Northwest RIVER PARTNERS™

Hydropower for a better Northwest

DOLLARS & SENSE PART II:

An Examination of Reservoir Methane Claims

Abstract

Energy experts indicate that existing hydroelectric projects have among the lowest carbon footprint of any electric generating resource. However, some anti-dam advocates claim the lower Snake River dams are a significant source of greenhouse gas emissions compared to other energy resources. This whitepaper examines those assumptions and conclusions.

October 11, 2021

Contents

Objective

Examine the suite of DamSense analyses to identify methodological, logical or calculational deficiencies underlying DamSense's conclusions.

Executive Summary

DamSense is an organization that advocates for the breaching of the four lower Snake River dams (LSRD). Literature produced by DamSense states that breaching these select dams will result in large reductions in the pollution from greenhouse gas (GHG) emissions. However, analyzing the information provided in the reports uncovers multiple areas where crucial considerations were ignored and where faulty comparisons were utilized. The following is a summary of key shortcomings in DamSense's methane (CH_4) analysis:

- DamSense overreaches in its conclusions, implying because dam reservoirs are responsible for some level of GHG emissions that hydropower shouldn't be considered a clean energy resource. Repeated studies contradict this DamSense conclusion; existing hydropower plants—especially those in non-tropical climates—are some of the least GHG-intensive power generation sources on an annual or full-lifecycle basis according to trusted experts. Also, utilizing hydroelectric dams results in a cumulative reduction in the emissions of other air pollutants, which can be harmful to human health and the environment.

- DamSense, in comparing the LSRD to a proxy natural gas plant, fails to disclose the GHG emissions adjusted for the amount of energy generated. Using DamSense's own LSRD emissions estimates, it is clear the LSRD would only produce a tiny fraction (roughly 2%) of the $C0_2$ equivalent on a per MegaWatt hour basis as the natural gas-fueled power plant that DamSense references.

- DamSense neglects to mention the high degree of uncertainty surrounding existing research methods for calculating methane emissions from reservoirs.

- DamSense attributes GHG emissions solely to the dam reservoirs, but freshwater systems also emit methane. To achieve an accurate estimate of the net effect of dams, one must first know or estimate freshwater emissions in the absence of the dams.

- The LSRD, because of their built-in locks, allow for barging of agricultural products and other goods. Barging is a low-carbon means of shipping. If the LSRD were to be breached, shipping would be confined to rail and truck and lead to a significant increase in GHG emissions. DamSense fails to net out this impact in its calculations.

Approach

This analysis entails examination of the major position papers, videos, and technical analyses publicly available from DamSense. We considered the scientific and data analyses principles underpinning the DamSense work and its ultimate conclusions.

Additionally, scientific papers and works by the US Army Corps of Engineers, US Bureau of Reclamation, Pacific Northwest Waterways Association (PNWA), and other regional stakeholder groups were analyzed and included to provide a stronger foundational understanding of the issues. This whitepaper seeks to identify methodological, logical, or factual issues with the conclusions reached by DamSense.

