Greenhouse gases

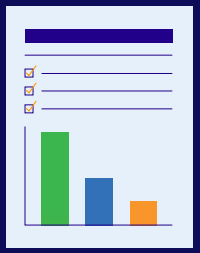
Calculating the carbon footprint of Québec hydropower using life cycle assessment (LCA)

Greenhouse gases (GHGs) have a significant impact on the climate. Several gases can contribute to global warming, including carbon dioxide (CO_2) and methane (CH_4). Although they are part of natural ecosystem dynamics, these gases are also produced by human activity, particularly because of the energy we generate and consume.

Québec hydropower is renewable and has a low carbon footprint. This is supported by rigorous field studies that measure the GHG emissions of our facilities, as well as by a comprehensive calculation method known as life cycle assessment (LCA). LCA is used to compare different types of energy based on the total carbon footprint of each kilowatthour generated, transmitted and distributed.

What is LCA?

LCA is a robust, globally recognized method governed by international standards. It assesses the environmental performance of a product or activity over its entire life cycle, from the extraction of raw materials to production, transport, distribution, use and end-of-life (CIRAIG, 2022).



In short

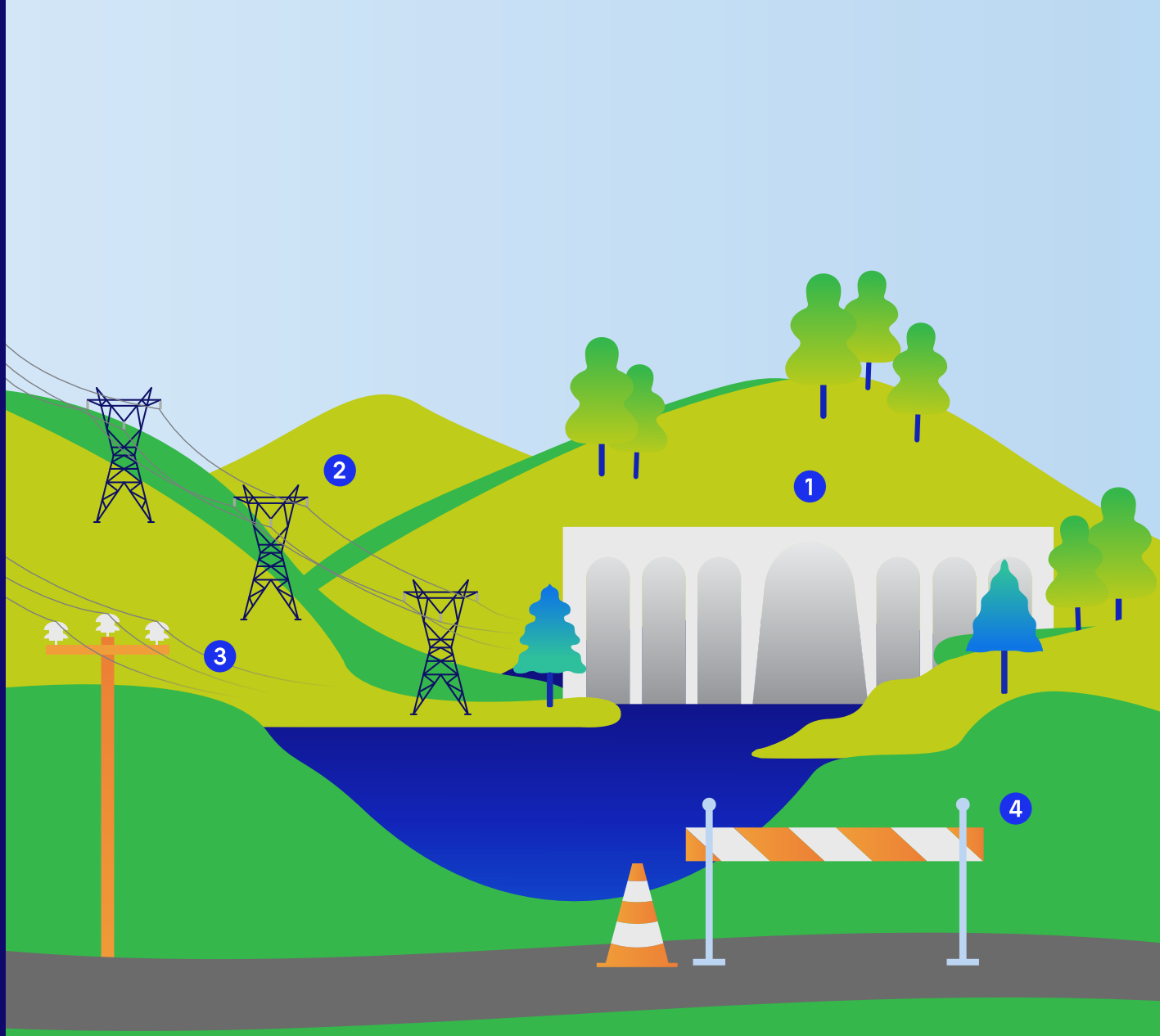
Conducting an LCA is like drawing up a balance sheet that quantifies all the materials and energy required to produce and use a product or carry out an activity, as well as the emissions and residual materials it generates.

