Manitoba Hydro Case Study

Exploring Climate Change Considerations for Evaluating Generating Station Upgrades

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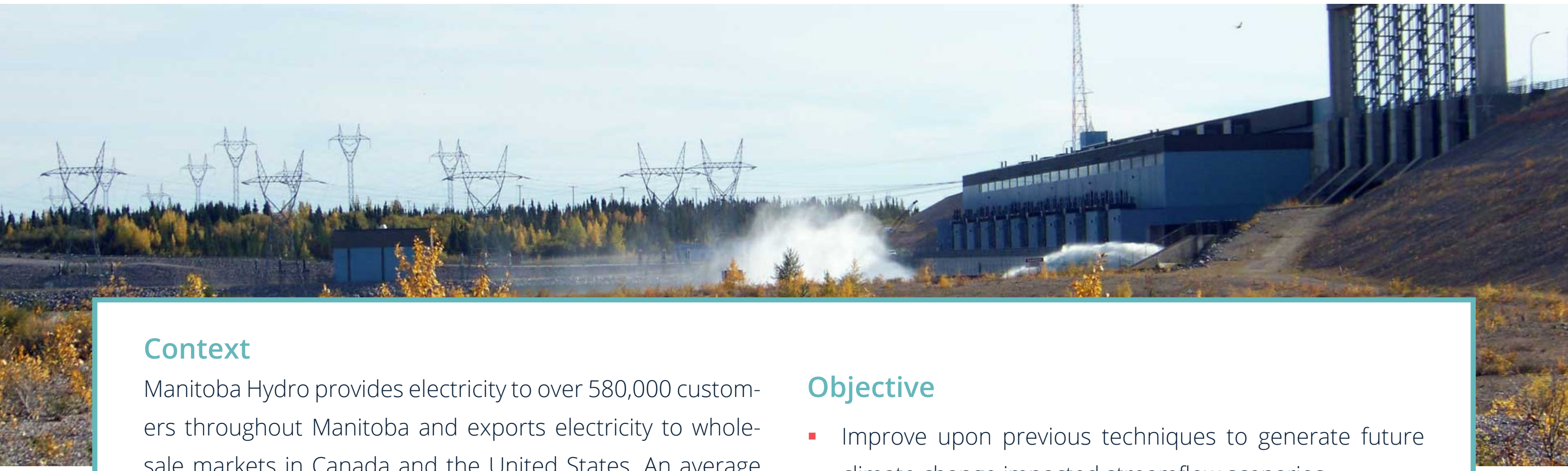


Context

Manitoba Hydro provides electricity to over 580,000 customers throughout Manitoba and exports electricity to wholesale markets in Canada and the United States. An average of 96 per cent of the electricity it generates annually comes from 15 hydroelectric generating stations, primarily on the Winnipeg, Saskatchewan and Nelson rivers.

With guidance from Ouranos, Manitoba Hydro Water Resources Engineering and Resource Planning professionals collaborated to explore the integration of climate change scenarios into existing hydrological modelling and resource planning modelling frameworks. This exercise merged climate science with industry practices to explore the topic pragmatically.

Objective

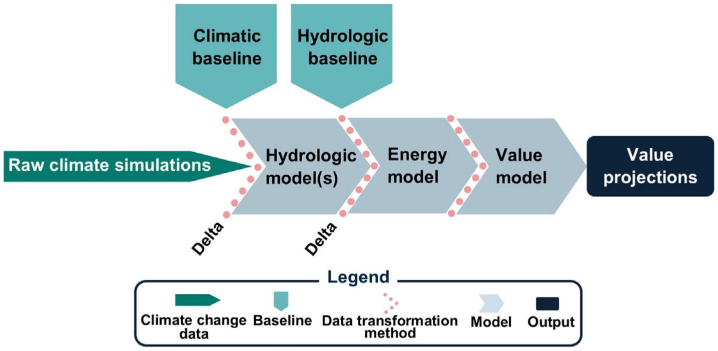
- Improve upon previous techniques to generate future climate change impacted streamflow scenarios.
- Generate future streamflow scenarios and test how these may be used in resource planning.
- Explore the impact of future streamflow scenarios on a potential generating-station upgrade.
- Investigate the process to integrate future streamflow scenarios into resource planning models.