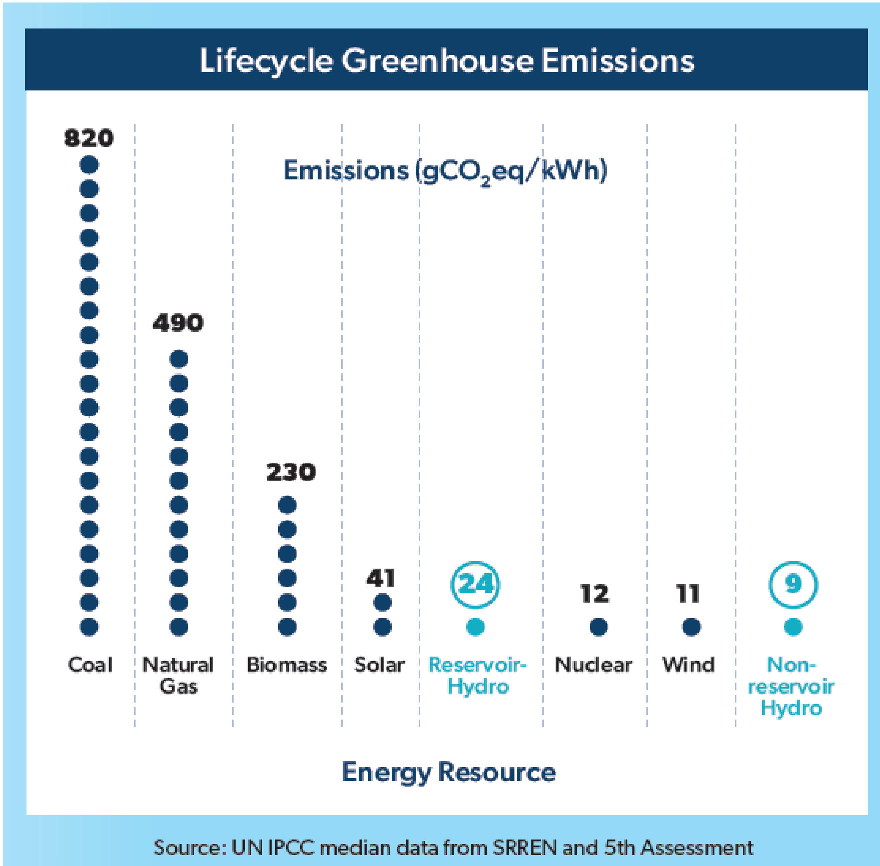
Discussion

DamSense claims that the dams are responsible for significant amounts of methane, however DamSense materials include many incorrect assumptions or ignored considerations that lead to questionable conclusions. This critique identifies four overarching shortcomings in DamSense materials that result in incorrect or potentially misleading estimates of reservoir emissions:

Error #1: Implying Hydropower Reservoirs Produce Significant Amounts of GHG Compared to Other Forms Energy Generation

A major shortcoming in the DamSense analysis is its failure to examine GHG emissions according to the amount of energy generated. It's only through this comparison that one can determine the cleanest energy resources.

1.1: Properly Comparing Hydropower to Other Energy Sources



[1]

Hydropower generation, which consists of a replenishable water supply flowing through a turbine, is a renewable way to generate electricity. It is reliable, affordable, and leads to lower GHG emissions in the environment compared to most other energy resources.

Unlike forms of generation that rely on fossil fuels, such as coal or gas, hydropower is one of the cleanest energy resources in the US according to the United Nations Intergovernmental Panel on Climate Change (UN IPCC).[2]

The chart above based on data from UN IPCC median data from SRREN[3] and 5th Assessment[4], conveys how both existing reservoir and existing non-reservoir hydropower have fairly low grams of carbon dioxide equivalent emitted per kilowatt-hour of electricity generated over their lifecycle. Reservoir hydropower has one of the lowest lifecycle emissions (gCO2eq/kWh), less than that of coal, natural gas, biomass, and solar sources of energy.

[1] Chart from National Hydropower Association (NHA). “Hydropower in Context: U.S. Greenhouse Gas Emissions”
[2] Special Report of the IPCC. “Renewable Energy Sources and Climate Change Mitigation”, 2012, chp.5. Link
[3] UN IPCC Special Report: Renewable Energy Sources and Climate Change Mitigation, 2012. Link
[4] UN IPCC 5th Assessment. 2014. Link

It is important to note the IPCC and other expert sources typically compare the lifecycle emissions costs of *existing* (i.e., already constructed) hydropower resources in contrast to the construction of new wind/solar resources. Comparisons are made on this basis because the construction of new, major in-river dams in the United States is largely infeasible due highly restrictive regulations.

Despite these restrictions, the US Department of Energy sees opportunities to increase hydropower capabilities through a combination of hydropower generation upgrades to existing plants, adding power at existing dams and canals, and limited development of new stream-reaches, as well as the addition of pumped storage capacity.

According to the Department of Energy's Hydropower Vision Report, "…increasing hydropower's capacity by 50 gigawatts by 2050 reduces greenhouse gas emissions by 5.6 billion metric tons and saves $209 billion in avoided global damages from GHG emissions, including $185 billion in savings from the existing hydropower fleet being operated through 2050."[5] [6]

Besides serving as one of the lowest GHG-emitting power-production alternatives available, hydropower is also exceptionally important for its ability to help us add intermittent renewable energies such as wind and solar power. The viability of such renewables depends upon storage capacity or reserve power production by thermal or hydroelectric power plants to follow rapidly changing power demand and provide power during hours of darkness or calm winds. By providing storage and load-balancing services, hydropower supports variable renewable energy sources.[7]

1.2: Pacific Northwest Example

Multiple DamSense reports contend that, since reservoirs behind dams such as the LSRD emit some greenhouse gases, hydropower should not be considered a clean form of energy.[8]

As an example, DamSense estimates greenhouse gas emissions of the LSRD are equivalent to 86,053 metric tons of CO_2 per year ("CO_2e metric tons/year").[9] DamSense then makes a misleading conclusion, implying the LSRD produce as much carbon as a typical natural gas plant.

