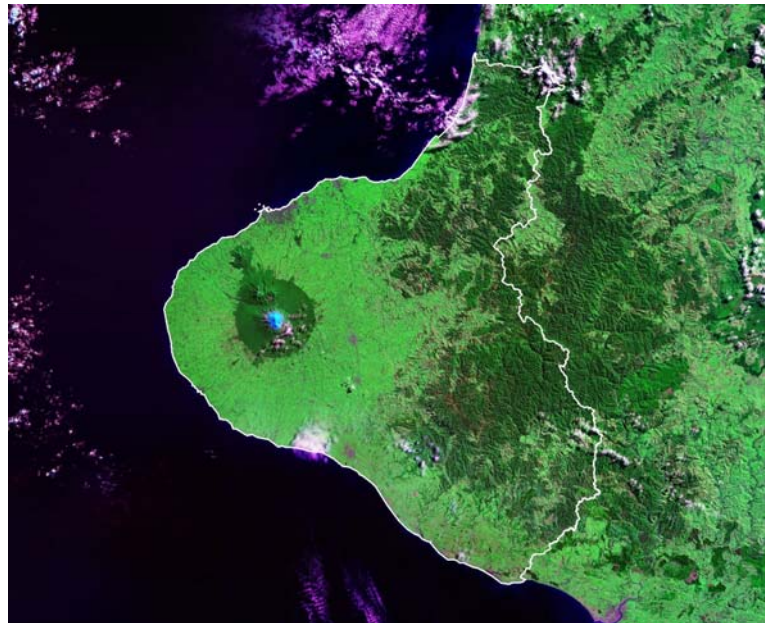


Renewable Energy Assessment



TARANAKI REGION

- Final Report
- 18 July 2006



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Executive Summary

This study aims to identify and assess the renewable energy potential in the Taranaki Region and assist Taranaki Regional Council (TRC) to identify where it can play a role in realising that potential using both regulatory and non-regulatory approaches.

The uptake of renewable energy is constrained by a wide range of barriers that not only includes the technical challenges and costs of developing such resources, but also the cultural and environmental concerns surrounding use of natural resources.

Most renewable energy projects have relatively high capital costs for plant and a revenue stream that is linked to the often periodic or intermittent nature of some renewable sources. The potential effects on areas of high cultural, ecological and landscape value mean that there are limitations as to where renewable projects may be acceptable. Another limitation is the current capacity of the existing transmission network. Most projects attract opposition from some sectors and face long consenting and development times.

At the same time, greater uptake of renewable energy presents national benefits such as enhanced security of supply and reduced climate change effects. In addition, greater uptake of renewable energy would allow regions, districts and cities to address issues such as: high liquid fuel and electricity costs that could contribute to a significant economic downturn; transmission / distribution constraints leading to supply disruptions and loss of economic activity; uncertainties associated with other conventional energy sources such as gas reserves and coal fired power plants which may lead to local supply shortfalls; and the economic opportunities presented by the application of mature, cost effective renewable energy technologies in the short-term and the development / commercialisation of emerging technologies in the medium-term.

An initial assessment of the renewable energy development potential of the region is provided in this report. The estimates of renewable energy potential seek to identify major resources that are available and to provide an indication of their relative magnitude. It is to be noted that the assessment has not accounted for how environmental and cultural issues will affect renewable energy potential. Rather, the assessment presents indicative estimates for the amount of renewable energy that could be realised in terms of the resource available outside National Parks and Department of Conservation lands (as a working, first order definition of what projects may be environmentally acceptable) using technologies that are already economic or are likely to become economic over the course of the next ten years (i.e. the review period of Regional Policy Statements).



