Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.
COMMUNITY OWNED AND OPERATED RENEWABLE ENERGY SCHEMES IN RURAL NEW ZEALAND

A thesis presented in partial fulfilment of the requirements for the degree of Master of Applied Science in Natural Resource Management at Massey University, Palmerston North, New Zealand.

Glenn Irving
2000
Errata

The following references are missing from the reference list:


Shaw, et.al. (1996). Final Year Research Project, Massey University

ABSTRACT

Due to the introduction of the Electricity Act (1992) and its later amendments, the future security of electricity supply to rural New Zealand is under question. Lines companies are legally obliged to maintain supply to existing customers until April 1st 2013, but can disconnect unprofitable customers after this date.

One option for rural customers is to establish their own community owned and operated renewable energy schemes. This study is the first step in identifying the engineering design, ownership, and environmental issues relating to this type of scheme.

Two case study sites – one in the North Island and one in the South Island – differed in their remoteness, population density and primary income sources.

Solar radiation and wind was measured at both sites. Power consumption data was also obtained from meters installed at the sites by Industrial Research Limited.

A review of legal ownership structures suitable for community owned electricity generation schemes was made and recommendations given from a New Zealand lawyer. Environmental issues associated with the development of electricity generating plants were identified, along with the implications of the Resource Management Act for renewable energy schemes.

A computer model was designed to assist a community in understanding the supply options available. It is based on present day costs of system components, and is designed to give maximum flexibility of design to the model user depending on resource availability.

For each site a number of options were identified and the costs of these options quantified. Comparisons were made between the options to identify the best for the site.
Acknowledgements

Although this thesis has been written by me, it has been contributed to by many. In order to unravel the complexities of a community owned renewable energy scheme I have had to work with people from many different sectors of society. There are far too many to name, so generalised acknowledgements will have to suffice.

First thanks goes to my wife, Lynn, for her unwavering support, and giving me the freedom to carry out a research project that involved so much travel.

To the team at Powerflow Ltd., for welcoming me into their company and providing me with some very valuable work experience. Thanks also for covering the costs of travel and equipment and for all the advice.

To my supervisors, Assoc. Prof. Ralph Sims and Dr. John Holland, for all their advice, time and expertise.

To Technology New Zealand, for the GRIF Scholarship that enabled me to work with Powerflow Ltd. on this project.

To the communities of Kumeroa, D'Urville Island, and Akitio for their hospitality and willingness to provide me with the information I required.

To God, who gave me the opportunity to work on a thesis that was enjoyable, challenging, rewarding and will hopefully be of use to many remote rural communities throughout New Zealand in the future.

"Coming together is a beginning
Keeping together is progress
Thinking together is unity
Working together is success"

Anonymous
Table of Contents

1 INTRODUCTION

1.1 ELECTRICITY IN NEW ZEALAND TODAY 1
1.2 FACTORS INFLUENCING THIS STUDY 1
1.3 THE PRESENT ROLE OF RENEWABLE ENERGY SOURCES IN NEW ZEALAND 3
1.4 OBJECTIVES 4
1.5 SCOPE 5
1.6 REPORT STRUCTURE 6

2 DISTRIBUTED POWER SUPPLY SYSTEMS - LITERATURE REVIEW 8

2.1 THE HISTORY OF RURAL ELECTRICITY RETICULATION IN NEW ZEALAND 8
2.1.1 THE PRESENT SITUATION 10
2.2 COMMUNITY OWNED RENEWABLE ENERGY SCHEMES 11
2.2.1 OVERSEAS EXPERIENCE 12
2.2.2 COMMUNITY STRENGTHENING 13
2.2.3 URBAN DRIFT 13
2.2.4 PROJECT OWNERSHIP AND LEADERSHIP 14
2.2.5 CONSULTATION 15
2.3 RELEVANT LAW 18
2.3.1 ELECTRICITY ACT 1992 18
2.3.2 ELECTRICITY INDUSTRY REFORM ACT 1998 18
2.3.3 RESOURCES MANAGEMENT ACT (RMA) 1991 19
2.4 RENEWABLE ENERGY - THE DESIGN PROCESS 21
2.4.1 DESIGN PROCESS OVERVIEW 21
2.4.2 LOADING PATTERNS 23
2.4.3 SOLAR ENERGY 25
2.4.4 WIND ENERGY 28
2.4.5 MICRO-HYDRO ENERGY 34
2.4.6 POWER MANAGEMENT - STORAGE, REGULATION AND INVERTING 38
CASE STUDY SITE DESCRIPTION