---

[5] "National Hydropower Association Statement on Reservoir GHG Emissions", September 2016, p.1.
[6] U.S. Department of Energy. "Hydropower Vision Report", October 2016, p.316. Link
[7] Killingtveit, Anund. "Future Energy (Third Edition)", 2020, chp. 15. Link
[8] Twa, John. "An Update to the 2016 Paper, 'The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas'", July 2020, p.2. Link
[9] Twa, John. "An Update to the 2016 Paper, 'The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas'", July 2020, p.2. Link

DamSense draws this conclusion by examining the Encogen natural gas-fired plant in Bellingham, WA.[10] According to EPA's GHG emissions sources website, the plant emitted 96,453 metric tons of CO_2 in 2018.

This comparison is misleading, because DamSense does not analyze the emissions on an energy output basis. The LSRD produce, on average, approximately 1,000 average MegaWatts of output, which equates to 8,760,000 MegaWatt hours (MWh) of energy per year.[11] If one assumes DamSense is correct in its CO_2e production estimate for the LSRD, it equates to approximately 0.01 metric tons of CO_2e per MWh.[12]

Going back to our natural gas plant example, the Bellingham Encogen plant generated 200,543 MWh in 2018 and 401,290 MWh in 2019 [13] (emitting 191,710.2 metric tons of CO_2 in 2019.[14])

Therefore, in both 2018 and 2019, the plant emitted approximately 0.48 metric tons of CO_2e per MWh.[15] Consequently, on an energy output basis, the natural gas plant released almost 50 times the amount of CO_2e as the LSRD.

Coal power plants emit a considerably greater amount of greenhouse gases. For example, the Big Hanaford coal plant, located in Centralia, WA, emitted close to 8 million metric tons of CO_2 in 2019 [16] while generating 10,478,711 MWh, resulting in 0.76 CO_2e per MWh.[17] [18]

Using the DamSense estimates for LSRD methane emissions, the GHG emissions from the LSRD only represent 2.1% of the GHG emissions from the natural gas plant and 1.3% of the GHG emissions from the coal plant on a per-MWh basis.

It should also be noted that hydropower usage results in a cumulative reduction in the emissions of air pollutants such as sulfur dioxide, nitrous oxides, and particulate matter compared to fossil-fueled generation.[19] [20]

This cumulative reduction is important. Sulfur dioxide is a harmful pollutant that contributes to the production of acid rain and can cause significant health problems.[21] With a reduction in 1.64

---

[10] Twa, John. "An Update to the 2016 Paper, 'The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas'", July 2020, p.5. Link

[11] BPA. "Lower Snake River Dams provided crucial energy and reserves in winter 2021", June 2021. Link

[12] 1000 aMW *8760 hours = 8,760,000 MWh
86,053 CO2e metric tons/8,760,000 MWh = 0.01 CO2e metric tons per MWh

[13] US Energy Information Administration (EIA). "Form EIA-923 detailed data with previous form data (EIA-906/920)", 2018, 2019. Link (open zipped file, open Excel sheet with schedules 2,3,4,5, etc., go to Page 4: Generator Data)

[14] EPA. GHG Data. Link 1, Link 2

[15] 2018: 96,453 CO2e metric tons/200,543 MWh = 0.48 CO2e metric tons per MWh
2019: 191,710.2 CO2e metric tons/401,290 MWh = 0.48 CO2e metric tons per MWh

[16] EPA. GHG Data. Link 1, Link 2

[17] Power Technology. "Centralia Power Plant New CCGT Unit, WA". Link

[18] 8,000,000 CO2e metric tons/10,478,711 MWh = 0.76 CO2e metric tons per MWh.

[19] "National Hydropower Association Statement on Reservoir GHG Emissions", September 2016, p.3.