For the Taranaki Region, this renewable potential comprises:

- Wave energy in the thousand MW range, ignoring environmental constraints and conflicts with other maritime users.
- Approximately 300 MW of wind capacity, depending on the degree of acceptance of adverse effects.
- Less than one million litres per year of ethanol for transport fuel from grain crops currently grown in the region. About 10 million litres per year of ethanol or 40 GWh per year of electrical energy from woody biomass derived from lower-grade forestry.
- Remaining hydro potential of about 60 MW, in mini, small, and medium scale projects lying outside the Department of Conservation land or Native Forest areas, compared to the existing installed capacity of 47 MW.
- Significant potential for solar thermal hot water systems, considerably less for solar photovoltaic

Development of this renewable potential could be assisted by:

- Increasing the range of expertise within the council such that the council's capacity with regard to renewable energy is commensurate with that of its other functions, *e.g.* soil conservation or water quality.
- Developing an energy plan / strategy.
- Developing spatial representations of renewable energy resources overlaid with information relating to development constraints (*e.g.* outstanding landscapes, areas of high cultural value).
- Establishing a programme of energy forums involving selected councils from across New Zealand.
- Advocating the implementation of appropriate economic instruments at a national level.
- Working with energy generators, District Councils, tangata whenua and other interested bodies to develop industry codes of practice for renewable energy production.

Regional Policy Statements

- Identifying in the Regional Policy Statement, areas within the region suitable for renewable energy development including wind, hydro, geothermal and marine based generation.
- Ensuring that the Regional Policy Statement includes a series of objectives and policies outlining how “trade offs” between localised effects and the benefits of renewable energy should be made.
- Amending the Regional Policy Statement to recognise the potential future renewable energy technologies and make high level policy provision for such



- Monitoring the state of technology development and making appropriate provision for emergent technologies by making changes to the Regional Policy Statement.

Regional Plans

- Ensuring that Regional Plans provide for existing renewable energy generation facilities.
- Amending Regional Plan rules to:
 - reduce consent thresholds for energy generation based on renewable resources
 - provide longer consent periods for renewable energy projects
 - provide greater air discharge thresholds for biomass energy generation where this is consistent with ambient air quality criteria
 - recognise the potential of and make high level policy provision for future renewable energy technologies.

District Plans

- Ensuring that District Plans provide for existing renewable energy generation facilities.
- Working closely with the District Councils within the region to ensure that district plans reflect the renewable energy objectives and policies of the Regional Policy Statement.
- Amending District Plans to:
 - ensure that rules do not preclude renewable energy development in areas identified in the Regional Policy Statement (*e.g.* landscape protection areas should not include areas deemed suitable for wind power generation in the Regional Policy Statement).
 - give effect to the objectives and policies proposed above for the Regional Policy Statement
 - make appropriate provision for various scale energy generation facilities
 - allow small scale renewable energy production (*e.g.* solar and wind) as permitted activities
 - provide subdivision rules that encourage appropriate site orientation in order to support solar heating and power generation and reduce shading
 - ensure that rules do not unreasonably preclude domestic scale renewable energy production (*e.g.* allows solar panels on roofs) and protect solar access to nearby properties.



Contents

1.	Introduction	1
1.1	Background	1
1.2	Study Objectives	1
1.3	Report Structure	2
1.4	Data Sources and Quality	3
2.	Drivers	4
2.1	Introduction	4
2.2	Economic Growth	4
2.3	Current Energy Mix	5
2.4	Energy Costs	8
2.5	Security of Supply	10
2.6	Local Benefits	12
2.7	Climate Change	13
2.8	Resource Management Act	13
2.9	Barriers to Renewable Energy	15
2.10	Potential Role for Local Government	18
3.	Technologies	19
3.1	Technical and Economic Considerations	19
3.1.1	Wind power generation	19
3.1.2	Solar PV generation	20
3.1.3	Solar thermal conversion	20
3.1.4	Hydro generation	20
3.1.5	Geothermal power generation	21
3.1.6	Marine power generation	21
4.	Renewable Energy Potential	31
4.1	Introduction	31
4.2	Wind	31
4.2.1	Wind Resource	31
4.2.2	Potential Electricity Generation from Wind	32
4.3	Solar	36
4.3.1	Solar Resource in the Taranaki Region	36
4.3.2	Potential for Solar Thermal	38
4.3.3	Potential for Solar Photovoltaic	38
4.3.4	Potential for Passive Solar Building Design	38
4.4	Hydro	38



