

# Canada's used nuclear fuel

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For decades, Canadians and Indigenous peoples have been using electricity generated by CANDU nuclear power reactors in Ontario, Quebec and New Brunswick. Used nuclear fuel is a byproduct of this process.

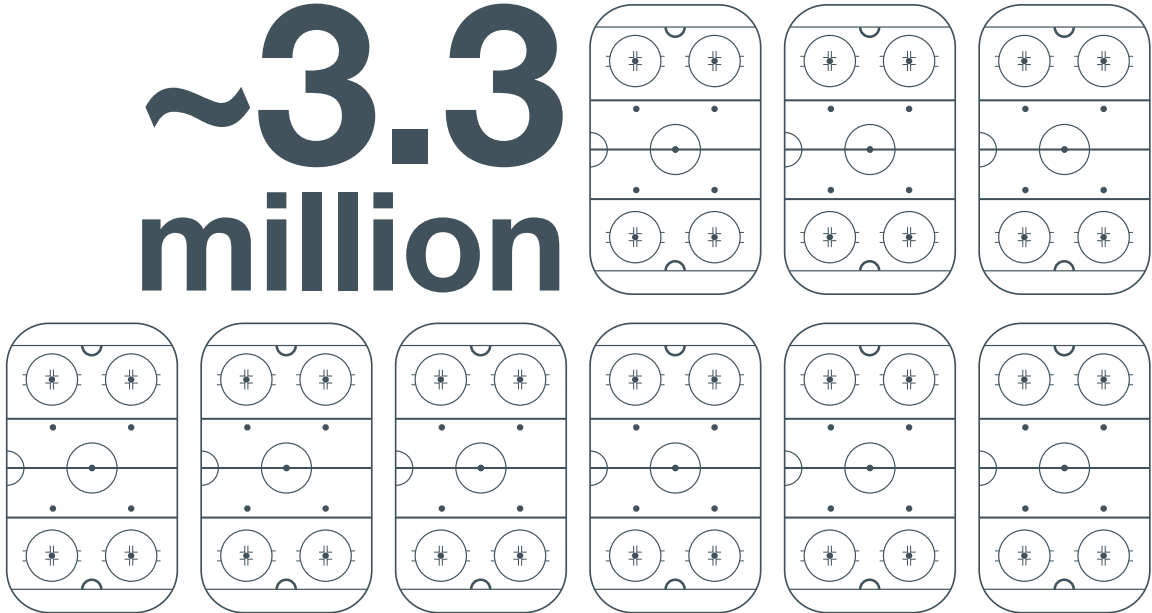
In Canada, the nuclear sector is also actively exploring new technologies such as small modular reactors (SMRs). New nuclear technologies may result in different types of used fuel.

Currently, used nuclear fuel is safely stored on an interim basis at existing reactor sites in Canada. The current storage method is safe, but temporary.



Through the *Nuclear Fuel Waste Act (NFWA)*, the Government of Canada assigned responsibility for the safe, long-term management of all Canada's used nuclear fuel to the Nuclear Waste Management Organization (NWMO). We led the development of a long-term plan, called Adaptive Phased Management (APM), that is based on the values and priorities of Canadians and Indigenous peoples and aligns with international best practices. In 2023, Canada's Minister of Energy and Natural Resources also tasked the NWMO with a new mandate to include planning for the safe, long-term management of intermediate-level and non-fuel high-level waste. We are now implementing both of these plans.

# ~3.3 million



If stacked like cordwood, Canada's existing inventory of about 3.3 million used nuclear fuel bundles could fit into about nine hockey rinks from the surface of the ice to the top of the boards.

Currently, Canadian reactors produce about 90,000 used CANDU fuel bundles per year. As of June 30, 2023, there are about 3.3 million used CANDU nuclear fuel bundles in Canada. If stacked like cordwood, all this used nuclear fuel could fit into about nine hockey rinks from the surface of the ice to the top of the boards. At the end of the planned operation of Canada's existing nuclear reactors, including planned refurbishments, the number of used CANDU nuclear fuel bundles could total up to about 5.6 million. Recent announcements around further refurbishments could see this projection increase from 5.6 million bundles depending on which projects go ahead. For example, the proposed refurbishment of the Pickering Nuclear Generating Station would take the total to about 6 million bundles.

