Designing Sustainable Distributed Generation Systems for Rural Communities

An Application of Optimisation Modelling and Decision Analysis to include Sustainability Concepts and Uncertainty into Design Optimality

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Abstract

The deregulation of the electricity supply industry in New Zealand has led to an increased level of interest in the security of electricity supply to rural communities. This in turn has led to questions about sustainable alternatives to conventional methods of electricity supply. A solution may be the adoption of sustainable community sized renewable energy (RE) based distributed generation systems. However, choosing between the myriad of possibilities requires much data and analysis.

An accurate analysis of electricity load and RE resource matching is normally required. In most cases, this is an expensive and time-consuming assessment. In order to minimise these costs, and yet give due consideration to stakeholder preferences and technical uncertainty, a process incorporating the economic, social, environmental, and technical aspects of sustainable design in a relatively short timeframe will be required.

This study developed such a method through the integrated use of the wind atlas assessment and analysis program (WAsP), the micropower optimisation model (HOMER), and three methods of decision analysis using Logical Decisions for Windows (LDW) software, which formed the decision analysis framework, SPiRAL (Sustainable Power in Rural Areas and Locations).

The efficacy of the integrated use of the software in the SPiRAL framework was tested through two analyses using electricity load and RE resource data from a case study site. The first was an analysis using a full-year of data in a multi-method decision analysis process thus setting the framework in place. A further analysis then tested the minimum monitoring time required to obtain and analyse the data for modelling meaningful results.

In both analyses, the results were ranked based on stakeholder preferences between the economic, social, environmental, and technical aspects of sustainable energy systems. The clear representation of the uncertainty of the electricity loads and the RE resources was paramount in the results. The short-term analysis results differed in small ways from the full-term, but were essentially similar.

This study developed a decision analysis framework that delivered transparent results in a manner likely to instil insight and confidence in them, and this would provide the decision-maker with much valuable information on which to base their decision.

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Sir Isaac Newton said "If I have seen further, it is by standing on the shoulders of giants". It is in this same light that I would like to acknowledge the ever ready and willing assistance I received throughout this research and without which, it would not have been as rewarding, fun or as good as it has been. Therefore, my first thanks must go to my research supervisors – Professor Ralph Sims and Dr John Holland – as much for the benefit of their advice and patience, as for their friendship. My life lately has revolved around some of their decisions, knowledge, and wit. I have enjoyed it very much and am a better person for it.

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