4.4.1	Previous Hydropower Capacity Studies	38
4.4.2	Developed Hydropower Resources	41
4.4.3	Possible Future Hydropower Potential	41
4.4.4	Other Possible Hydropower Options	44
4.4.5	Summary	45
4.5	Biomass	46
4.5.1	Biomass Resource in Taranaki Region	46
4.5.1.1	Agricultural Crops for Energy	47
4.5.1.2	Forestry and Wood Processing Residues	47
4.5.1.3	Short Rotation Woody Biomass for Energy	48
4.5.1.4	Livestock Farming – Dairy and Meat	48
4.5.1.5	Sewage	50
4.5.2	Technology	51
4.5.2.1	Transport Biofuels	51
4.5.2.2	Electricity generation	53
4.5.3	Summary of Resource Potential	53
4.6	Geothermal	54
4.6.1	Power Generation	54
4.6.2	Direct Use	54
4.6.3	Summary of Resource Potential	59
4.7	Marine	59
4.7.1	Tidal Resource	59
4.7.2	Wave Resource	62
5.	Enabling Assistance	66
5.1	Introduction	66
5.2	Renewable Energy Expertise	66
5.3	Renewable Energy Plans / Strategies	67
5.4	Resource / Constraint Mapping	67
5.5	National Renewable Energy Forums	68
5.6	Economic Instruments	68
6.	Regulatory Approaches	69
6.1	Current Regulatory Approaches	69
6.2	Potential Regulatory Approaches	70
6.2.1	Identification of Suitable Renewable Energy Locations	71
6.2.2	Non-Locational Policy Development	72
6.2.3	Consents	73
6.2.4	Domestic or Small Scale Developments	74
6.2.5	District Plans	74
6.2.6	Future Proofing Policy Statements and Plans	75



7. References	76
Appendix A Previously Identified Hydro Schemes	78
Appendix B Resource Maps	80



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1. Introduction

1.1 Background

The growth in New Zealand's energy demand over the past three decades has mainly been met by non-renewable sources despite the widespread availability of potential renewable resources throughout the country.

Renewable energy resources face barriers to development that often include high capital costs, difficulty securing access to use natural resources and the practicalities of delivering the energy to where it is to be used. Consequently, the Government has developed energy strategies and made recent changes to the Resource Management Act (RMA) to encourage greater uptake of renewable energy, reduce climate change effects and increase security of energy supply.

While councils and territorial authorities play a significant role in the consenting process for any renewable energy development, this role has (with a few notable exceptions) largely been in reaction to applications. Under the recent changes to the RMA there is a greater requirement on councils to provide for renewable energy, but as yet there is no coherent knowledge base on the nature of the resources themselves nor a precedent for policy development that meets the new requirements.

1.2 Study Objectives

The Energy Efficiency and Conservation Authority (EECA) has implemented a program of Renewable Energy Assessments to assist councils with their policy and plan reviews and their new infrastructure responsibilities for renewable energy under the RMA.

EECA appointed Sinclair Knight Merz (SKM) to undertake a study whose objectives were to identify, assess, report and advise on the:

- Renewable energy potential in each region.
- Councils' role in realising the potential.
- Council's regulatory approaches.
- Information to enhance councils' knowledge.

By providing reliable renewable energy resource information and analysis, these assessments will help direct accurate targeting of renewable energy development opportunities; raise the profile of renewable energy; and provide a sound underpinning of policy development and private investment in renewable energy.



This report is one of eight assessments prepared under this program.

In New Zealand there are a total of 85 councils. In addition to 53 district councils and 15 city councils, territorial authorities which fall under the control of 12 regional councils, there are 5 unitary authorities that lie outside the jurisdiction of a regional council and have responsibilities of both territorial and regional councils. After discussions led by EECA, six regional councils and two unitary authorities (Marlborough and Tasman) were included within the study:

- Environment Canterbury
- Environment Waikato
- Horizons Regional Council
- Marlborough District Council
- Northland Regional Council
- Taranaki Regional Council
- Tasman District Council
- Greater Wellington Regional Council

Throughout this report, 'council' is used as a collective term for regional councils and unitary authorities.

