Quantifying the trade-offs in re-operating dams for the environment in the Lower Volta River

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Response to reviewers:
The authors thank the reviewer and editor for their comment on expanding the discussion on the impact of hydropower reduction on the Ghanaian economy and power system operation costs. Below is the detailed response to this comment.

Location	**Comment and Response**
Discussion	**Comment:** The reviewer has a minor comment regarding your discussion and suggest you expand on how hydropower reduction can impact Ghanaian economy and power system operation costs. I look forward to receiving your revised manuscript. **Response:** The authors are grateful for this comment and have updated the Discussion to include a paragraph on the potential impact of dam re-operation on the energy landscape of Ghana, carbon emissions from the country, as well as energy pricing and economic implications. In lines 457 to 481, we write: *Expanding on the current electricity generation portfolio of Ghana, the contribution of other renewable energy sources besides hydropower to the power mix has remained under 1% since 2000, despite an on-grid target of 10% by 2020 (now extended to 2030) (Acheampong et al., 2021; Energy Commission Ghana, 2022). The alternative sources of electricity in Ghana use carbon fuels for thermal power generation, accounting for approximately 65% of the electricity generation portfolio in 2020 (Dye, 2020; Acheampong et al., 2021; Energy Commission Ghana, 2022). It is expected that these alternative carbon-based power sources contribute more to climate change compared to power generation from Akosombo and Kpong dams due to the fact greenhouse gas emissions from hydropower dams is negatively correlated with dam age and even the more recent dam, Kpong, has been in operation for over 35 years (dos Santos et al., 2006; Barros et al., 2011). As such, dam re-operation in Ghana may have the long-term environmental and economic consequences of higher greenhouse gases emissions if it results in a higher reliance on the existing carbon-based power generation options, rather than other renewables like solar and wind power. Furthermore, in Ghana, hydropower has traditionally been a cheaper source of electricity compared to fossil fuel-based power generation and as*

Location	Comment and Response
	Ghana has increased its reliance on the latter, electricity generation costs have increased resulting in higher tariffs for consumers (Energy Commission Ghana, 2022; Public Utilities Regulatory Commission, 2015). Finally, any reduction in hydropower production from Akosombo and Kpong dams due to re-operation may result in reduced overall electricity supply in Ghana as experienced during periods of drought in the past (Dye, 2020). It is estimated that the negative economic impacts of power shortages and load shedding, such as decreased productivity in industries, loss of revenue for businesses, and increased costs for backup power sources led to a GDP reduction of about 1.8-2% during the 2014-2016 power crisis (Acheampong et al., 2021). Considering these potential adverse impacts of dam re-operation, it is recommended that future studies encompass a deeper analysis of the energy landscape of Ghana and investigate carbon emissions and the path to greener energy in the country, as well as energy pricing and economic implications. Acheampong, T., Menyeh, B. O., and Agbevivi, D. E.: Ghana's Changing Electricity Supply Mix and Tariff Pricing Regime: Implications for the Energy Trilemma, Oil, Gas & Energy Law, 19, 2021. Barros, N., Cole, J. J., Tranvik, L. J., Prairie, Y. T., Bastviken, D., Huszar, V. L. M., Del Giorgio, P., and Roland, F.: Carbon emission from hydroelectric reservoirs linked to reservoir age and latitude, Nat Geosci, 4, 593–596, https://doi.org/10.1038/ngeo1211, 2011. Dye, B. J.: Structural reform and the politics of electricity crises in Ghana: tidying whilst the house is on fire?, Manchester, 2020. Energy Commission Ghana: 2022 National Energy Statistics, Accra, 2022. Public Utilities Regulatory Commission: Public Utilities Regulatory Commission Press Release: Approved Electricity and Water Tariffs Effective 14th December 2015 , 2015. dos Santos, M. A., Rosa, L. P., Sikar, B., Sikar, E., and dos Santos, E. O.: Gross greenhouse gas fluxes from hydro-power reservoir compared to thermo-power plants, Energy Policy, 34, 481–488, https://doi.org/10.1016/J.ENPOL.2004.06.015, 2006.