Approach

Starting with an ensemble of 40 climate model simulations (Manitoba Hydro, 2020), projected changes in precipitation, minimum, and maximum temperature were combined with a climatic baseline to generate future climate scenarios for the 2050s across the Nelson-Churchill watershed (1.4 million km^2). Future climate scenarios were then used to drive WATFLOOD distributed hydrologic models to produce future streamflow scenarios.

Uniquely positioned with Long Term Flow Data (LTFD; 106 year hydrologic baseline), the approach was tailored to use LTFD, which is fundamental to resource planning studies. WATFLOOD streamflow scenarios were used to develop a set of quantile-based future flow correction factors (deltas) to assess changes in means, extremes and variability. Deltas were applied monthly, seasonally and semi-annually to generate future LTFD scenarios.

To best utilize computational and staff resources, cluster analysis was used to select a subset of six future LTFD scenarios that represent a broad range of energy-production impacts. The subset was used to drive a suite of resource planning models to evaluate energy and economic impacts of various upgrade options under future streamflow scenarios.



Results

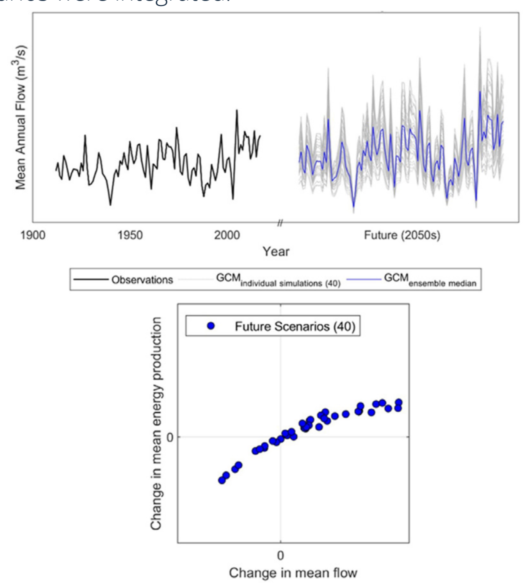
WATFLOOD hydrologic models were developed and calibrated to a range of historical conditions. Due to uncertainties in simulating future regulation, models were configured to simulate natural conditions at key flow index locations.

Adjustment factors from quantile maps, comparing baseline to future (2050s; 2040-2069) WATFLOOD output, were applied to create future LTFD scenarios. Due to the LTFD record length, a de-trending/re-trending approach was followed, but this step remains an area for further study.

Overall, the ensemble of 40 future LTFD scenarios tend towards wetter conditions, but some scenarios indicate decreasing flows. Using a screening level energy production model, LTFD scenarios were evaluated for changes in mean annual energy production. Results show that flow increases generally lead to increases in energy production but begin to plateau as flows approach powerhouse capacities. A cluster analysis algorithm was used to select a sub-set of six scenarios for further analysis, capturing 97.3% of the ensemble range in future energy production change. The sub-set is important since it is computationally and time prohibitive to evaluate all scenarios in a detailed resource planning modelling framework.

The sub-set of future LTFD scenarios were run through a suite of resource planning tools. LTFD scenarios were first run through a coarser resolution system wide production model which simulates reservoir operations, electricity generation and export revenue using inputs such as a load forecast, export price forecast and operational limitations. Outputs from this model inform a production model with representation of individual generating station unit operations. For exploratory purposes, climate change impacts are considered in isolation of other effects, as only LTFD and upgrade options were changed from baseline conditions.

This process allows testing of various generating station upgrade options for comparison against one another under baseline conditions and with climate change. In this preliminary work, upgrade options were found to be economically robust using baseline LTFD and when future climate change scenarios were integrated.



Lessons learned

- Early collaboration between areas of expertise (climate science, hydrology, energy-production modelling) was instrumental in project execution and in refining the methodology.
- While many sources of uncertainty exist in hydrologic and energy modelling, exploring the scope of impacts coming from future climate scenarios can be a valuable sensitivity analysis.
- While climate change impacts on streamflow can affect project economics, other factors, such as capital costs, energy prices and discount rate were found to be more significant factors.
- Multi-year hydrological drought plays an important role in long-term resource planning. Understanding the climate change impacts on these unique extreme events is of interest for future work.

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

Manitoba Hydro (2020, March). Manitoba Hydro's Climate Change Report. https://www.hydro.mb.ca/environment/pdf/climate_change_report_2020.pdf