and taking action on climate change. One of the cornerstones of our national economic policy, making Canada an energy superpower, is largely based on the rapid development of fossil fuel resources. While this creates jobs and economic growth it also makes better management of greenhouse gas (GHG) emissions imperative.

One proven Canadian energy advantage —Enhanced CANDU 6 (EC6) nuclear reactors—needs immediate attention. This technology can help achieve significant GHG emission reductions; generate abundant, reliable and affordable electricity; improve our energy security; support the transition to emission-free electric vehicles; and produce economic wealth.

Environment Canada data indicates that by 2020, GHG emissions from the oil sands will exceed those from all transportation and electricity generation in Canada and the total emissions of every province except Alberta and Ontario. Both oil sands extraction technologies, mining and "in situ" development will contribute; however, in situ production is more GHG intensive and will overtake mining by 2017.

This will continue to put pressure on Canada's global environmental brand. However, as noted in a September 2011 National Roundtable on the Environment and Economy (NRTEE) report there is also a substantial financial cost for all Canadians. Unless our GHG emissions are reduced, the economic impacts of climate change on Canada could be billions of dollars per year.

Globally, nuclear generation avoids about two to three billion tonnes of carbon dioxide emissions per year. In Canada CANDU reactors have avoided 2.4 billion tonnes of GHG emissions since 1972. On an annual basis Canada's CANDU fleet avoids about 90 million tonnes of GHG emissions, the equivalent of about 18 million cars, or about 12 percent of Canada's total emissions.

With continued investments in CANDU reactors, these GHG emission reductions can be sustained while generating significant economic wealth for Canada. This can be accomplished by continuing support for uranium mining operations and ongoing reactor refurbishments; constructing two new reactors at the Darlington Generating Station in Ontario; building new reactors in western Canada to help with in situ oil sands production; and revitalizing international reactor sales initiatives.

Canada's $6 billion plus a year nuclear industry supports 160 supply chain companies and 60,000 high value jobs. A 2012 Canadian Manufacturers and Exporters study indicates that new investments could drive an estimated 40 percent growth in Canada's nuclear industry employment over the next five years. Building a pair of Enhanced CANDU 6 EC6 reactors outside of Canada supports over 2,200 person-years of direct, high-wage work and over $2.5 billion in economic activity here in Canada.

CANDU reactors have safely provided affordable, low-carbon electricity for over fifty years to Canadian homes and businesses. CANDU reactors, 29 of which have been constructed in seven countries, are one of Canada's few high technology exports. This technology has also helped make Canada a leader in nuclear medicine as well as materials innovation and development while benefiting our universities and research agencies.

By continuing to support this unique reactor design with its inherent competitive advantages, our provincial and federal leadership can better position Canada in the estimated trillion dollar global nuclear market. It would offer additional promising economic and environmental opportunities here at home by powering tomorrow's zero-emission vehicles and backstopping climate-change-vulnerable hydroelectric generation. Realizing these opportunities requires leadership that takes decisive action.

Specifically, Ontario must select Enhanced CANDU 6 technology for its new reactors and the federal government must provide the support required to secure project financing. This collaborative support is essential to secure CANDU reactor sales in other provinces and countries.

There is too much at stake for all Canadians for our leadership to ignore the potential of our CANDU technology.