1.3 Report Structure

The remainder of this report is structured in the following manner:

- **Chapter 2 - Drivers** outlines the national-level drivers for renewable energy in terms of: policy, energy use, supply and pricing. This chapter also provides a summary of key barriers to greater uptake of renewable energy.
- **Chapter 3 - Technologies** presents a tabular summary of existing and emerging renewable energy technology options for New Zealand.
- **Chapter 4 - Local Potential** describes the region's renewable energy resource and provides a preliminary indication of the magnitude of the utilisable resource.
- **Chapter 5 - Enabling Assistance** provides suggestions for how the council could promote renewable energy using non-regulatory methods.
- **Chapter 6 - Regulatory Approaches** summarises the region's existing regulatory approach to renewable energy and outlines alternative approaches for consideration.



Reports have been prepared for each of the eight councils using the above structure. In addition, a summary report has been prepared for EECA.

1.4 Data Sources and Quality

This assessment of the renewable energy potential within the regions relies primarily on previously published, publicly available information and data. We have used recent summaries of renewable energy potential, but where possible also reverted to the original sources of data.

Some of these sources are contradictory or very non-specific. While some of the available data (such as the hydro power potential) is quite detailed and has been thoroughly reported, other data (such as the wind energy) are poorly defined by existing assessments and not reliable for identifying more than broad parts of the regions that may have high energy potential.

Commentary on the status of marine energy technologies and their costs has been provided by the New and Renewable Energy Centre (NaREC) in the UK which is an independent test facility and technology assessment specialist. NaREC also made first order assessments of tidal current energy from basic published flow data.

The timing and scope of this work has not allowed any extensive new independent assessment of natural resources, although we have re-evaluated some technical and cost criteria for defining resources within the earlier assessments based on our own recent resource evaluations for individual projects or made some preliminary estimates based on published primary information.

Where no energy assessment data has been published (such as tidal current energy) we have made preliminary estimates using suitable guidelines applied to primary data that may be available (such as current velocity in the case of tidal flows). Estimates of the portion of the resource that may practically be used have been made by determining whether any restrictions such as Conservation land may restrict access.

Overall, the resource assessments must be regarded as first order indications of the magnitude and location of each resource. Defining the location, magnitude and probable delivery cost for each type of resource, for each scale of development (from large scale grid-based power generation to micro applications) would be a substantial exercise but could be justified if this were to be the basis for specific designation-based planning approaches.

Existing policy and plan documents for the region have been examined and supplemented by discussions with council representatives.

Interviews have been conducted with TrustPower and Mighty River Power to gain their perspectives on the issues facing the development of renewable energy projects.



2. Drivers

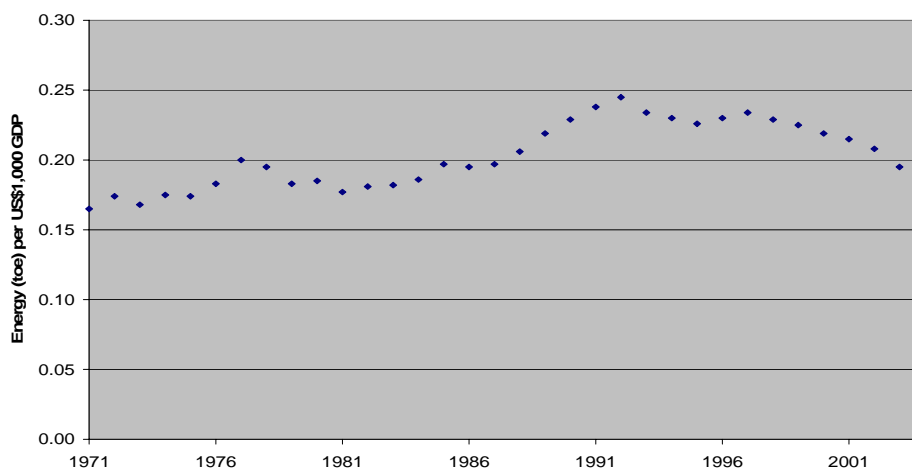
2.1 Introduction

This chapter outlines the national-level drivers for renewable energy in terms of policy, energy use, supply and pricing. In addition, this chapter provides a summary of key barriers to greater uptake of renewable energy.

