Brookfield Renewable Case Study

Application of the Delta Method to the Penobscot and Susquehanna Watersheds for Future Climate Change Hydrology Scenarios

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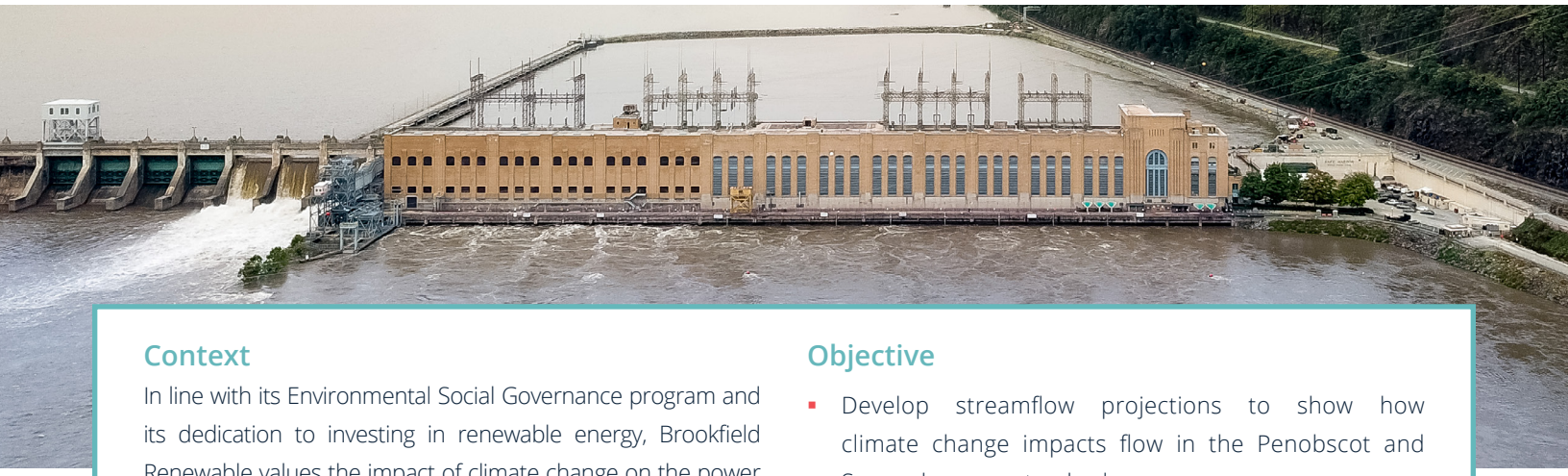


Context

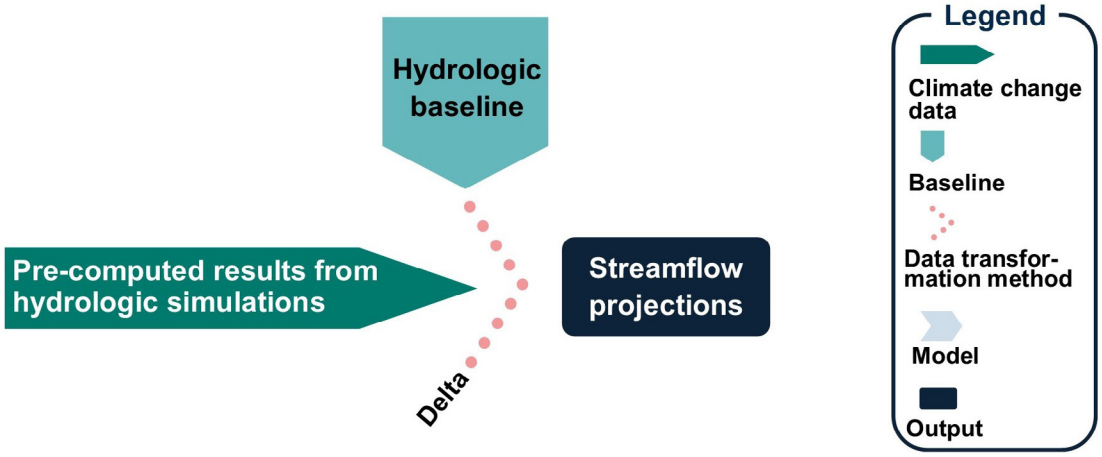
In line with its Environmental Social Governance program and its dedication to investing in renewable energy, Brookfield Renewable values the impact of climate change on the power generation potential of hydroelectric assets. The purpose of the case study is to show how the delta method described in Ouranos's Guidebook on Valuation of Hydropower Assets and Climate Change Physical Impacts (Fournier et al., 2020) can assist in developing streamflow projections under climate change scenarios. The case study was conducted on the Penobscot and Susquehanna watersheds, where Brookfield Renewable owns and operates many hydropower assets.