As of the end of 2023, the NWMO is aware of three SMR projects in the licensing process. As potential SMR projects are still in the early stages of development and regulatory decision-making, it is too early to include their potential used nuclear fuel in our forecasting. As these projects advance to later stages of development, including construction and operations, this will be addressed in the NWMO's planning and projections.

No matter the source of the fuel, safety will always be our top priority.

## What is the long-term plan for used nuclear fuel?

Canada's plan, known as Adaptive Phased Management (APM), is both a technical method (what we plan to build) and a management approach (how we will work with people to get it done).

### Technical method

- Centralized containment and isolation of used nuclear fuel in a deep geological repository
- Continuous monitoring
- Potential for retrievability
- *Optional* step of temporary storage (not included in current implementation plan)<sup>1</sup>

<sup>1</sup> We do not expect to need the optional step of temporary storage as used fuel will remain at interim storage facilities until the repository is operational.

### Management approach

- Flexibility in pace and manner of implementation
- Phased and adaptive decision-making
- Responsive to advances in technology, research, Indigenous Knowledge and societal values
- Open, inclusive and fair siting process to seek informed and willing hosts
- Sustained engagement of people and communities throughout implementation

The end point of the technical method is the centralized containment and isolation of Canada's used nuclear fuel in a deep geological repository in an area with suitable geology and informed and willing hosts. APM also involves the development of a transportation system to move the used fuel from the facilities where it is currently stored to the new site.

The management approach involves realistic, manageable phases, each marked by explicit decision points. It allows for flexibility in the pace and manner of implementation, and fosters the sustained engagement of people and communities throughout its implementation.

Canada's plan emerged from dialogue with Canadians, Indigenous peoples and experts, and best meets the key priorities considered important by citizens. It was selected as Canada's plan by the federal government in June 2007.

APM is designed to meet rigorous safety standards throughout all aspects of its design and implementation. The plan is consistent with the long-term management approach adopted by other countries with nuclear power programs such as Finland, Sweden, Switzerland, the United Kingdom and France.

