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Hydrology and Earth System Sciences Discussions

Interactive comment on "The water footprint of electricity from hydropower" *by* M. M. Mekonnen and A. Y. Hoekstra

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We thank the referee for the constructive comments.

Re note #1 The referee notes the relevance of precipitation recycling (Eltahir et al., 1996), also called moisture recycling in some recent studies (see e.g. Van der Ent, 2010). We recognize the relevance of this phenomenon at a regional scale, but at the scale of a reservoir catchment the fraction of additionally evaporated water from a reservoir that will return as precipitation above the same catchment will generally be very small. We haven't found any specific studies on the topic of the fate of water evaporated from hydropower reservoirs. We acknowledge that it is good to add a disclaimer in our paper to point out the fact that we haven't included the potential effect

of returning water at a local scale.

Re note #2 The evaporation rates and resulting water footprint figures for the 35 reservoirs considered vary widely. Evaporation rates vary from ∼500 mm/yr (Sayano Shushenskaya in Russia) to ∼3000 mm/yr (Cahora Bassa, Mozambique). The water footprint of hydro-electric energy varies from 0.3 m3/GJ (San Carlos, Colombia) to 846 m3/GJ (Akosombo-Kpong, Ghana).The variation in evaporation rates is due to variations in climate; the variation in the water footprint per GJ is also related to the variation in MW/ha over the various reservoirs studied and is therefore even bigger than the variation in evaporation rates. By showing the figures for reservoirs from different climates and for reservoirs with different ratio MW/ha, we show that the WF of hydro-electricity depends on both climatic factors and reservoir characteristics. In the paper we do not state that our sample is a representative set for all hydropower reservoirs in the world; instead, we took the largest plants in terms of hydroelectric generation.

Re note #3 The selected reservoirs have primarily been designed and built for hydroelectric generation. It is true that a number of them are now also used for other purposes, though the main value of the reservoirs is still hydroelectric generation. For multi-purpose dams, the total WF should be divided over the different purposes based on the relative economic value of the different purposes (in line with LCA studies and WF assessment methodology). In our study, we may overestimate the WF of hydroelectricity indeed for those reservoirs where other values have become significant in economic terms relative to the economic value of hydroelectricity (first paragraph in the Discussion section). The reason that we haven't done an effort to account for this effect is the absence of reliable data on the relative economic value of the 'byproducts' of our selected reservoirs.

Re note #4 We will add a paragraph in the discussion section on the limitations of the WF concept. The limitation lies within the definition and goal of the WF concept. The WF is an indicator of water consumption (and pollution, but this is not included in the current paper). As such, it shows the volume of consumptive water use related

to a certain activity (in this case: hydro-electric generation). It does not show the opportunity cost of not allocating the water to an alternative activity; it also does not show the impact of the consumptive water use on downstream users. Further, the WF shows consumptive water use, not the total water need. For hydroelectric generation there is a big demand for water in a non-consumptive sense, but this water remains in the river, so it cannot be seen as 'water consumption'. The WF is a measure of freshwater appropriation, like the ecological footprint is a measure of the appropriation of land. It is a resource use indicator, not an ecological or social impact indicator. Dams are often associated with all sorts of ecological impacts (river fragmentation, effects on water quality and biodiversity) and social impacts (displacement of people). As a freshwater resource use indicator, the WF does not intend to be an indicator of all what can be seen as the downside of dams.

The minor comments provided can easily be addressed when revising the paper. Thanks.

References

Eltahir, E. A. B. and R. L. Bras: Precipitation recycling, Rev. Geophys., 34(3), 367–378, 1996.

Van der Ent, R.J., Savenije, H.H.G., Schaefli, B. and SteeleâĂŘDunne, S.C.: Origin and fate of atmospheric moisture over continents, Water Resour. Res., 46, W09525, doi:10.1029/2010WR009127, 2010

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