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Estimate of Greenhouse Gas Emissions (GHG) for the future Site C Hydropower Project in British Columbia

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Over the last few decades, hydropower projects have come under increasing scientific scrutiny because of the greenhouse gases they emit. Dozens of scientific studies have found that hydropower projects can emit varying levels of GHGs, and sometimes emit even more GHGs than coal-fired powerplants producing an equal amount of electricity[1][2][3][4]. Using readily available formulas that estimate GHGs from hydropower projects, and using data provided on the Site C Project website[5], we estimate GHGs for the future Site C Project if/when it becomes operational.

The Site C website estimates the project will generate 5.1 GWh of energy per year when completed. The project will include an earthfill dam approximately 1,050 metres long and 60 metres high above the riverbed; and an 83-kilometre-long reservoir that will be, on average, two to three times the width of the current river.

GHG emissions can be estimated and reported in both "yearly operational emissions" and "lifecycle emissions" formats to compare emissions across platforms and sources. We offer both yearly operational emissions estimates, as well as lifecycle emissions estimates, in this analysis. We use a common GHG reporting metric for hydroelectric projects of "kg CO_2e/MWh", which is "kilograms of Carbon Dioxide Equivalent per Megawatt hour" and project emissions over 100 years of the Site C project, a common metric in hydropower greenhouse gas accounting.

Greenhouse gas emissions caused by this project are expected to come from the following sources:

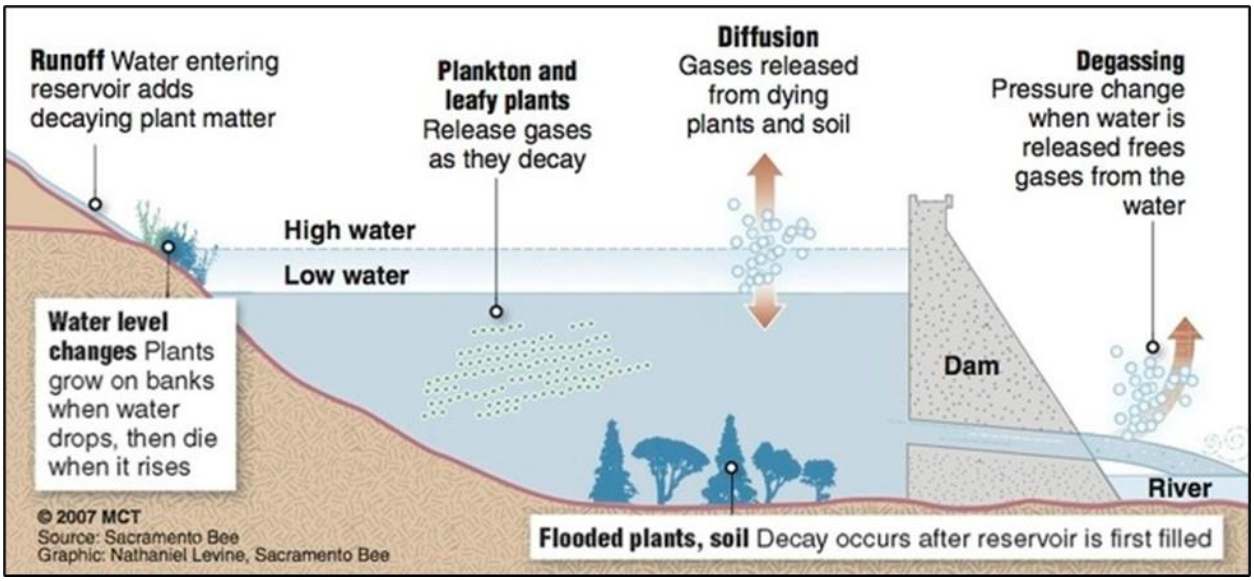
1. **For Operating Site C on a Yearly Basis:**