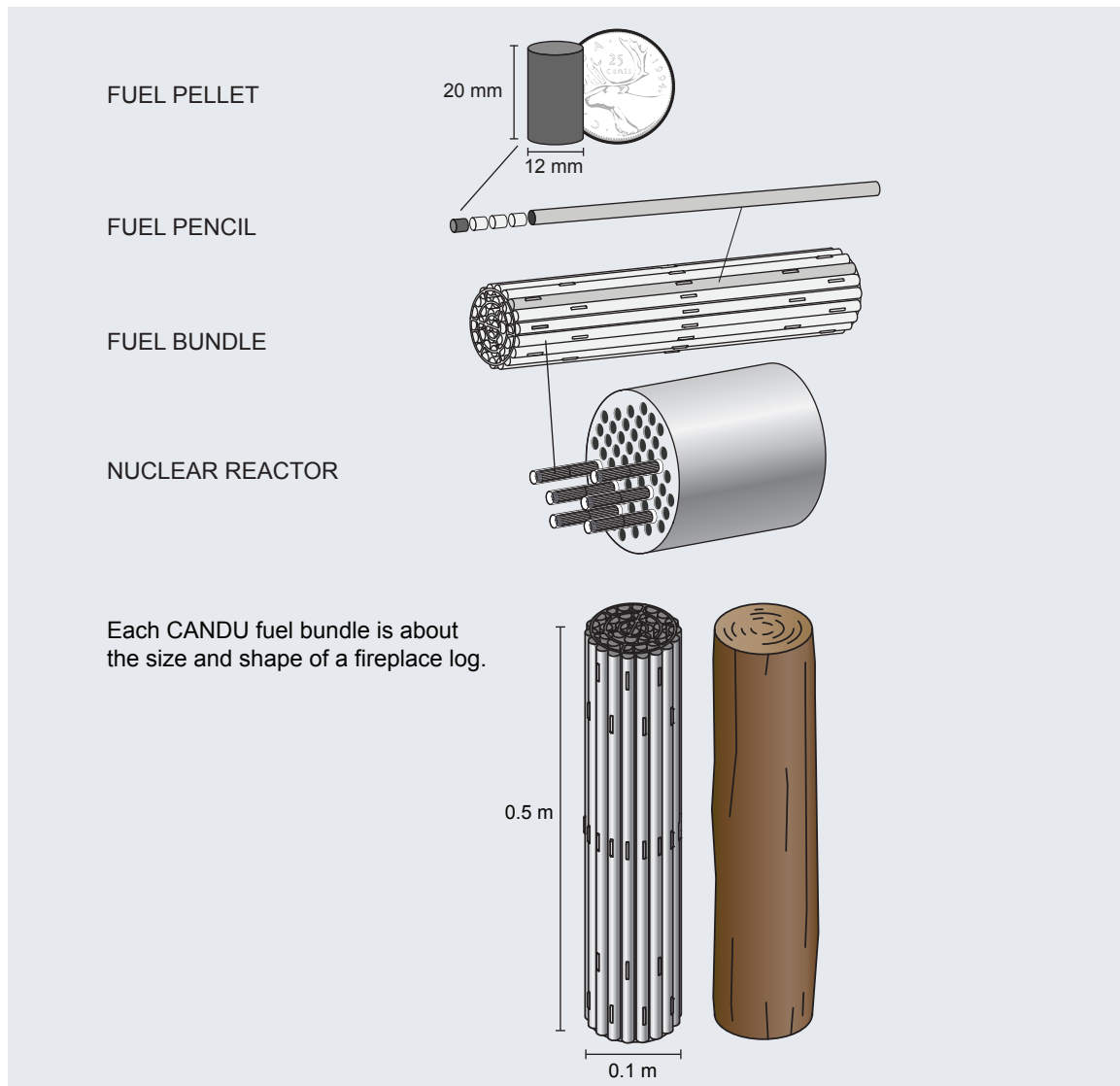
The deep geological repository will need to be large enough to contain and isolate the inventory of used fuel from nuclear plants in Canada.

Canada's plan was developed for managing Canada's used nuclear fuel. No foreign used fuel will be placed in the repository.

## CANDU nuclear fuel

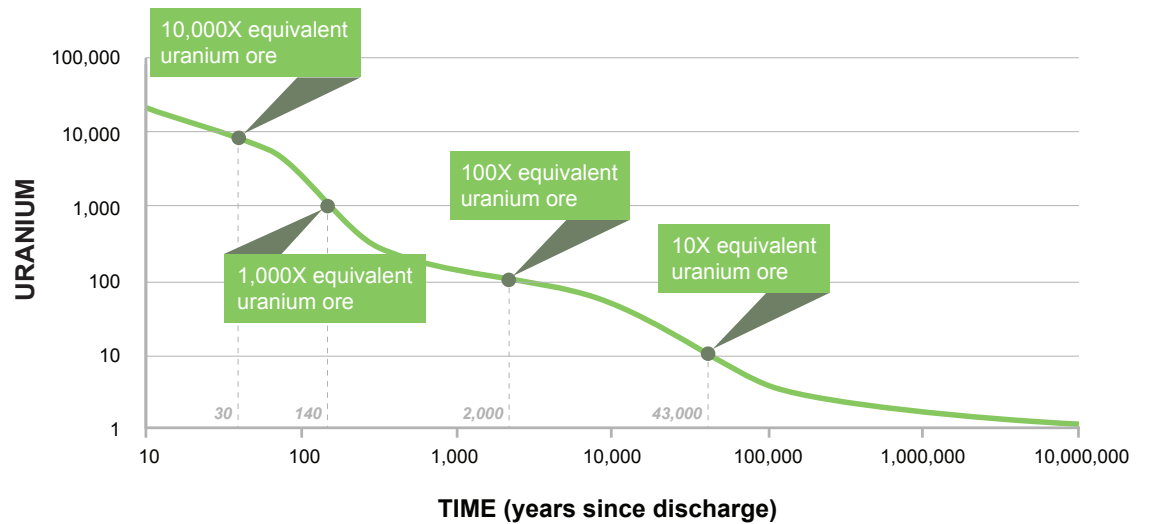
In Canada, most used nuclear fuel that exists today is CANDU fuel. This fuel is not a liquid or a gas — it is a stable solid. Under Canadian and international regulations, it is not classified as a flammable, explosive or fissile material.