Objective

- Develop streamflow projections to show how climate change impacts flow in the Penobscot and Susquehanna watersheds.
- Demonstrate the applicability of the delta method and its ability to apply a pre-computed climate change hydrology scenario to a hydrology baseline and obtain future climate change streamflow projections.

Approach

The delta method involves a perturbation of the baseline using the relative or absolute change between the simulated reference and future periods within a given simulation integrating climate change. The perturbation is based on a pre-computed climate change impacted hydrologic scenario. The scenario is the product of a previously completed case study and was subjected to validation techniques to ensure it is applicable to the hydrology baseline.



Results

The case study was applied to two American watersheds: Penobscot (New England region) and Susquehanna (Atlantic seaboard). Literature review yielded two studies presenting pre-computed climate change hydrology scenarios: Hayhoe (2007) and Johnson (2015). The Hayhoe article computes its climate change hydrologic scenario with an estimated increase in runoff, while the Johnson article computes its climate change hydrologic scenario with an estimated increase in flow.

The pre-computed simulations were assessed by comparing them with the historical baseline flows from Brookfield Renewable, based on their average flows and standard deviations. To confirm the adequacy of the pre-computed climate change hydrology simulations, the difference between the average flows and between the standard deviations should each be less than 25%.

For the application of the Johnson (2015) article, the pre-computed climate change hydrologic scenarios came from the Merrimack and the Susquehanna watersheds, which were applied to the Penobscot and Susquehanna watershed baselines, respectively. The Merrimack watershed scenario passed the validation test, with differences in average streamflow of less than 15% and in standard deviation of approximately 20% compared to the Penobscot watershed's historical baseline flow. The Susquehanna watershed scenario was also deemed adequate, with a difference of approximately 25% between the historical baseline flows. However, the Hayhoe (2007) scenario was deemed inadequate, as the differences exceeded 25%.

Once the Johnson (2015) article results were successfully validated, the delta method was applied to the historical Penobscot and Susquehanna watershed baselines to obtain future climate change hydrologic projections. The average flow perturbations applied to the Penobscot and Susquehanna watersheds were +0.4% and +0.2%, respectively.

These estimated increases in flow represent valuable information that will help Brookfield Renewable make long-term business decisions related to investments, contract renewals, asset refurbishments and environmental interventions. However, a more in-depth analysis should be conducted to obtain more precise results.

Lessons learned

- The application of the case study worked best when using flow rather than runoff. Additionally, the watersheds used for the pre-computed and the baseline scenarios should be comparable to obtain valid results.
- The granularity and details of the applied perturbation depend on those of the selected studies.
- The delta method is fast, easy and convenient to use. However, the novice practitioner can get lost in the literature review (i.e. finding studies to establish the perturbation factor). The method would benefit from the establishment of a library of relevant studies.
- Criteria to establish hydrologic similarity between watersheds are very simple, yet only a limited number of reference watersheds is available. This restricts the extent to which the method can be applied. The method would gain from further studies on additional basins.

Reference

This case study was developped as part of the Guidebook: Fournier, E., Lamy, A., Pineault, K., Braschi, L., Kornelsen, K., Hannart, A., Chartier, I., Tarel, G., Minville, M. et Merleau, J. (2020). Valuation of Hydropower Assets and Climate Change Physical Impacts A Guidebook to Integrate Climate Data in Energy Production for Value Modelling, Ouranos, Montréal, 208 pages.

Hayhoe, K., Wake, C. P., Huntington, T. G., Luo, L., Schwartz, M. D., Sheffield, J., ... & Troy, T. J. (2007). Past and future changes in climate and hydrological indicators in the US Northeast. Climate Dynamics, 28(4), 381-407. https://doi.org/10.1007/s00382-006-0187-8

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