CASE STUDY COMMUNITY 1 – TOTARA VALLEY
3.1.1 REASONS FOR INCLUSION IN THE STUDY
3.1.2 LOCATION
3.1.3 PROPERTIES

CASE STUDY COMMUNITY 2 – D'URVILLE ISLAND
3.2.1 REASONS FOR INCLUSION IN THE STUDY
3.2.2 LOCATION
3.2.3 TOPOGRAPHY AND GEOLOGY
3.2.4 POPULATION
3.2.5 EXISTING COMMUNITY STRUCTURE

CASE STUDY COMMUNITY 3 – AKITIO
3.3.1 REASONS FOR INCLUSION IN THE STUDY
3.3.2 TOPOGRAPHY
3.3.3 POPULATION
3.3.4 PROPERTIES
3.3.5 INCOME SOURCES

4 HOUSEHOLD QUESTIONNAIRE

4.1 QUESTIONNAIRE SAMPLE
4.1.1 TOTARA VALLEY
4.1.2 D'URVILLE ISLAND
4.1.3 AKITIO

4.2 METHOD OF ADMINISTRATION

4.3 QUESTIONNAIRE DESIGN

4.4 PILOT QUESTIONNAIRE

4.5 FINAL QUESTIONNAIRE
4.5.1 TOTARA VALLEY
4.5.2 AKITIO
4.5.3 D'URVILLE ISLAND
4.5.4 SURVEY RESPONSE RATE

4.6 RESULTS AND DISCUSSION
4.6.1 TOTARA VALLEY
4.6.2 D'URVILLE ISLAND
4.6.3 AKITIO
5 LEGAL OWNERSHIP

5.1 LEGAL STRUCTURES SUITABLE FOR COMMUNITY ENERGY SCHEMES
5.2 OPTIONS FOR NEW ZEALAND COMMUNITIES
5.3 INCORPORATED SOCIETIES
5.3.1 THE EFFECTS AND BENEFITS OF INCORPORATION
5.3.2 REGISTRATION REQUIREMENTS
5.4 SPECIAL PARTNERSHIP
5.4.1 CHARACTERISTICS OF A SPECIAL PARTNERSHIP
5.4.2 ESTABLISHING A SPECIAL PARTNERSHIP
5.4.3 MAINTAINING A SPECIAL PARTNERSHIP
5.5 PRIVATE COMPANY
5.5.1 DEFINITION OF A PRIVATE COMPANY
5.5.2 ADVANTAGES AND DISADVANTAGES OF A PRIVATE COMPANY
5.5.3 FORMATION OF A COMPANY
5.5.4 CHARGES
5.6 SUMMARY AND RECOMMENDATIONS

6 THE RESOURCE MANAGEMENT ACT (1991)

6.1 RESOURCE CONSENTS
6.1.1 TYPES OF RESOURCE CONSENT
6.1.2 APPLYING FOR A RESOURCE CONSENT
6.1.3 INFORMATION REQUIRED FOR RESOURCE CONSENT APPLICATION
6.2 TOTARA VALLEY
6.2.1 DESIGNATION
6.2.2 TARARUA DISTRICT PLAN
6.2.3 HORIZONS.MW LAND AND WATER PLAN
6.2.4 CONSENTS REQUIRED
6.3 D'URVILLE ISLAND
6.3.1 DESIGNATION
6.3.2 POLICIES AND OBJECTIVES
6.3.3 RULES
6.3.4 CONSENTS REQUIRED
7 ENERGY RESOURCE AND ELECTRICITY DEMAND

7.1 TOTARA VALLEY
  7.1.1 ENERGY RESOURCES
  7.1.2 ELECTRICITY DEMAND
  7.1.3 ENERGY EFFICIENCY OPTIONS

7.2 D'URVILLE ISLAND
  7.2.1 ENERGY RESOURCES
  7.2.2 ELECTRICITY DEMAND

8 RENEWABLE COMMUNITIES – COMPUTER MODEL

8.1 ELECTRICITY DEMAND
  8.1.1 TARIFFS
  8.1.2 ELECTRICITY CONSUMPTION

8.2 HYDRO RESOURCE AND TECHNOLOGY
  8.2.1 CALCULATIONS PERFORMED
  8.2.2 TURBINE SUPPLIERS AND COST
  8.2.3 RESOURCE CONSENTS

