V2G and G2V smart grid optimization study in a Renewable-Fossil Based Energy System for Northern WECC

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Research Question

- How EV batteries can be utilized for larger renewable penetration
- How can a smart grid concept enable EVs to be utilized as storage devices for larger renewable integration into the grid
- What is the effect on transmission lines when EV charging location is far from wind generation regions

Methods and Data

- A mixed-integer multi-objective optimization model is developed on MESSAGE (Model for Environmentally Compatible Energy Supply Strategies and their General Environmental Impacts) platform to connect the supply and demand in an integrated energy system including EVs
- Assuming EV vehicles reaching 100,000 by 2020 in Vancouver, BC.
- BC and Alberta are divided into 8 geographical regions, each bus representing demand for the region
- Resolution of time slices is hourly for 8760 hours of the year enabling hourly smart grid decisions
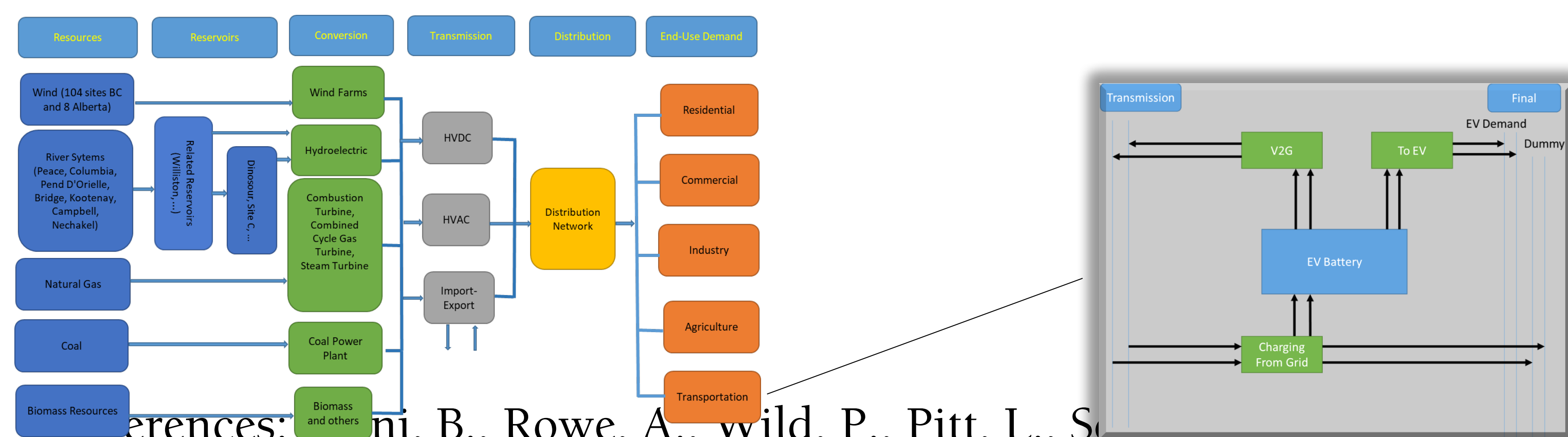
References: Kiani, B., Rowe, A., Wild, P., Pitt, L., Sopinka, A., Pedersen, T. F. (2013). "Optimal electricity system planning in a large hydro jurisdiction: Will British Columbia soon become a major importer of electricity?" Energy Policy, Vol. 54, March 2013, pp. 311-319
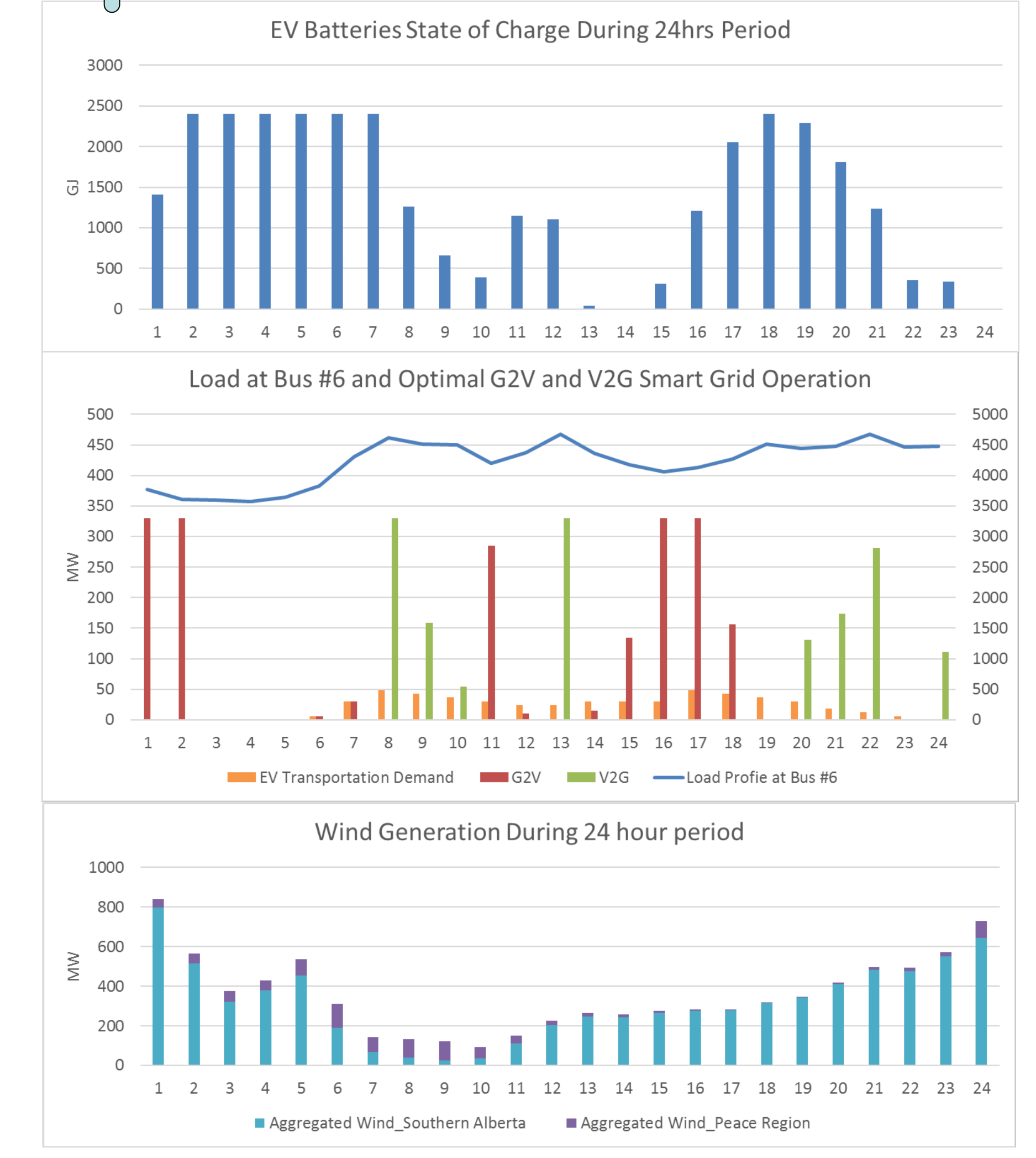
Results

