Greenhouse gases

Greenhouse gas emissions from hydroelectric reservoirs

Greenhouse gas (GHG) emissions constitute a relatively well-known global issue. A number of gases, including carbon dioxide (CO_2) and methane (CH_4), contribute to atmospheric change. These gases are not only attributable to human activity—they are also part of normal ecosystem dynamics. In the context of the energy transition, it is important to understand how hydroelectric reservoirs temporarily impact GHG.

Greenhouse gas emissions in natural environments

The planet's atmosphere interacts with three main types of ecosystems: marine ecosystems (oceans, seas, estuaries, etc.), terrestrial ecosystems (peatbogs, wetlands, forests, etc.) and aquatic ecosystems (lakes, rivers, streams, etc.).

The vegetation that thrives in terrestrial ecosystems, such as forests and peatbogs, absorbs atmospheric CO_2 as it grows. These ecosystems are therefore generally regarded as carbon sinks. However, virtually all aquatic ecosystems, such as lakes, rivers and streams, naturally release GHGs (CO_2 and CH_4).

In aquatic environments, GHG emissions occur when bacteria break down organic matter. CO_2 is generally released during the decomposition process, as it requires oxygen. In specific conditions in which oxygen is lacking (anoxia), methane (CH_4) may be produced (Prairie et al., 2017, Deemer et al., 2016).

Lakes and rivers receive more organic matter than they are capable of fixing, for example through fish and algae growth. This is why GHGs are released into the atmosphere, because emissions constitute the means by which all ecosystems tend to reach equilibrium.

In lakes and rivers, GHGs are generally emitted through two pathways:

Diffusion

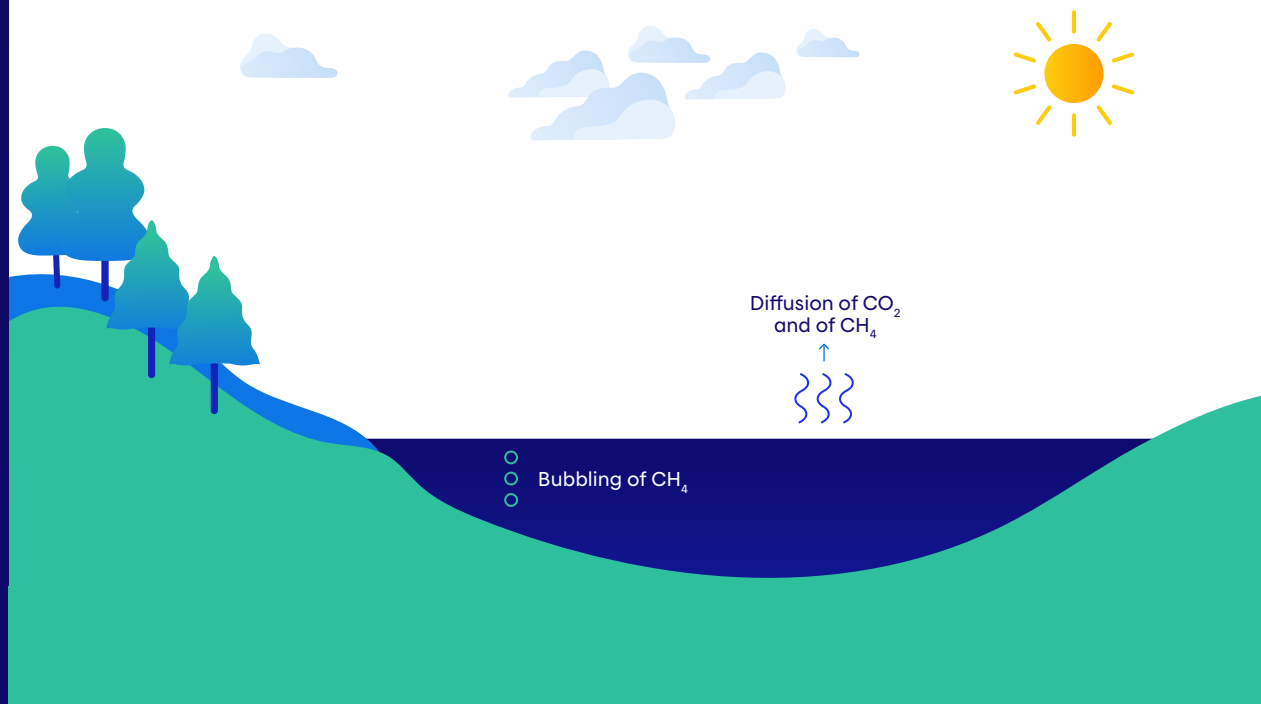
Diffusion at the surface of an aquatic ecosystem or air-water exchange:

- Diffusion is a type of gas exchange that occurs in lakes and rivers, as higher gas concentrations in the water seek an equilibrium with the lower concentrations in the atmosphere.
- In Québec, diffused CO_2 emissions are, by far, the most significant type of emissions.
- Diffusion also occurs in falls and rapids, where the considerable turbulence forces the water and atmosphere to reach equilibrium.