2.2 Economic Growth

In the majority of countries, there is a very strong link between economic growth and growth in energy supply. Over the years, there has been much discussion of decoupling these two factors in developed countries such that strong economic growth could be achieved whilst reducing total energy supply. Although the energy efficiency of some economies has improved, economic growth has been such that total energy supply has steadily increased.

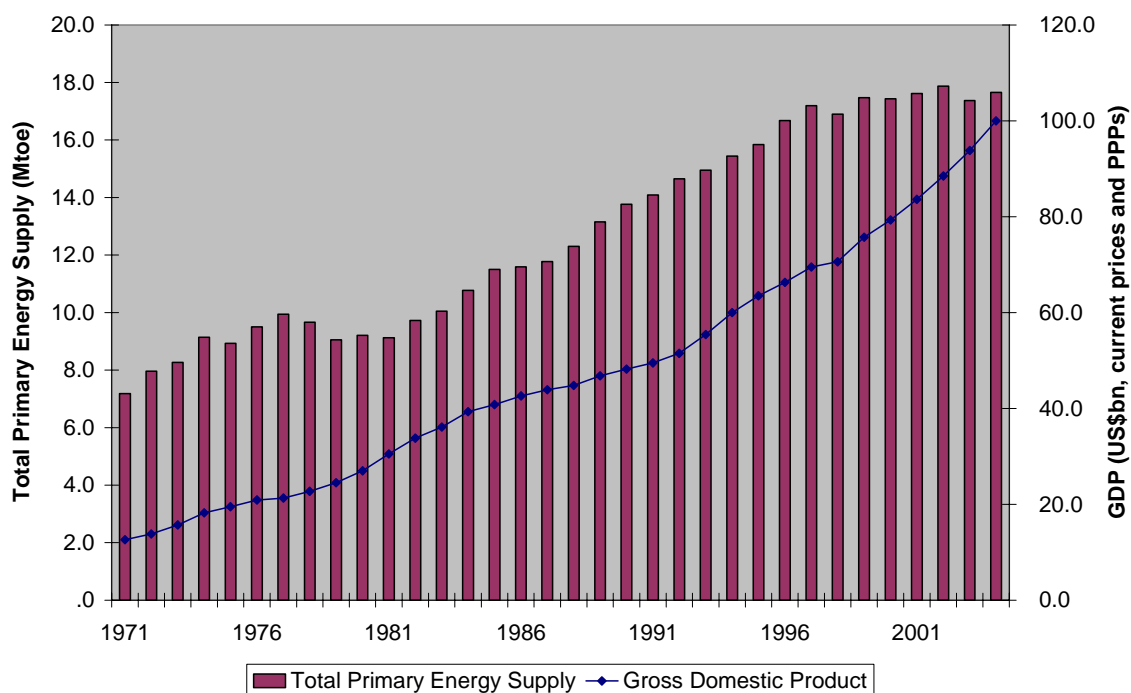
In New Zealand, the long-term energy efficiency of the economy has improved (Figure 1)¹. This long term increase in energy efficiency has been brought about by GDP growth that has exceeded growth in total primary energy use (Figure 2). It is to be noted that the total primary energy supply figures are distorted to some degree by the geothermal component which includes a large portion of un-used heat energy.



■ **Figure 1 Energy efficiency of the New Zealand economy 1971-2004 (OECD², 2006)**

¹ Tonnes of oil equivalent (toe) per thousand US dollars of GDP using Purchasing Power Parity (PPP).

