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, 2011)
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"Computational Tools for the Adaptation of Energy Systems to Climate Change and Water Resource Constraints"

Department of Mechanical Engineering

Wednesday, November 30, 2016
9:00 A.M.
Engineering Office Wing
Room 108

Supervisory Committee:
Dr. Ned Djilali, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Andrew Rowe, Department of Mechanical Engineering, UVic (Member)
Dr. Tom Gleeson, Department of Civil Engineering, UVic (Outside Member)

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Dr. Doug Magnuson, School of Child and Youth Care, UVic

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Abstract

Energy systems are increasingly vulnerable to the effects of climate change and water resource variability. Yet, the majority of long-term energy infrastructure plans ignore adaptation strategy. New analytical approaches are needed to address the complex challenge of assessing energy systems at spatial and temporal scales relevant to both climate change and water resources. This dissertation focuses on the development of a number of enhanced computational tools for the adaptation of energy systems to climate change and water resource constraints. Conventional engineering-economic energy planning tools are extended to incorporate: (1) robust capacity decisions in light of impacts from Hydroclimatic change and uncertain environmental performance of technology options; (2) an endogenous representation of water systems and feedbacks with energy demand; and (3) extension to multi-criteria decision-making. The developed tools are demonstrated within four regional case study analyses. Application of the robust adaptation planning framework to the power system in British Columbia, Canada, reveals technology configurations offering long-term operational flexibility will be needed to ensure reliability under projected climate change impacts to provincial hydropower resources and electricity demand.

The imposed flexibility requirements affect the suitability of technology options, and increases the cost of long-term electricity system operation. The case study analysis then focuses on the interaction between groundwater conservation and concurrent policy aimed at reducing electricity sector carbon emissions in the water-stressed country of Saudi Arabia. Application of the novel water-energy infrastructure planning framework reveals that transitioning away from non-renewable groundwater use by the year 2050 could increase national electricity demand by more than 40 % relative to 2010 conditions, and require investments similar to strategies aimed at transitioning away from fossil fuels in the electricity sector. The research in this dissertation demonstrates the crucial need for regional planners to account for adaptation to climate change and water resource constraints when developing long-term energy strategy, and offers improved tools for its integration into engineering practice.