[20] U.S. Department of Energy. "Hydropower Vision Report", October 2016, p.316. Link

[21] United States Environmental Protection Agency. "Power Plant Emission Trends". Link

million metric tons of sulfur dioxide, 2.76 million metric tons of nitrous oxides and 0.33 million metric tons of particulate matter (or 5%, 9%, and 6%, respectively over 2017-2050), there will be "nearly 5 million fewer cases of acute respiratory symptoms and 750,000 fewer cases of childhood asthma." [22] [23] On top of this, there will also be less environmental harm due to less sulfur dioxide emissions and acid rain being formed.[24]

Error #2: Over-Confidence in Unverified Reservoir Emissions Estimates

The study of reservoir emissions is a relatively new field.[25] Because of this relative newness, there are discrepancies surrounding the estimates that must be acknowledged as part of a scientifically thorough analysis. Those discrepancies are noted below:

2.1: Relying on Modeling Rather than Measurement

The U.S. Department of Energy's Hydropower Vision states that studies estimating GHG reservoir emissions are filled with large uncertainties.[26] As an example, there are no permanent CH_4 monitors on the lower Snake River.[27] Therefore, currently, it is only through modeling—not actual measurements—that one is able to estimate yearly LSRD reservoir emissions.

While the use of models can be appropriate, DamSense relies on its own unverified model and implies its model provides a reasonable estimate for measured levels of CH_4.[28] Models have some margin of error and DamSense's CO_2e output model is no exception. However, DamSense makes no attempt to quantify or even qualify this uncertainty.

2.2: Questionable Methodology Utilized

DamSense determined a yearly annual GHG production estimate for the lower Snake River based on methane emission rates found in a Pacific Northwest National Laboratory study.[29] [30]

---

[22] "National Hydropower Association Statement on Reservoir GHG Emissions", September 2016, p.3.
[23] U.S. Department of Energy. "Hydropower Vision Report", October 2016, p.316. Link
[24] U.S. Environmental Protection Agency (EPA). "What is Acid Rain?". Link
[25] World Bank. "Greenhouse Gases from Reservoirs Caused by Biogeochemical Processes", December 2017, p. 1. Link
[26] Arntzen, et. al. U.S. Department of Energy. "Evaluating greenhouse gas emissions from hydropower complexes on large rivers in Eastern Washington", March 2013, p.1. Link
[27] Waddell, James. "Methane Emissions on the Lower Snake", *YouTube*, December 2020, 49:00-49:49. Link
[28] Twa, John. "The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas", December 2016, p.4. Link
[29] Twa, John. "The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas", December 2016. Link
[30] Twa, John. "An Update to the 2016 Paper, 'The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas'", July 2020. Link

However, as DamSense notes, the PNNL study was not intended to estimate total methane emissions from reservoirs, but instead to contrast two types of pathways in which methane emissions can occur in lakes and reservoirs (i.e., through diffusion and ebullition). To quote from the PNNL study, "Our investigation was considered preliminary and not designed in order to estimate reservoir wide greenhouse gas emissions via the ebullition pathway;"[31]

Because of this intent, the PNNL researchers selected sampling locations and times where methane ebullition would likely be at its highest.

DamSense extrapolated these sample readings to sections of the river it believes were apt to emit GHG through ebullition, without actually observing or measuring ebullition in those areas to confirm the veracity of its calculations. The legitimacy of the DamSense GHG estimates is wholly dependent on the reliability of its unverified methodology.

2.3: Model Does Not Attempt to Measure Net GHG Emissions Due to Dams

The DamSense methodology fails to recognize that all bodies of water, including rivers without dams, produce GHGs. Accordingly, to determine the GHG contribution of the LSRD, the DamSense model should have netted its forecast against a modeled forecast for the river under a free-flowing scenario.

Because we lack methane data from the lower Snake River before the dams were constructed, the best available comparison for a free-flowing lower Snake River would likely be other free-flowing rivers in similar climates that have comparable characteristics. There is no way to entirely avoid site-specificity but providing a comparable option will allow for an accurate free-flowing baseline comparison.

Error #3: Failure to Consider Confounding Variables

Estimates of emissions from aquatic ecosystems are complex and difficult to replicate because of the many variables to consider, such as depth, temperature, duration, location, latitude, land uses, climate, presence of biological materials which can decompose.[32]

When trying to determine if a cause-and-effect or even a correlation truly exist in complicated biological systems, it is important to consider one influencing variable (i.e., an independent variable) at a time, while keeping other independent variables constant. Doing so allows one to determine the likelihood that an independent variable is influencing the outcome.

However, a complicating situation arises when a variable that is not included in the experiment, still affects the relationship between the two variables in an experiment. This type of variable

[31] Arntzen, et. al. U.S. Department of Energy. "Evaluating greenhouse gas emissions from hydropower complexes on large rivers in Eastern Washington", March 2013, p.22. Link
[32] Prairie et. al. "Greenhouse Gas Emissions from Freshwater Reservoirs: What Does the Atmosphere See?", 2017. Link

can confound the results of an experiment and lead to unreliable findings, so it is known as a confounding variable.