² Organisation of Economic Cooperation and Development

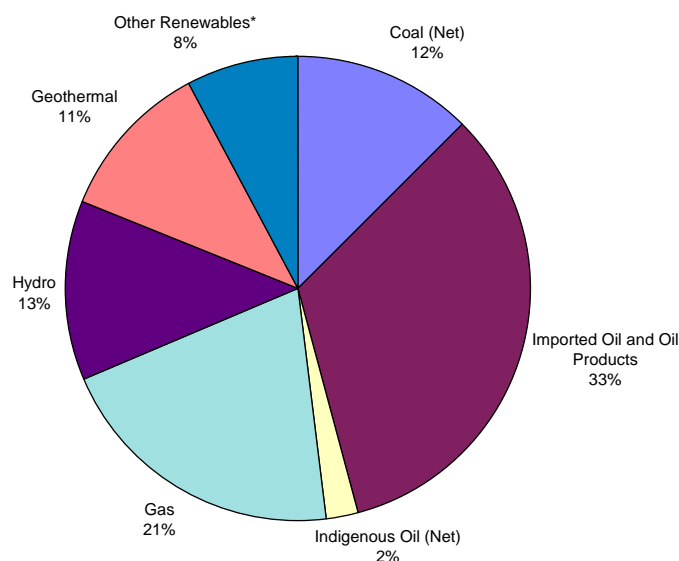


■ **Figure 2 New Zealand economy and energy supply 1971-2004 (OECD, 2006)**

2.3 Current Energy Mix

In 2004, about one third of New Zealand’s total primary energy supply was secured from renewable energy sources, one third from imported oil products and the remaining third from indigenous natural gas and a mix of local and imported coal (Figure 3). Of the energy finally utilised, 40% is for transportation and about 30% is delivered as electricity.

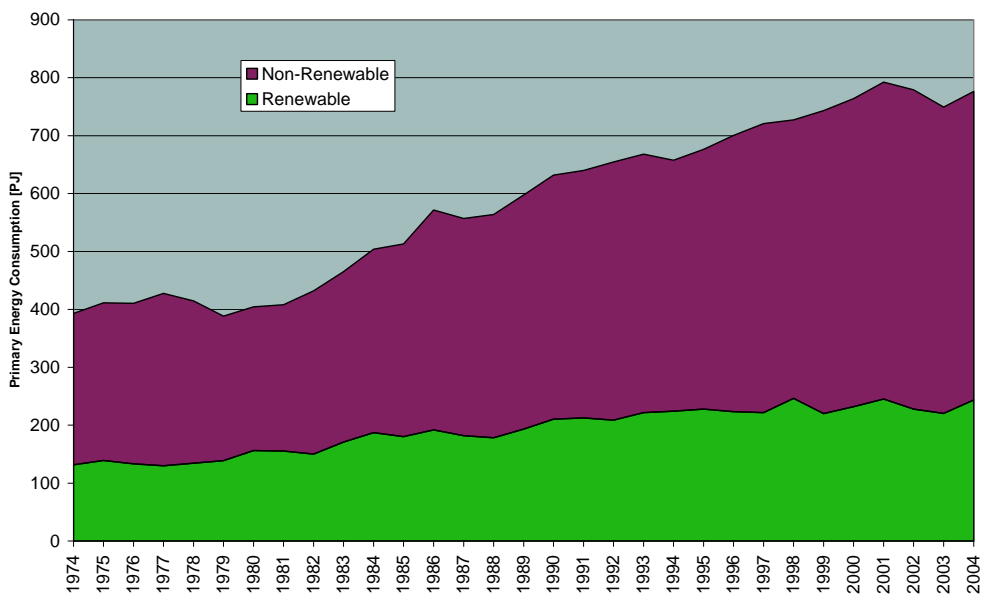
Waste heat used for co-generation of electricity has been reported as a renewable energy in the published energy data, however much of this is derived from coal fired heat (e.g. the Glenbrook Steel Mill) and so is not renewable. As noted above, the renewable energy resource data include all the geothermal heat as extracted from the reservoir, making no allowance for the conversion efficiency to electricity. Hence the magnitude of New Zealand’s energy derived from renewable sources is effectively over-stated in the published data.