The LCA of hydropower

At Hydro-Québec, conducting the LCA of each kilowatthour distributed through the grid involves taking several key elements into account.

1. Building the hydroelectric facility including the access roads and infrastructure
2. Building the transmission lines
3. Building the distribution lines
4. Maintaining and refurbishing the infrastructure

Dismantling of infrastructure of hydropower production is not considered in the LCA because it is assumed that the facilities undergo regular refurbishment.



The extraction of raw materials and manufacturing must be considered:

Fuel

Steel

Concrete

The emissions from the electricity distributed in Québec

Hydro-Québec's grid distributes electricity that is primarily generated from hydropower, which explains why most related emissions are linked to this source. However, some emissions originate from other energy sources and imports.

Emissions Profile

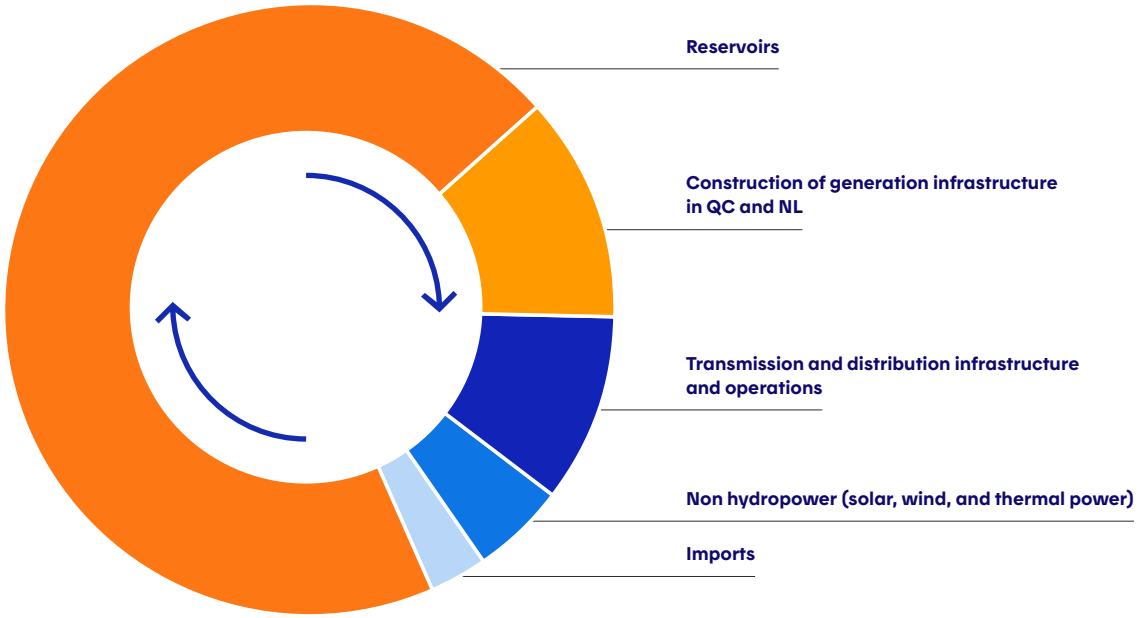
Most of the emissions from the electricity distributed in Québec originate from reservoirs, due to the decomposition of organic matter that occurs after impoundment. Hydro-Québec is a pioneer in measuring these emissions and ensures ongoing monitoring of the reservoirs, as well as of the aquatic and terrestrial environments they replace. This is how we can determine their net emissions (Teodoru et al., 2012; Demarty et al., 2025). Our studies show that emissions peak shortly after impoundment and then return to levels comparable to those of natural lakes after about 20 years (Tremblay et al., 2005).