Bubbling

Bubbling or release of bubbles:

- Bubbling is mainly due to CH_4 accumulation in sediment as a result of anaerobic degradation of organic matter (i.e., degradation without oxygen). Most of the time, it occurs in the shallower sectors of lakes, where hydrostatic pressure is low.
- Bubbling emissions are low and limited in Québec's cold, oxygen-rich waters.



Greenhouse gas emissions from hydroelectric reservoirs

When hydroelectric reservoirs are impounded, the decomposition of the vegetation that is flooded temporarily generates more GHG emissions. This is a well-known phenomenon (Tremblay, et al., 2005).

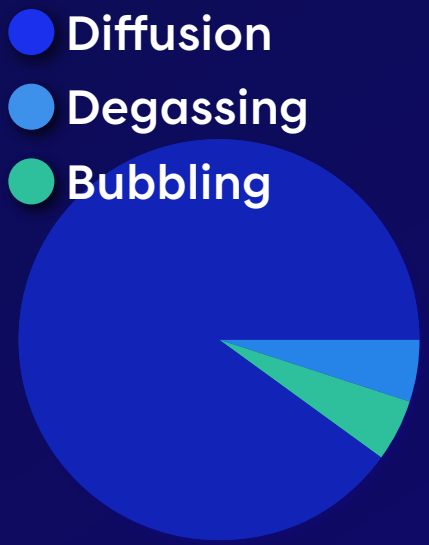
The decomposition rate of vegetation varies significantly according to the geographic location of the reservoir. It is based on factors including the type and quantity of flooded vegetation, as well as water temperature, because the vegetation cover decomposes at a slower rate in reservoirs located in northern Québec than in tropical zones, for example (Deemer et al., 2016).

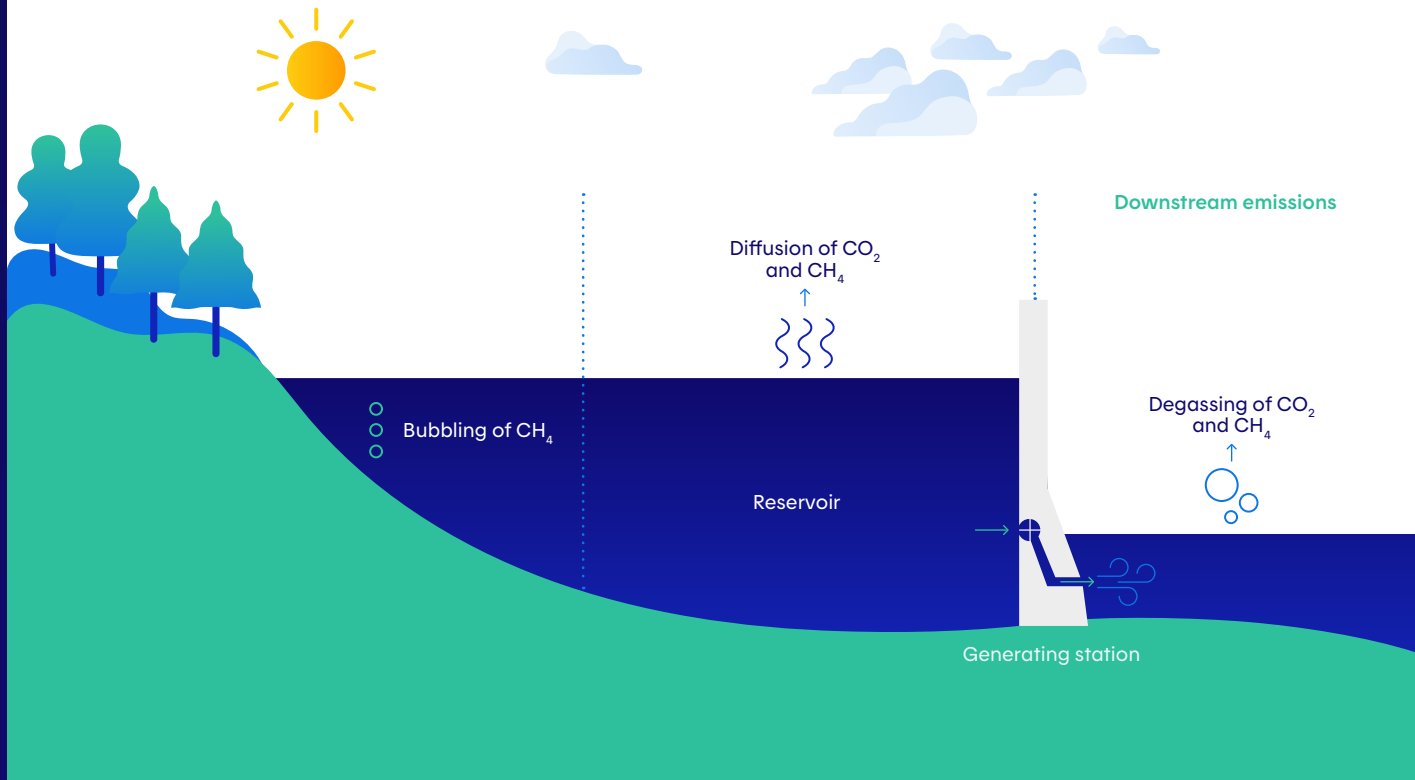
In reservoirs, as in lakes and rivers, GHG emissions may be released by diffusion or bubbling in larger quantities in the first years following impoundment. The impoundment of a reservoir is generally associated with the commissioning of at least one generating station, which creates another GHG emissions pathway: downstream degassing.

