The Growth of Non-Hydro Renewables and Canada's Electricity System

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Overview

Canada's electricity system is in transition, with one of the key changes being the integration of more non-hydro renewable sources. Over the past decade, non-hydro renewables such as wind and solar power have grown from very small amounts to now make up a significant part of many provincial electricity grids. Growth in renewables is likely to continue, driven by continued falling costs as well as policy initiatives. For example the government of Saskatchewan aims to have 50 per cent of its electricity capacity be renewable by 2030 and Alberta is aiming to have 30 per cent of its electricity generation be renewable by the same time. In the latest National Energy Board Energy Futures 2018 (EF18) report, Canada's installed capacity of non-hydro renewables is projected to reach 34 GW by 2040 in the baseline Reference Case (or 20 % of total installed capacity).

This study expands on the EF18 annual analysis with respect to the growth of non-hydro renewables in Canada's energy system. It expands the temporal resolution from annual to hourly time slices to focus on the opportunities and challenges as additional non-hydro renewables are added to Canada's electricity mix. It primarily focuses on Western Canada given the targets noted above, as well as the potential role renewables may have as Alberta and Saskatchewan phase out their coal generation by 2030.

Methods

The EF2018 projections are developed using the NEB's Energy Futures Modeling System. This includes a variety of modules covering various sections of the energy system based on a common set of assumptions. Modules include: Demand and electricity (using the ENERGY2020 energy systems model), crude oil and natural gas production (using NEB developed models), and macroeconomics (provided by Stokes Economics).

The electricity supply and demand projections created by ENERGY2020 are made at an annual level. For the purpose of this study we took the annual results for Alberta and Saskatchewan and extrapolated them down to an hourly resolution. A combination of PyPSA, a Python based electricity optimization model, and the NEB's supplementary tools are used to provide an hourly generation profile to compliment the EF18 annual outlook. An optimal power flow for Western Canada is generated by PyPSA, with simulated variable wind and solar generation used as an input into the model.

Results

On a national level, in 2015 non-hydro renewables accounted for 10% of total installed capacity, this more than doubles by 2040 in the EF18 Reference Case. The EF18 Technology Case explores a scenario where the globe shifts towards a lower carbon economy. More aggressive assumptions on cost declines for wind and solar are key elements of this scenario. In the Technology Case installed capacity for solar and wind reach 11 GW and 33 GW respectively by 2040. The shift towards wind and solar causes Canada's already low emitting electricity sector to become even greener.

The deployment of renewables varies greatly between regions, for example, half the solar capacity in 2040 comes from Ontario alone and the majority of wind additions are from Alberta and Saskatchewan. In the Reference Case, Alberta's installed wind capacity increases from 0.5 GW in 2015 to 7.5 GW in 2040. While Saskatchewan's wind capacity goes from 0.2 GW in 2015 to 3.0 GW in 2040. The high penetration of renewable wind generation in Western Canada poses challenges. For example, Alberta's grid is characterized by high base load demand, making it less flexible in accommodating the intermittency of wind generation, a similar situation also arises in Saskatchewan. During hours of high wind generation, curtailment of generation may be needed to balance the grid. This has already been seen in Ontario, with curtailments being required during certain hours. Additionally, when simulating subsequent hours of highly variable wind generation, the remainder of the generating fleet is forced to ramp up and down in a manner which may not be feasible.

Potential solutions to these problems include electricity storage and increased firm hydro imports from neighboring provinces. Different levels of storage are modelled using varying cost assumptions. Storage technology is found to be a viable solution in complementing renewable generation if its costs are low enough.

Conclusions

EF18 projects that non-hydro renewables to become an increasingly large part of Canada's electricity mix, and the diversification of Canada's energy mix as a whole. In both the baseline Reference Case and low-carbon transition Technology Case, wind and solar electricity increases. This paper finds that increasing temporal resolution on the capacity and generation mix reveals potential system challenges such as those described above. It also finds that there are a variety of ways to deal with challenges.

References

PyPSA - https://pypsa.org/

National Energy Board (2018). *Canada's Energy Future: Energy Supply and Demand Projections to 2040*. Available: http://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2018/index-eng.html