8.3 WIND RESOURCE AND TECHNOLOGY
  8.3.1 REQUIRED INPUTS
  8.3.2 WIND TURBINE DATABASE
  8.3.3 WIND TURBINE SELECTION

8.4 SOLAR RESOURCE AND TECHNOLOGY
  8.4.1 REQUIRED INPUTS
  8.4.2 SOLAR PANEL DATABASE
  8.4.3 PANEL SIZING

8.5 STORAGE, TRANSMISSION AND SITE WORKS
  8.5.1 INPUTS REQUIRED

8.6 ANALYSIS
  8.6.1 ANALYSIS OPTIONS
  8.6.2 SYSTEM OPTIMISATION
  8.6.3 ANALYSIS REPORT

9 RESULTS AND RECOMMENDATIONS

9.1 TOTARA VALLEY
List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1.1</td>
<td>New Zealand’s electrical energy sources in 1998</td>
<td>3</td>
</tr>
<tr>
<td>Table 2.1</td>
<td>A load analysis for a remote dwelling with six residents</td>
<td>25</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Correction factors for the float method of determining stream flow rate</td>
<td>35</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Summary of questionnaire response rates</td>
<td>52</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>Energy resources on D’Urville Island as identified by property owners</td>
<td>59</td>
</tr>
<tr>
<td>Table 5.1</td>
<td>Charges for registering as a company in New Zealand</td>
<td>79</td>
</tr>
<tr>
<td>Table 5.2</td>
<td>Required community size and registration costs for the recommended legal structures</td>
<td>79</td>
</tr>
<tr>
<td>Table 6.1</td>
<td>Type of consent available under the RMA</td>
<td>81</td>
</tr>
<tr>
<td>Table 7.1</td>
<td>Flow measurements at the Totara Stream culvert</td>
<td>97</td>
</tr>
<tr>
<td>Table 7.2</td>
<td>Maximum half hourly average load and total daily electricity consumption during shearing days at Farms 1 and 2</td>
<td>109</td>
</tr>
<tr>
<td>Table 7.3</td>
<td>Peak loads calculated for analysis scenarios</td>
<td>110</td>
</tr>
<tr>
<td>Table 7.4</td>
<td>Head, flow and pipe length measurements for six D’Urville Island streams identified as being suitable for micro-hydro development</td>
<td>112</td>
</tr>
<tr>
<td>Table 7.5</td>
<td>$R^2$ values obtained using different types of trendlines</td>
<td>117</td>
</tr>
<tr>
<td>Table 8.1</td>
<td>Head limits used to determine micro hydro turbine type</td>
<td>124</td>
</tr>
<tr>
<td>Table 8.2</td>
<td>Surface Roughness Coefficients used in the model</td>
<td>126</td>
</tr>
</tbody>
</table>
Table 8.3: Ground reflectivity values used in the model
Table 9.1: Scenarios considered for the Totara Valley community analysis
Table 9.2: Cost of grid connection and renewable energy for Totara Valley scenarios
Table 9.3: Ratio of scenario cost allocated to each farm
Table 9.4: Scenarios considered for the D'Urville Island community
Table 9.5: Results of D’Urville Island analyses
Table 9.6: Annualised costs of options for each community member willing to be part of a renewable energy generating scheme on D’Urville Island
Table 9.7: The percentage of the total system cost allocated to each member

List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1:</td>
<td>Energy consumed by sectors of New Zealand society</td>
<td>1</td>
</tr>
<tr>
<td>Figure 1.2:</td>
<td>New Zealand’s total primary energy production in 1998</td>
<td>3</td>
</tr>
<tr>
<td>Figure 2.1:</td>
<td>Consumers assisted by RERC subsidies</td>
<td>9</td>
</tr>
<tr>
<td>Figure 2.2:</td>
<td>The process of establishing a community owned renewable energy scheme</td>
<td>17</td>
</tr>
<tr>
<td>Figure 2.3:</td>
<td>The process of applying for a resource consent</td>
<td>20</td>
</tr>
<tr>
<td>Figure 2.4:</td>
<td>Flow chart showing the various parts of a renewable energy system and the flow of electricity through the system</td>
<td>21</td>
</tr>
<tr>
<td>Figure 2.5:</td>
<td>Daily loading patterns for a house (a) in mid winter and (b) in mid spring</td>
<td>23</td>
</tr>
<tr>
<td>Figure 2.6:</td>
<td>The photovoltaic effect in a silicon cell</td>
<td>27</td>
</tr>
<tr>
<td>Figure 2.7:</td>
<td>The effects of wind turbulence over various land forms</td>
<td>29</td>
</tr>
<tr>
<td>Figure 2.8:</td>
<td>The relationship between wind speed and the specific power output of a turbine</td>
<td>31</td>
</tr>
<tr>
<td>Figure 2.9:</td>
<td>The power curve of a Windflow 500kW wind turbine</td>
<td>32</td>
</tr>
<tr>
<td>Figure 2.10:</td>
<td>Types of wind turbine</td>
<td>32</td>
</tr>
<tr>
<td>Figure 2.11:</td>
<td>The float method of measuring flow</td>
<td>35</td>
</tr>
<tr>
<td>Figure 2.12:</td>
<td>Turbine selection chart for flows less than 200l/s</td>
<td>37</td>
</tr>
<tr>
<td>Figure 2.13:</td>
<td>Turbine selection chart for flows up to 10,000l/s</td>
<td>37</td>
</tr>
</tbody>
</table>
Figure 2.14: Inverter wave forms