- Hourly optimized V2G and G2V smart grid operation are obtained for 8760 hours during 2020
- Optimization results for two sample days are shown below
- Many other factors such as hydro-electric generation, transmission lines between regions, losses, etc. have impact on the results
- The optimal results show logical decisions between peak load, wind generation and off-peak load for smart grid G2V and V2G operations.

Hourly Optimization Results for Jan 6th, 2020
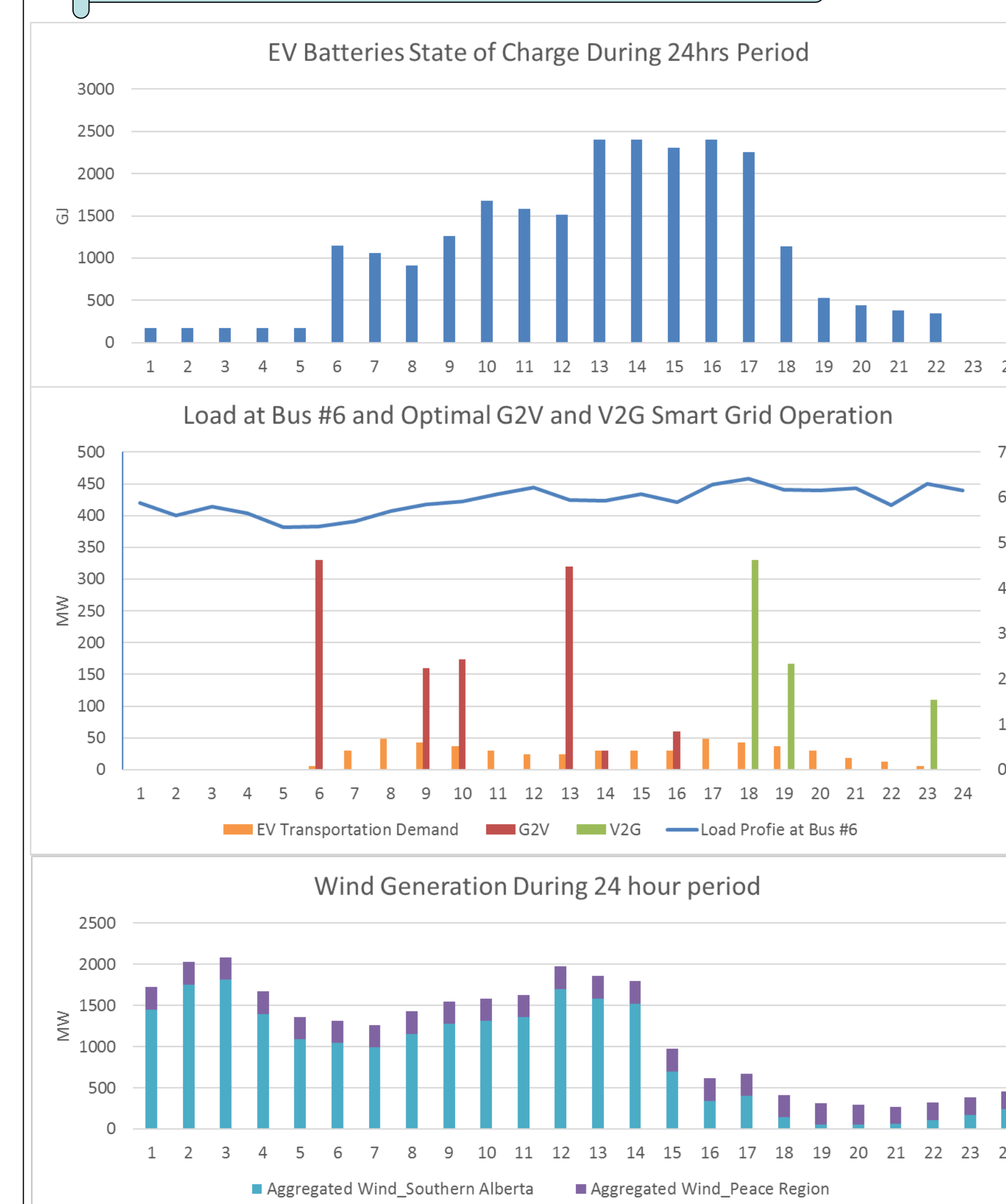
Hourly Optimization Results for June 4th, 2020

This study was done for EVs in Vancouver, BC. The results show that utilizing EV batteries lowers the total cost of operating the renewable based grid

Future Work: CA Study

- In California, beside wind, there is also large solar generation. This results in a deeper "duck curve" shape of the net load, d.t. increased renewables.
- STEPS researchers are now starting a project on environmentally compatible transportation technologies in California focusing on EV and hydrogen in the transportation sector, to utilize their storage capability for more renewable energy penetration.
  - Expand BC study methods to California's renewable intensive market & ultimately US nationwide.
  - Conduct a thorough study considering more energy storage possibilities, and focus on the transportation sector.

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