An example is the role of climate change. DamSense claims that the LSRD are causing river temperatures to rise. Rising river temperatures, in turn, lead to an increase in the release of methane over time. Therefore, DamSense blames the rise in methane levels on the LSRD.

However, the assumption that LSRD are causing river temperatures to rise lacks empirical evidence and scientific agreement.

Ignoring or erring on the role of climate change and its effect on river temperatures will confound or confuse the DamSense model and result in unreliable outcomes.

3.1: Confounding Variables in Calculating GHG Emissions Over Time

DamSense's 2016 reporting indicated that 50,744 metric tons of CO_2e are emitted yearly by the LSRD reservoirs. Meanwhile, in 2020, the DamSense estimate jumped to 86,053 metric tons of CO_2e per year which represents a 70% increase.

An increase in river temperatures inputs is partially responsible for this increase, as the number of days that water temperatures exceed 17° C is utilized in the model.[33]

DamSense states that the LSRD inflate the surrounding water temperature by 0.7 C to 3.2 C during the summer and fall seasons, [34] relying on the output of an EPA model.

However, here is where the confounding variable comes into play; there is scientific disagreement about the effect of dams on river temperatures. The only peer-reviewed study on the LSRD's impact on river temperatures indicates the dams create a thermal inertia effect that reduces spring and summer river temperatures but carries additional—though less intense—heat into the fall.[35]

The only empirical data on the subject comes from a team of researchers who conducted a study on behalf of the US Army Corps of Engineers in 2002. They compared pre-lower Snake River dam temperatures to measurements after the lower Snake River dams were constructed and found no evidence that river temperatures had increased, although the data set was quite limited.[36]

Accordingly, attributing higher levels of river temperatures to the LSRD and then indicating the higher interpolated GHG emissions are, therefore, the fault of the LSRD may be scientifically unsound and should be noted as a potential critical shortcoming in the DamSense conclusions.

---

[33] Twa, John. "An Update to the 2016 Paper, 'The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas'", July 2020, p.5. Link

[34] Twa, John. "An Update to the 2016 Paper, 'The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas'", July 2020, p.7. Link

[35] Perkins, W. and Richmond, M. PNNL. "Long-term, One-dimensional Simulation of Lower Snake River Temperatures for Current and Unimpounded Conditions", February 2001, p.V. Link

[36] Peery, C. and Bjornn, T. "Water Temperatures and Passage of Adult Salmon and Steelhead in the Lower Snake River", 2002, p.49. Link

Northwest RIVERPARTNERS
Hydropower for a better Northwest

Error #4: Excluding Transportation Emissions Implications

The LSRD help provide environmentally-friendly forms of transportation. For example, the dams enable low-carbon barging.

4.1: Low-Carbon Barging

The LSRD include locks (i.e., water elevators) that allow for barging of goods. According to a study conducted by the FCS Group, over 3.5 million metric tons of commodities were transported by barge through the lower Snake River during the nine operation months of 2017. Included in this transportation by barge is 2.6 million tons of outbound products (mostly grain) and 874,000 tons of inbound shipments.[37]

Without barging, other transportation methods, such as rail lines and semi-trucks would have to be utilized more frequently, which would lead to an increase in GHG emissions.[38] Given current barging freight levels, this redistribution would result in at least 201 additional unit trains added each year, which equates to about 20,000 train cars.[39] There would also be an additional 23.8 million miles on the road every year from an increased use in trucks to transport goods, which is three times the current amount.[40]

Such an increase would cause the amount of carbon emissions from shipping to double. Currently, approximately 508,000 tons of CO2 are emitted annually from barging. However, without a barging option on the lower Snake River, CO2 annual emissions jump to 1.36 million tons.[41]

Total impact of the additional harmful emissions includes[42]:

- 855,000 tons of carbon dioxide
- 70 tons of carbon monoxide
- 306 tons of nitrogen oxide
- 7 tons of volatile organic compounds
- 7 tons of particulate matter

Losing the dams would eliminate the option of barging and would represent a significant setback for the region's decarbonization goals.

---

[37] FCS Group. "National Transportation Impacts and Regional Economic Impacts Caused by Breaching Lower Snake River Dams", January 2020, p. 5. Link

[38] US Army Corps of Engineers, Bureau of Reclamation, Bonneville Power Administration. "Columbia River System Operations Draft Environmental Impact Statement (CRSO DEIS)", 2020, chp.3, section 9. Link.