Degassing downstream of a generating station

- Emissions from degassing are caused by the difference in pressure at the turbine inlets and outlets and by the turbulence of the downstream waters that force the water and atmosphere to reach equilibrium, just as they do in natural river rapids.
- In Québec, emissions from degassing are limited.

Emissions pathways in Québec reservoirs:





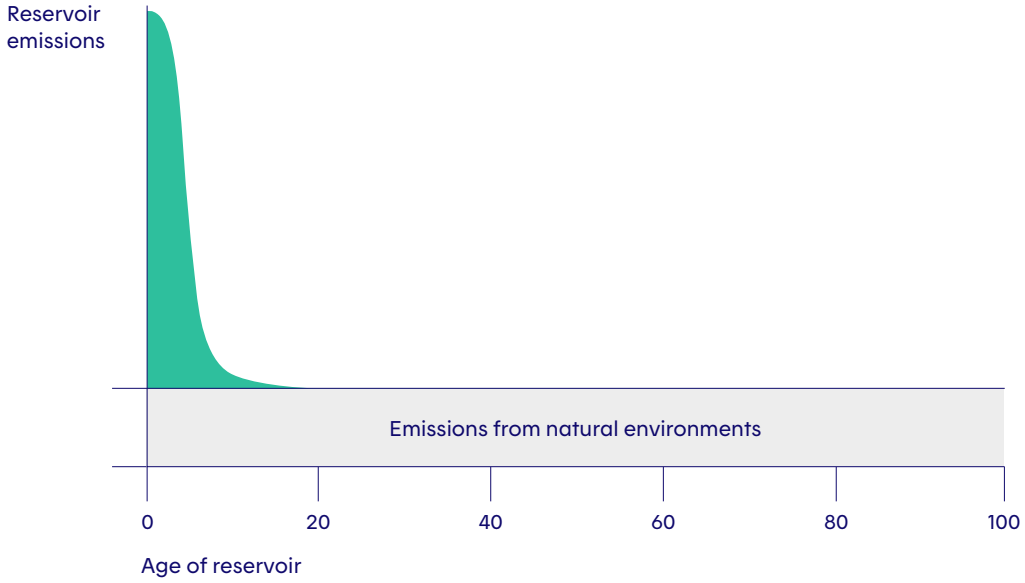
Balance of greenhouse gas emissions from Québec reservoirs

Since 1993, Hydro-Québec has assessed the GHG emissions of Québec's reservoirs in partnership with universities, research centers and other electricity producers. Today, it conducts emissions balances for its main reservoirs (Levasseur et al., 2021) by accounting for the three GHG emissions pathways. Degassing emissions are considered for the entire year, whereas diffusing and bubbling emissions are considered during ice-free season only. Diffusion and bubbling cease in the winter as the ice acts as a cover that prevents the majority of GHG emissions from escaping.

The data collected over the years reveal that the GHG emissions from Québec's northern reservoirs are higher in the years following impoundment and then rapidly decrease. After a period of about 15 years, they are generally comparable to the emissions of natural environments (Tremblay et al., 2005).

Hydroelectric reservoirs have a life cycle of several decades to over a century, and it can therefore be concluded that the increase in GHG emissions when land ecosystems are flooded is only temporary, when the reservoirs are first created, and the reservoirs generally act like natural environments for most of their life cycle.

GHG emissions from reservoirs



Photo

Cover: Romaine-2 dam spillway

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