[1] https://www.climatecentral.org/news/hydropower-as-major-methane-emitter-18246
[2] https://www.washingtonpost.com/news/energy-environment/wp/2016/09/28/scientists-just-found-yet-another-way-that-humans-are-creating-greenhouse-gases/
[3] https://www.latimes.com/science/la-xpm-2013-aug-01-la-dams-greenhouse-gas-hot-spots-20130801-story.html
[4] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0161947
[5] https://www.sitecproject.com/about-site-c/project-overview

a. Carbon dioxide, methane, and nitrous oxide emissions from the reservoir surface: These emissions come from the decomposition of vegetation and soil organic matter inundated by the dam, as well as in organic matter and sediment that flows into the reservoir during its life[6][7][8]. Models compiled by Scherer and Pfister[9] estimate emissions from the Site C reservoir of **381 kg CO_2e/MWh** per year.

b. Methane emitted from hydropower turbines: These emissions also come from the decomposition of vegetation and soil organic matter inundated by the dam, as well as in organic matter and sediment that flows into the reservoir during its life. Multiple studies indicate that methane emissions from hydropower turbines and from methane gas dissolution downstream has not been adequately studied[10][11]. Scherer and Pfister[12] compiled a model for methane emissions based on the limited studies available, and their model estimates that methane emissions from the Site C turbines would average **15 kg CO_2e/MWh** per year.

A depiction of these emissions sources is in Figure 1 below:



2. **Other Emissions For Operating Site C over its lifecycle, and non-quantified emissions:**

a. Dam construction: Fossil fuel emissions associated with operating heavy equipment at the dam site, mining and transporting aggregate and rock used in the dam, and

[6] https://www.researchgate.net/publication/324993878_Cradle-to-grave_greenhouse_gas_emissions_from_dams_in_the_United_States_of_America
[7] https://academic.oup.com/bioscience/article/66/11/949/2754271
[8] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0161947#
[9] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0161947#
[10] https://academic.oup.com/bioscience/article/66/11/949/2754271
[11] https://www.researchgate.net/publication/324993878_Cradle-to-grave_greenhouse_gas_emissions_from_dams_in_the_United_States_of_America
[12] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0161947#

manufacturing concrete all contribute to a significant pulse of emissions before the dam fills and hydropower turbines begin to operate, contributing on average at least **6 kg CO_2e/MWh** per year over 100 years.

b. Dam decommissioning: Carbon dioxide, methane, and nitrous oxide emitted during dam removal and site remediation: Song *et al.* (2018) note that dam decommissioning could be among the largest emissions contributing to the life cycle emissions of temperate and boreal hydropower systems. Pacca[13] estimated that decomposition of organic matter in sediments due to dam decommissioning contributed approximately **208 kg CO2e/**MWh (range of 18-190 kg CO2e/MWh) per year over 100 years.

c. Non-quantified emissions – Trace gas emissions from the reservoir banks: Maeck *et al*.[14] described methane hotspots in banks and near-shore inundated areas produced when dam levels fluctuate. This source category has not been adequately studied or quantified, and are likely to be highest in reservoirs with the greatest seasonal water level fluctuations.