[39] FCS Group. "National Transportation Impacts and Regional Economic Impacts Caused by Breaching Lower Snake River Dams", January 2020, p. 6. Link

[40] FCS Group. "National Transportation Impacts and Regional Economic Impacts Caused by Breaching Lower Snake River Dams", January 2020, p. 6. Link

[41] K.C. Mehaffey. "Study: Loss of Snake River Barges Would Add CO2, Cost $2.3 Billion", Clearing Up, January 2020. Link

[42] FCS Group. "National Transportation Impacts and Regional Economic Impacts Caused by Breaching Lower Snake River Dams", January 2020, p. 12. Link

A proper study of the net GHG impacts of the LSRD should include the implications for transportation sector emissions.

Conclusion

DamSense contends that it makes sense to breach the four lower Snake River dams, in part because they are responsible for some degree of CH_4 emissions.

However, reviewing DamSense materials, it is clear several significant DamSense assumptions and conclusions are inconsistent with best scientific practices.

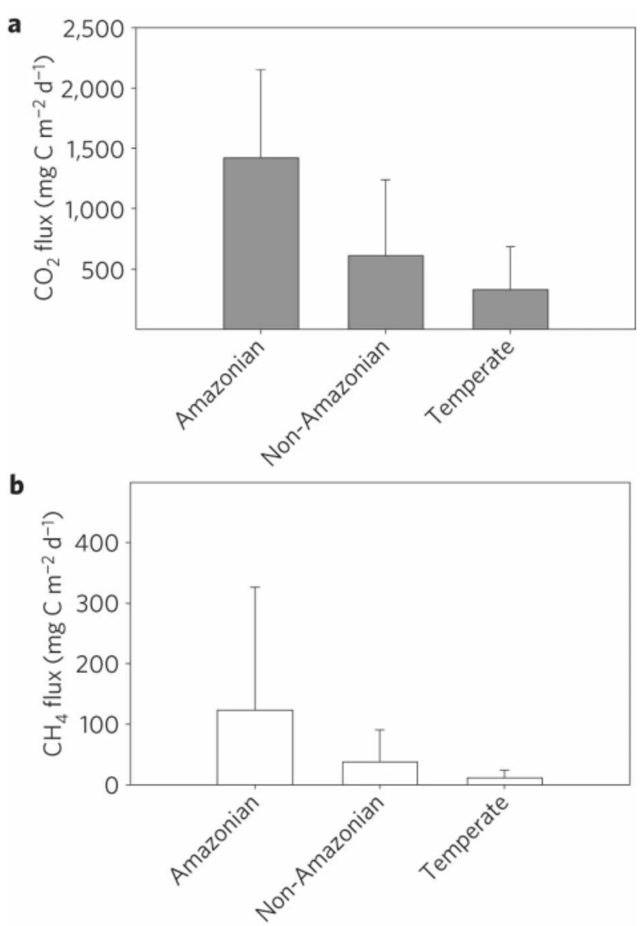
There is broad consensus in the scientific community that hydropower dams are important sources of clean, renewable energy that allow for the cumulative reduction of carbon dioxide and other harmful pollutants such as sulfur dioxide.

Appendix

Confounding Variables When Comparing Hydropower Reservoirs in Different Climates

While not pertaining to the DamSense analysis, in a discussion of reservoir methane emissions, it is important to note the differences in climate.

Annual CH_4 emissions are likely to be much higher within tropical climates than in temperate/moderate ones.[43] [44]



Mean (bars) and standard deviation (lines) of the **a**, CO_2 and **b**, CH_4 fluxes in the 85 hydroelectric reservoirs worldwide distributed clustered by region. The tropical region was split into Amazonian and non-Amazonian regions.

---

[43] Pfister, S. and Scherer, L. "Hydropower's Biogenic Carbon Footprint", September 2016. Link

[44] Steinhurst, W., Knight, P., Schultz, M. "Hydropower Greenhouse Gas Emissions", Synapse Energy Economics, Inc., February 2012. Link

The charts above illustrate the fluxes of CO_2 and CH_4 in different climate zones. It is seen that the flux for both is the lowest in temperate climates.[45]

Examining the charts above, it's important to understand the Snake River is considered a moderate climate zone.

[45] Barros, et. al. "Carbon Emission from Hydroelectric Reservoirs Linked to Reservoir Age and Latitude", July 2011. Link