University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

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BSc (Université Laval, 2017)

"Methods for Assessing the Economic Viability of Stand-Alone Hybrid Renewable Energy Systems"

Department of Mechanical Engineering

Wednesday, August 28, 2019
10:00 A.M.
Engineering Office Wing
Room 106

Supervisory Committee:
Dr. Curran Crawford, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Bradley Buckham, Department of Mechanical Engineering, UVic (Co-Supervisor)

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Dr. Justin Albert, Department of Physics and Astronomy, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The addition of renewable energy in a previously diesel-powered off-grid microgrid results in what is known in the field as a *Stand-Alone Hybrid Renewable Energy System* (HRES). The electrification of Canadian remote communities is a near-term target of both federal and provincial governments. Not only does it reduce environmental hazards like leaks, spills and air pollution, but the combination of renewable energy and fossil fuel generators increases stability and lowers the cost of electricity. It is deemed a crucial step towards a clean energy future, but also a necessity in the reconciliation process with Indigenous Peoples of Canada – many of which inhabit off-grid communities.

To be successful, HRES need to be carefully planned; the variable and uncertain behaviour of natural resources add a level of complexity to the preliminary design stage. Energy systems are therefore simulated and optimized to estimate the lifecycle cost by determining the nature and capacity of their components and their operational strategy. Many modelling tools are available, ranging from full-factorial and linear optimization techniques that can solve single-objective problems, to meta-heuristic algorithms. One of the distinction between different HRES modelling tools is the foresight horizon being used. The foresight approach is usually inherently built into a tool and cannot be modified by the user. Linear programming tools commonly have a perfect foresight over the typical year analysed, for both demand and natural resources. This can lead to an overly optimistic prediction of the lifecycle cost of a system when the reality of implementations comes with uncertainties. On the other hand, tools that use myopic foresight, or no knowledge of future parameters, can lead to pessimistic lifecycle cost estimates since the demand and power output of certain renewable energy technologies, like solar panels, can be known within a few hours. The purpose of the second chapter of this thesis is to guide readers towards the right tool in the context of energy system modelling for the preliminary design of HRES.

The use of energy system modelling tools is often reserved for highly qualified personnel and is therefore costly for prospective communities. To improve community readiness with minimal investment, a free, simple and quick alternative to energy system modelling is proposed in the third chapter. A series of logical conditions applicable to Canadian communities was demonstrated to inform the viability of a tidal stream turbine project in terms of cost reduction

in comparison to the business as usual scenario. From those results, it was estimated that of the 10 sampled communities in British Columbia, four could install tidal stream turbines with savings on the cost of electricity of 10 % or more.

The long-term objective of this work is to provide remote communities with an integrated, affordable, and turnkey solution for the displacement of diesel in their energy systems. The next steps in achieving this include augmented optimization tools to quantify and capture non-monetary value so that the modelling and multi-criteria decision-making steps of the design process can be bridged together.