University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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MASc (University of Victoria, 2014)
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"Energy modelling for low carbon pathways for the electricity and transportation systems in British Columbia and Alberta"

Department of Mechanical Engineering

Wednesday, July 17, 2019
9:00 A.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Andrew Rowe, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Peter Wild, Department of Mechanical Engineering, UVic (Co-Supervisor)
Dr. Bryson Robertson, Department of Mechanical Engineering, UVic (Member)
Dr. Christopher Kennedy, Department of Civil Engineering, UVic (Outside Member)

External Examiner:
Dr. Rupp Carriveau, Department of Civil and Environmental Engineering, University of Windsor

Chair of Oral Examination:
Dr. Adel Guitouni, Peter B. Gustavson School of Business, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Currently, the electricity, heat and transport sectors are responsible for 40% of all global greenhouse gas emissions. To avoid intensification of anthropogenic climate change, emissions from these sectors must be significantly decreased in the coming decades. This dissertation focuses on pathways to low-carbon futures for the electricity and transport systems using the Canadian provinces of British Columbia and Alberta as case studies. Firstly, a model of the Alberta system is used to study coal-to-biomass conversion as a means to achieve mid term renewable energy targets at lower cost. Results show that meeting a 30% renewable energy target by 2030 with a 7% share of bioenergy leads to electricity system cost reductions of 5%, compared to a system where this target is met predominantly with wind generation. Further, it is shown that although bioenergy has a higher unit energy cost than wind, a small share of bioenergy leads to lower system cost due to lower backup capacity needs.

The second study focuses on the conversion of the Alberta heavy duty transport system to battery electric or fuel cell vehicles with and without carbon taxes and assesses the impact of electrification on buildout of electricity generators, costs and emissions. It is found that without carbon taxes, electrifying the heavy duty transport sector leads to a combined electricity system and heavy duty transport system cumulative emission reduction of only 3% by 2060, in the best case, relative to a scenario where electrification does not take place. However, when a carbon tax of $150/tCO2e is applied, cumulative emission reductions of up to 43% are achieved. Further, it is found that although overall electricity demand is 10% higher in scenarios with fuel cell vehicles, compared to scenarios with battery electric vehicles, system costs may be up to 4% lower. The flexibility provided by electrolysers enables the buildout of low cost solar generators which leads to this cost savings.

Finally, the third study focuses on the electrification of all modes of road transport in British Columbia with and without a 93% renewable energy penetration target. Varying levels of controlled charging are assessed as a method to manage variability of wind and solar photovoltaic generators. Model results show that the electricity system capacity doubles by 2055, relative to current values, to accommodate growing electricity demand associated with population growth, industry expansion and electric vehicles. Furthermore, use of utility controlled charging leads to a decrease in excess electricity generation and lower capacity installation, however, no further decrease in excess energy is achieved for a utility controlled charging with a participation rate of 30% of the vehicle fleet.