Figure 3.1: Topographic map of the Totara Valley

Figure 3.2: Map of D'Urville Island showing location of permanent residents

Figure 3.3: Topographic map of Akitio

Figure 4.1: Level of objection to sharing electricity with other community members

Figure 4.2: Energy sources used to meet heating and cooling loads

Figure 4.3: Level of satisfaction with present supply

Figure 4.4: View of how the community works together

Figure 4.5: Trust of other community members

Figure 4.6: Involvement in the community through meetings and community newsletters

Figure 4.7: Level of support for a community owned renewable energy scheme

Figure 4.8: Uptake of energy efficient practices

Figure 4.9: Income sources for D'Urville Island

Figure 4.10: Level of objection to supplying other community members with electricity generated on respondents’ properties

Figure 4.11: Level of objection to being supplied with electricity generated on other properties

Figure 4.12: Willingness of respondents to generate electricity on their own properties

Figure 4.13: Energy sources used to meet heating and cooling loads

Figure 4.14: Grid connected customers' satisfaction with their present power supply

Figure 4.15: View of how the community works together

Figure 4.16: Trust of other community members

Figure 4.17: Involvement in the community through meetings and community newsletters

Figure 4.18: Level of support for a community owned and operated renewable energy scheme

Figure 4.19: Uptake of energy efficient practices

Figure 4.20: Income sources of Akitio respondents
Figure 4.21: Level of objection to supplying other community members with electricity generated on respondents' properties 66
Figure 4.22: Energy sources used to meet heating and cooling loads 67
Figure 4.23: Grid connected customers' satisfaction with their present power supply 68
Figure 4.24: View of how the community works together 68
Figure 4.25: Trust of other community members 69
Figure 4.26: Involvement in the community through meetings and community newsletters 69
Figure 4.27: Level of support for a community owned renewable energy scheme 69
Figure 4.28: Uptake of energy efficient practices 70
Figure 7.1: Location of energy resources and buildings 95
Figure 7.2: The culvert used to measure flow in the Totara Stream 96
Figure 7.3: Culvert dimensions 97
Figure 7.4: The second stream identified within the Totara Valley catchment 98
Figure 7.5: The wind monitoring equipment 99
Figure 7.6: Average monthly wind speeds for Totara Valley in 1999 100
Figure 7.7: Windspeed distribution and calculated and optimised Weibull curves for the period 26/02/1999 to 26/02/2000 101
Figure 7.8: Percentage of the monitoring period that the wind blew from each direction 102
Figure 7.9: The solarimeter used to monitor global solar radiation 102
Figure 7.10: Global solar radiation in 1999 103
Figure 7.11: Monthly electricity consumption profile based on Scanpower data 105
Figure 7.12: The author downloading data from Siemens meters 105
Figure 7.13: Electricity consumption profiles for Totara Valley properties 106
Figure 7.14: Electricity consumption during a day of shearing at Farm 1 (20/01/2000) 108
Figure 7.15: Electricity consumption during a day of shearing at Farm 2 (5/12/1999) 109
Figure 7.16: (a) Wind monitoring equipment installed at the D'Urville Island site  
           (b) the view to the saddle where the anemometer was sited  

Figure 7.17: Monthly average wind speed for the D'Urville Island site  

Figure 7.18: Wind speed distribution and calculated and optimised Weibull curves for the period 10/11/1999 to 01/03/2000  

Figure 7.19: Percentage of the monitoring period that the wind blew from each direction  

Figure 7.20: Average daily global solar radiation (10/11/1999 to 01/03/2000)  

Figure 7.21: Scatter plot of D'Urville Island and Nelson Airport hourly average wind speed data (10/11/1999 to 31/12/1999)  

Figure 7.22: Scatter plot of D'Urville Island and Nelson global solar radiation data (11/11/1999 to 29/02/2000)  

Figure 7.23: Average daily global solar radiation levels for D'Urville Island, correlated from historical Nelson Airport data ($R^2 = 0.68$)  

Figure 7.24: Location of properties where load meters were installed.  

Figure 7.25: Annual electricity consumption of 11 D'Urville Island landowners willing to be part of a community scheme  

Figure 8.1: Energy and network tariff input page  

Figure 8.2: Hydro analysis input page  

Figure 8.3: Wind analysis input page  

Figure 8.4: Solar analysis input page  

Figure 8.5: Storage and transmission and site works input pages  

Figure 8.6: Example of a summary report prepared by the computer model  

Figure 9.1: Cost of scenarios to each farm (including water heating))  

Figure 9.2: The location of community members interested in being part of a renewable energy electricity generating scheme