The construction of generation, transmission and distribution infrastructure is the second-largest contributor to the carbon footprint.

Finally, a small share of emissions is attributable to the electricity generated from other sources, such as wind and solar power, and to the electricity we import from outside Québec, which is crucial during periods of high demand, like in winter.

These data provide a comprehensive picture that accurately reflects the reality of the electricity distributed in Québec.

Composition of the carbon footprint of electricity distributed in Québec



Comparing different energy sources

We use the data gathered through the LCA of our electricity to calculate the carbon footprint of a kilowatthour generated in Québec and compare it with energy produced from other sources.

The specific case of boreal reservoirs

Location

Vegetation is sparse in northern environments, and because the reservoirs are far from agricultural or urban areas, the run-off that reaches them contains very little organic matter and nutrients. As a result, the reservoir and lake ecosystems in northern Québec emit fewer greenhouse gases than those in other regions (Deemer et al., 2016).

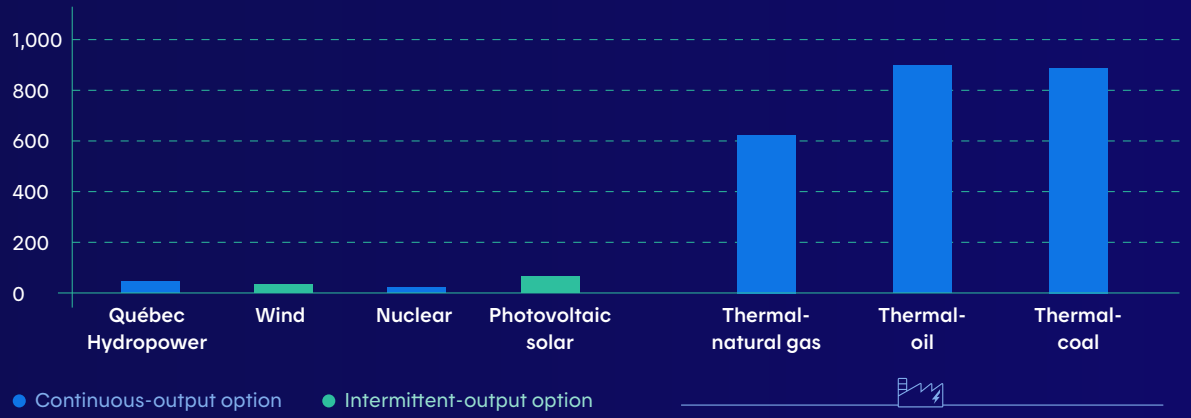
Low temperatures

The colder the water, the more dissolved oxygen it contains, which supports the production of CO_2 instead of CH_4 when organic matter decomposes. Since CO_2 has a much lower global warming potential than CH_4, this helps reduce the reservoir's overall carbon footprint (Forster et al., 2021).

Ice

An ice cover limits the diffusion of greenhouse gases and significantly reduces reservoir emissions in winter.

Power generation options based on life-cycle analysis (gCO_2eq/kWh)



Québec's hydropower emits far fewer GHGs than electricity generated from fossil fuel. Its carbon footprint is comparable to that of other renewables like wind and solar energy (CIRAIG, 2014; Levasseur et al., 2021).

LCA confirms that our renewable energy has a low carbon footprint, contributing to the decarbonization of Québec and its neighbouring provinces and states. It is a source of collective pride!





Photos

Cover: Aerial view of the Beauharnois generating station.

Page 2: Transmission line right-of-way in the Montmorency Forest.

Page 7, from left to right: Construction monitoring of the Appalaches–Maine transmission line; aerial view of the Daniel-Johnson dam; Baie-des-Sables wind farm; installation of solar panels on the rooftops of three buildings in downtown Lac-Mégantic; research work on the transmission line right-of-way in the Montmorency Forest.

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Legal deposit – 4th quarter 2025, Bibliothèque et Archives nationales du Québec
ISBN : 978-2-555-02551-6 (PDF v. fr.)
ISBN : 978-2-555-02552-3 (PDF v. ang.)

Document originally written in French.
Ce document est également publié en français.

Hydro Québec