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

of

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MASc (University of Victoria, 2001)
BEng (University of Victoria, 1998)

“Mitigating Risk of Emissions in Energy Planning
and the Operational Implications”

Department of Mechanical Engineering

Thursday, October 25, 2018
1:00 P.M.
Clearihue Building
Room B007

Supervisory Committee:
Dr. Andrew Rose, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Peter Wild, Department of Mechanical Engineering, UVic (Co-Supervisor)
Dr. Brad Buckham, Department of Mechanical Engineering, UVic (Member)
Dr. Jens Bornemann, Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. David Wood, School of Engineering, Mechanical and Manufacturing, University of Calgary

Chair of Oral Examination:
Dr. Alison MacIntosh, Department of Anthropology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies
Abstract

There is increasing imperative to reduce emissions from global energy systems to avoid catastrophic climate impacts. Much of the work on how countries can meet their emissions reduction targets assumes perfect knowledge of the emissions from energy technologies. This dissertation first implements a model that takes into account emissions uncertainties and evaluates the impacts considering uncertainty has on the long term system build out. It is found that an early build out of wind energy reduces the risk of exceeding emissions targets. Given the requirement of high penetrations of wind energy for reducing emissions risk, the second part of this dissertation evaluates the impact that high penetrations of wind energy have on system operations, and the value that storage and dispatchable loads can provide. Finally, this dissertation evaluates the impact that synchronous generation constraints have on system operation, and the optimal operation of storage. All three models are applied to the Alberta, Canada electricity system as a case study.

It is found that building out wind 5 years earlier for Alberta decreases the risk of missing emissions targets. Allowing nuclear energy in the system results in a lower overall cost and a reduced risk of missing emissions targets. To evaluate the impact that an early and large build out of wind has on the system a medium term model is developed that incorporates curtailment costs into the system operation. This shows that storage and dispatchable loads have the potential to reduce curtailment in the system and that including curtailment costs increases the value provided by between 10 and 60%. The value provided by storage for Alberta is very high at small installed capacities and diminishes with increased capacity while the value provided by dispatchable loads has a much more consistent value at different installed capacities. Finally, when the instantaneous penetration of renewable energy in the system is restricted, it is found that storage for integration of wind generation does not operate in a pre-defined manner but switches between peak shaving and wind shifting depending on the wind resource available in any given week.