CANDU nuclear fuel consists of uranium dioxide ( $\text{UO}_2$ ) made from natural uranium. During fabrication,  $\text{UO}_2$  powder is pressed into solid pellets and then baked into a ceramic form. The ceramic pellets are placed inside a tube made of a zirconium-tin alloy, with the completed assembly called a fuel element or fuel pencil. These fuel pencils are welded together into bundles the shape and size of a fireplace log. Each CANDU fuel bundle is about 0.5 metre long, has a diameter of about 0.1 metre, contains about 20 kilograms of uranium, and has a total mass of about 24 kilograms.



## Radioactive decay over time in used CANDU fuel

USED FUEL RADIOACTIVITY RELATIVE  
TO EQUIVALENT AMOUNT OF URANIUM



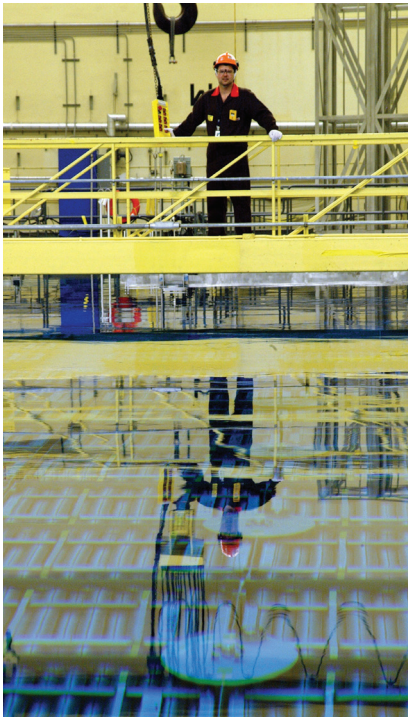
Although its radioactivity level decreases rapidly with time, residual radioactivity (together with some chemical toxicity) persists, and the used fuel remains a potential health risk for many hundreds of thousands of years.

