

Authors' response to the interactive comment of referee #2 on hessd-2019-475
Risks and opportunities for a Swiss hydropower company in a changing climate

We thank Prof. Dr. Franco Romerio for his helpful comments regarding the uncertainties of the European and Swiss energy markets and for lending his insight to improve our manuscript. Below we respond to his comments (*in blue*). We appreciate the time taken for this review, and we believe that our incorporation of his comments will improve the uncertainty discussion within the manuscript.

Referee #2:

The article "Risks and opportunities for a Swiss hydropower company in a changing climate" addresses relevant questions of scientific and practical nature. It can be published after a careful revision. The main added value is given by the definition of a set of hydrological indices related to the Group E's vulnerability (well summarized in table 2). Of significance are the seasonal changes in inflow distribution. On this basis, the risks and opportunities for the operator are estimated. However, there are some drawbacks that should be considered by the authors, that I summarize below.

The analysis focuses on water inflows and energy demand, but doesn't take into consideration other important characteristics of the energy turnaround and the opening of the power market to competition. Furthermore, as recognized by the authors, the analysis of the electricity demand is limited to the climate drivers. For instance, the authors point out "Under climate change, as flexibility decreases and energy demand likely increases due to heat waves [...], Groupe E stated that they would consider acquiring new sources of energy production to compensate for this loss." However, Groupe E forgets that very likely its customers will install solar panels and perhaps batteries for the storage of electricity at home. Its market will therefore change quite deeply. I understand that the authors can't develop this issue, which has not been studied. But they can't ignore it; on the contrary, they should emphasize it. Several times, the authors take as granted higher energy (in fact, electricity) prices in winter, "given that the winter period usually corresponds to higher energy prices". No doubt that this is a quite realistic scenario. But the problem is very complex and the future evolution of the market in Europe and Switzerland presents many uncertainties, as shown by a quite large literature. Some scenarios are not so favorable to hydropower. In any case, it is risky to assume a continuity between past and future.

We agree with your statements concerning the limitations of our study, namely that an economic study of the future value of water was not carried out. We recognize that there is room for expansion of this work, and indeed this is something that we are hoping will inspire other researchers and end-users. Within the next version of this article, we will further discuss the limitations of our study, in particular that we do not explicitly consider the economic uncertainties related to the European and Swiss energy markets. Groupe E itself has been clear about these uncertainties and about the fact that our projections are only a piece of the puzzle. We will make this clearer in the revised version of the manuscript. Importantly, Groupe E also asked for more projections with expanded indices and for additional reservoirs, which demonstrates that these projections are useful for their concession negotiation process, despite their uncertainties and limitations. We note that the need for projections during the concession negotiation process is also highlighted by Tonka (2015)*, who stated that there is a "striking lack of attention paid to climate change impacts on water resources availability in relicensure procedures in the USA. In Switzerland, studies on this topic have been undertaken only recently and climate change projections have not yet affected the content of renewed concessions." We will stress this too in the revised version.

**Tonka, L., Hydropower license renewal and environmental protection policies: a comparison between Switzerland and the USA. Regional Environmental Change 15, 539-548 (2015) doi:10.1007/s10113-014-0598-8*

The authors state: “The figures we provide will help Groupe E determine the value of water in the future and the price they are willing to pay for the renewal of their concessions.” I agree, but on two conditions: it must be recognized that an economic study of the value of water has not been carried out; one must be aware that only two drivers have been taken into consideration: water flows and energy demand.

We agree entirely, and perhaps our statements regarding this were overlooked. Within Section 2.1.1 we state, “During concession negotiations, Groupe E representatives stated that the following would be considered (i) the development of the energy market and competitors, (ii) the projected supply of water resources, (iii) changes in energy demand, and (iv) costs associated with adhering to new environmental standards. This study focuses on the estimation of future water resources (point ii) and providing preliminary insights into future energy demand (point iii).”

Within the next version of this article, we will make this point more explicit (likely by moving the text to the introduction). We agree that the incorporation of an economic study of the value of water into this project would provide additional insights and therefore improved guidance to water managers. We will expand Section 5.4, which is currently dedicated to the discussion of this point.

The collaboration with group E is the basis of this article. It produced interesting results. Group E must be thanked for its transparency. But my feeling is that the authors rely too much on the company’s expertise. It looks like that ultimately it belongs to the company to decide if the authors’ analyses are relevant or not. The authors should be a little more critical.

We agree and will change the text to be more critical of how our projections may be used by Group E.

Moreover, the company’s judgments depend on its strategy, which is not presented in the article.

Although Groupe E has been very transparent with us, their future strategies are not meant to be made public. Specific language about their future investments was purposely removed from the manuscript. We will work with our two Groupe E contacts (who are co-authors on this manuscript) in order to expand our discussion of Groupe E’s strategies where we can. We will also make clearer that Group E’s future strategy is confidential and cannot be fully disclosed in this paper.

The authors state: “This study illustrates the benefits of involving stakeholders in hydropower climate change impact studies”. In fact, only one stakeholder was involved in this study, i.e. a power company. It would have been more interesting to highlight the perception of different stakeholders (public bodies, environmental organizations, local communities, etc.) on these issues, as well as their convergences and divergences.

We agree that the inclusion of more stakeholders, public bodies, and environmental organizations would be an exciting and valuable way to move forward. It is not within the scope of this current project to include these additional complexities to the study. Nonetheless, this point will be elaborated upon within Section 5.4. This is indeed an important next step, and it so happens that the first author has a new project already underway to explore this level of collaboration and complexity within streamflow and water demand forecasting (within Australia).

The authors stress the importance of their results in the context of the negotiations of the concessions renewal, residual flows and water fees. However, in order to develop a strategy, one has to understand the point of view of the main stakeholders involved. For instance, I imagine that the Groupe E's request that "residual flow requirements should not increase or find a middle ground given the future behavior of low flows entering their reservoirs", will be challenged by stakeholders primarily concerned by environmental issues.

Our aim was to give Groupe E a first insight into the impacts of climate change on the inflow entering their reservoir and into possible changes in energy demand based on air temperature. It is true that Groupe E will likely face challenges from stakeholders during the negotiation process. We will develop our text further to reflect the need for future research that incorporates the viewpoints and concerns of all main stakeholders. We will also reiterate that the challenge of concession negotiations has multiple facets and that our focus in this study is to support these negotiations with climate change impact assessments using a bottom-up methodology.