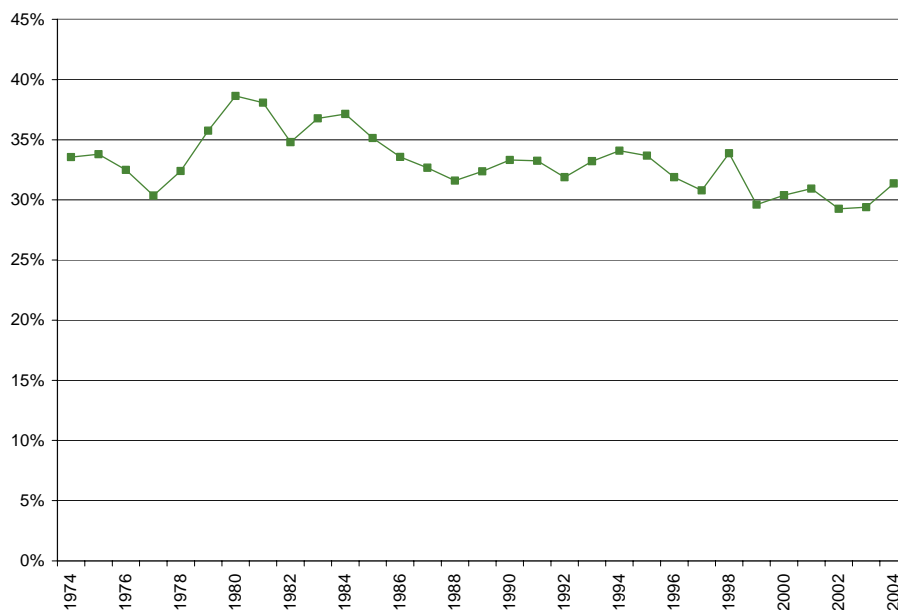
- **Figure 3 New Zealand's primary energy use by source, 2004. NB: Other Renewables* includes electricity generation from wind, biogas, industrial waste and wood, and solar water heating (MED³, 2006).**

Although there has been a growth in total renewable energy use since 1971 (Figure 4), the percentage of energy derived from renewable sources has fallen from 39% to 31% over the same period (Figure 5). The faster growth of non-renewable energy sources is driven largely by the transport sector.

³ Ministry of Economic Development



■ **Figure 4 New Zealand's primary energy usage 1974-2004 (MED, 2006)**



■ **Figure 5 New Zealand's primary energy supply from renewable sources 1974-2004 (MED, 2006)**

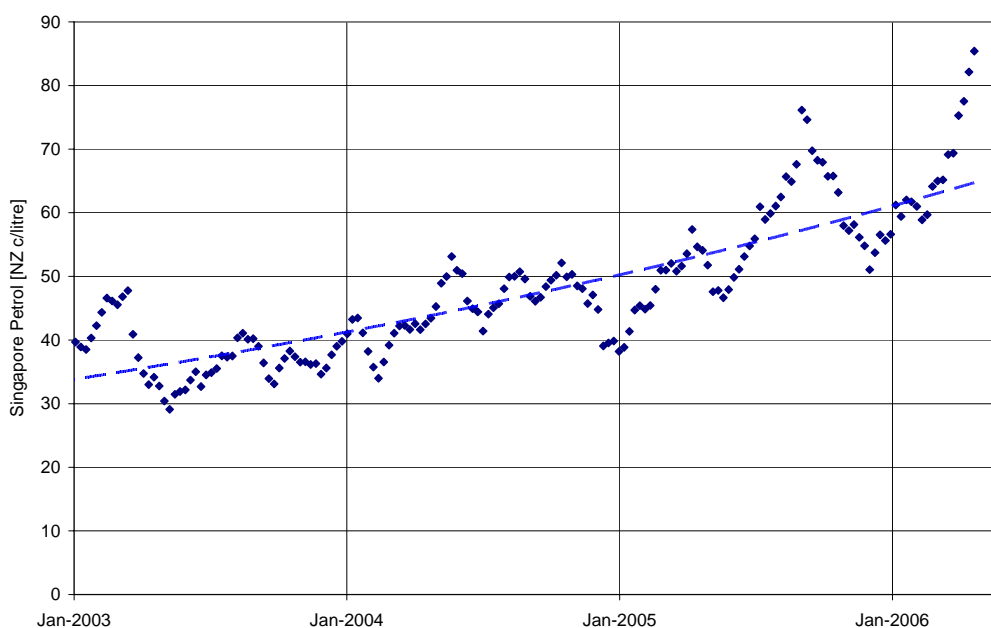
In summary, the majority of New Zealand's current energy supply comprises oil, gas and coal, a large proportion of which is imported. Furthermore, the current proportion of energy from renewable sources is near the thirty-year historic low. If the present situation is to be changed, there needs to be a very clear set of benefits for doing so in terms of energy costs, security of supply and climate change.