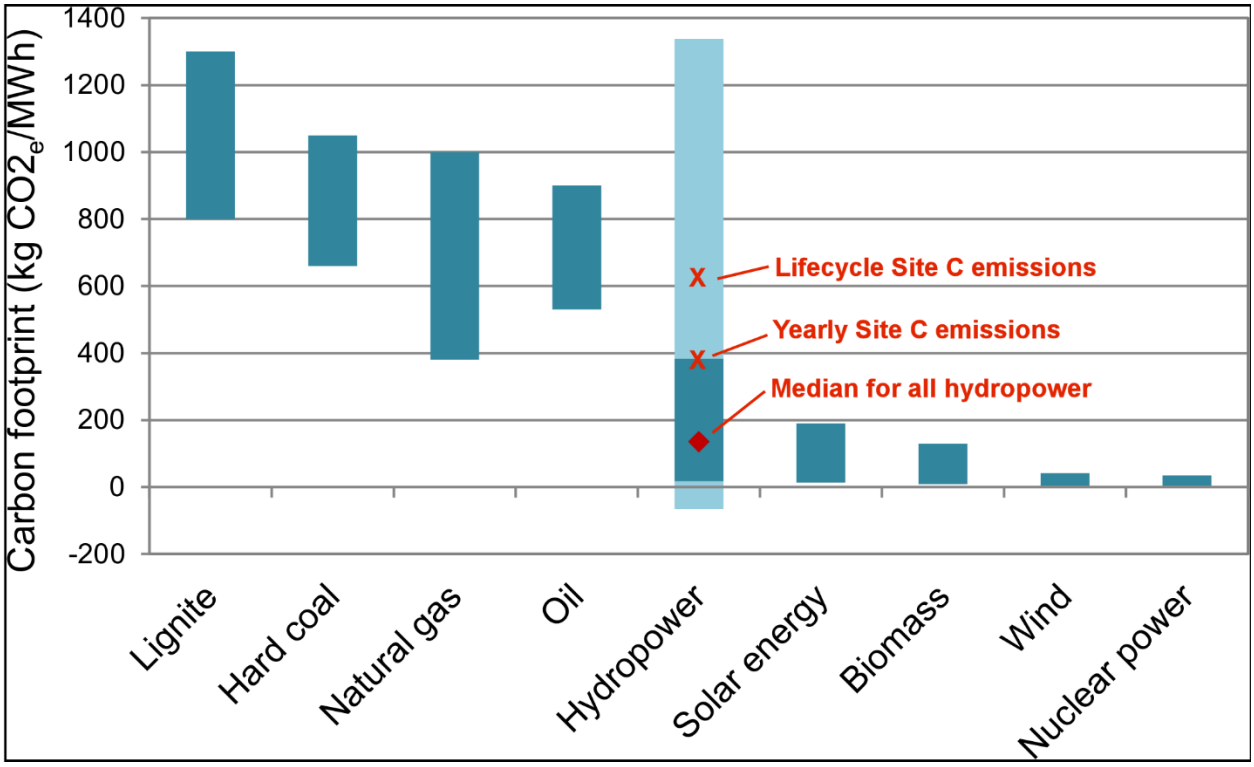
d. Non-quantified emissions – Fearnside[1516] calculated emissions from hydropower reservoirs in tropical climates that were at least four times those from coal-fired power plants, noting the potential for significantly undercounted emissions from reservoirs in temperate and boreal climates (like where the site C reservoir is located) as well as tropical regions.

When combined, yearly emissions caused by the operation of the dam equal at least **396 kg CO_2e/MWh**. Over a 100-year lifespan of the hydropower project, emissions equal at least **610 kg CO_2e/MWh**.

Figure 2 below is from Sherer and Pfister[1718], comparing yearly operational emissions from various electric power sources. Site C emissions are now included in the Figure 2 below in red.

[13] https://www.researchgate.net/publication/225766313_Impacts_from_decommissioning_of_hydroelectric_dams_A_life_cycle_perspective
[14] https://pubs.acs.org/doi/abs/10.1021/es4003907
[15] https://www.tandfonline.com/doi/abs/10.4155/cmt.13.57
[16] https://www.researchgate.net/publication/274511705_Tropical_Hydropower_in_the_Clean_Development_Mechanism_Brazil's_Santo_Antonio_Dam_as_an_example_of_the_need_for_change
[17] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0161947#
[18] https://iopscience.iop.org/article/10.1088/1748-9326/aaa817

Figure 2: Carbon Footprint of electricity sources, including Site C



The emissions from Site C are likely higher, considering that one major emissions source (methane from turbines) is widely believed to be undercounted, and one emissions source (trace gas emissions from reservoir banks) has not been quantified.

At a minimum as depicted in Figure 2 above, the best available science indicates that the estimated yearly operational carbon footprint of Site C is equal to the lowest of natural gas electricity production. As such, it is certainly disputable that Site C is a "clean energy project" as promoted on its website and in other marketing materials. Moreover, a graphic prepared by Site C (dated 7/9/2020) stated that the GHG emissions from the project would be 10.5 kg CO_2e/MWh – however, the best available science used in our report indicates that the yearly emissions are estimated to be **396 kg CO_2e/MWh**[19].

Further, the Site C website states: *"Site C will have among the lowest GHG emissions, per gigawatt hour, compared to other resource options."*[20] Our analysis, which uses the best available science to estimate emissions, indicates that this statement is incorrect – solar and wind, among other energy choices, would have lower GHG emissions.

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[19] http://savetheworldsrivers.org/wp-content/uploads/2021/05/IMG_5193-rotated.jpg
[20] https://www.sitecproject.com/why-site-c/project-benefits