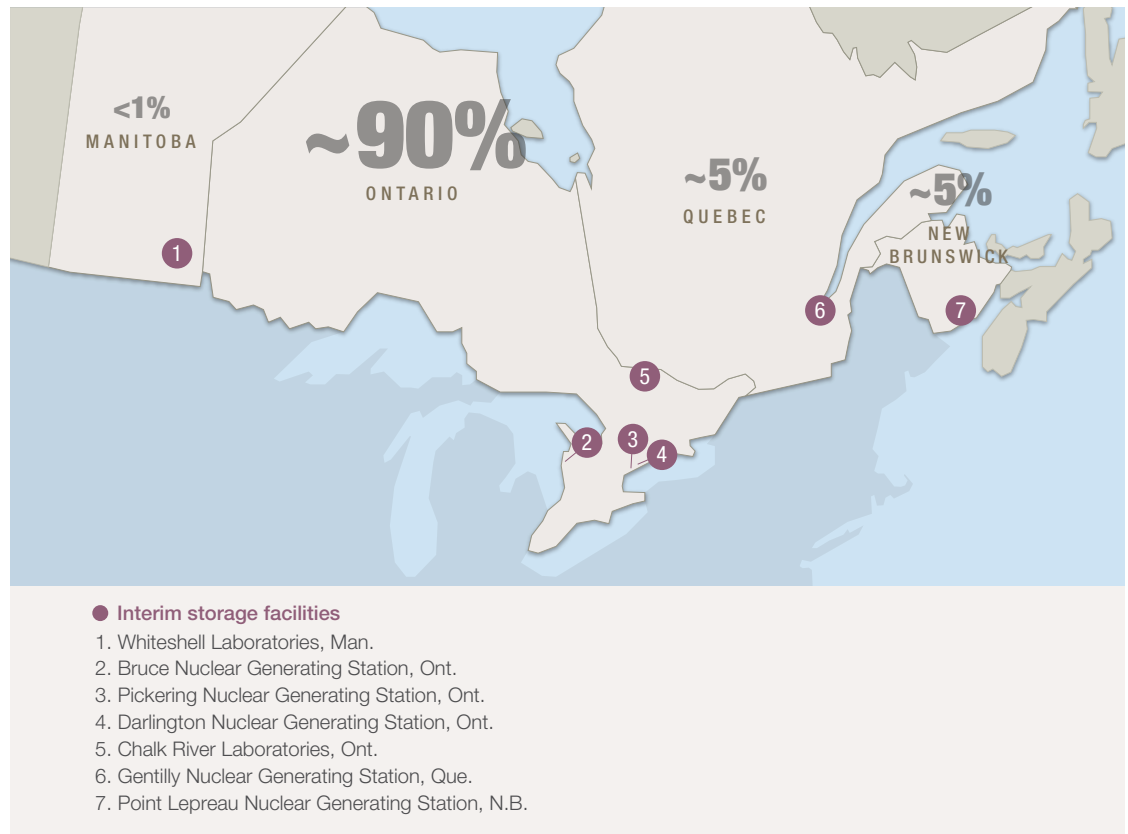
When CANDU fuel is removed from the reactor at the end of its useful life, it is considered a waste product. Used fuel is highly radioactive and requires careful management. Although its initial radioactivity level decreases rapidly with time, residual radioactivity (together with some chemical toxicity) persists, and the used fuel remains a potential health risk for a very long period of time.

It will take about one million years for the radioactivity level to reach about that of an equivalent amount of natural uranium.

## How used nuclear fuel is stored today

When used nuclear fuel bundles are removed from a reactor, they are placed in a water-filled pool to reduce their heat and radioactivity. After seven to 10 years, the bundles are placed in dry storage containers, silos or vaults. Dry storage is a proven technology that has been in use around the world since the 1980s.





Today, used nuclear fuel is safely stored near or at the sites where it is produced in facilities licensed by the national regulator — the Canadian Nuclear Safety Commission. There are also small quantities of used research and development fuels in licensed facilities at Atomic Energy of Canada Limited's Canadian Nuclear Laboratories.

Canada has a robust regulatory framework that governs the handling of used nuclear fuel. Used nuclear fuel is carefully managed and shielded at all times to ensure that no one is exposed to an unshielded bundle.

## Used fuel from small modular reactors

Canada's plan is designed to adapt to changes in technology, and we can build flexibility into repository designs so that we can be ready for future decisions. There is international consensus that deep geological repositories represent the best practice for the long-term management of used nuclear fuels resulting from SMRs, fuel reprocessing and other types of advanced reactors.

We are closely monitoring SMR projects in Canada, and are in dialogue with multiple SMR proponents, to help us prepare for decisions that could change the volume and type of used fuel we are responsible for managing. The NWMO is committed to working with these project proponents to ensure future fuel types and inventory can be safely accommodated.

As of the end of 2023, we are aware of three SMR projects in the licensing process. We continue to monitor for other potential projects, and as these projects advance to later stages of development, this will be addressed in the NWMO's planning and projections.

Host communities for the planned deep geological repository will be part of decision-making for any plans to manage SMR-related used nuclear fuel in the repository. For example, through discussions about partnership agreements, the NWMO will work with potential host communities to develop and agree on a process for managing future changes to the type or volume of waste to be managed in the repository.

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