2.4 Energy Costs

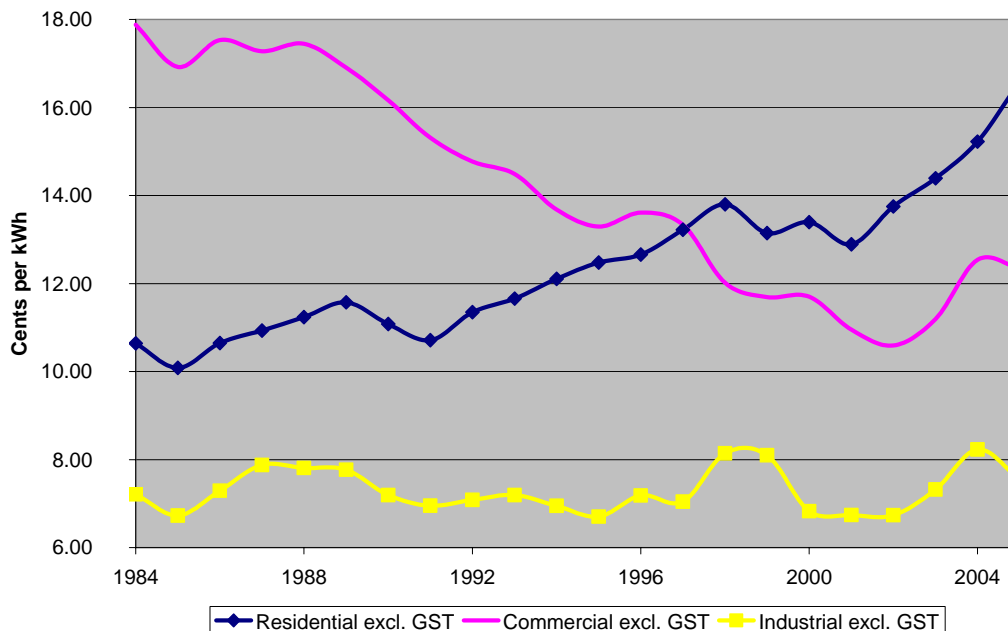
The cost of liquid fuels has grown rapidly over recent years, with the price of basic imported petrol (excluding taxes) doubling since 2003 (Figure 6). This trend is very much greater than that predicted by the Ministry of Economic Development (MED) in its 2003 projections of future energy costs, where even under the high cost scenario, crude oil was predicted to be US\$30 /bbl by 2025. However, by 2006, the cost was over US\$70 /bbl. The rapid increase in oil prices is symptomatic of rising energy prices across the board as international demand for raw materials grow, market forces set the price for substitute materials and security of supply concerns continue (e.g. Deffeyes, 2001).

Although increases in electricity prices have not been as substantial as those for liquid fuels, certain consumer groups, particularly residential consumers, have seen electricity prices (excluding GST) rise from 12.48 c/kWh⁴ in 1995 to 16.59 c/kWh in 2005, a 30% increase in real terms over ten years (Figure 7).



■ **Figure 6 Trends in the cost of imported liquid fuels in New Zealand. Cost of Singapore petroleum (NZ c/litre) (MED, 2006)**

⁴ kWh (kilowatt-hour) The standard unit of electricity supplied to the consumer. Equal to 1 kilowatt acting for 1 hour. Or 1 kWh = 3.60 x 10⁶ Joules



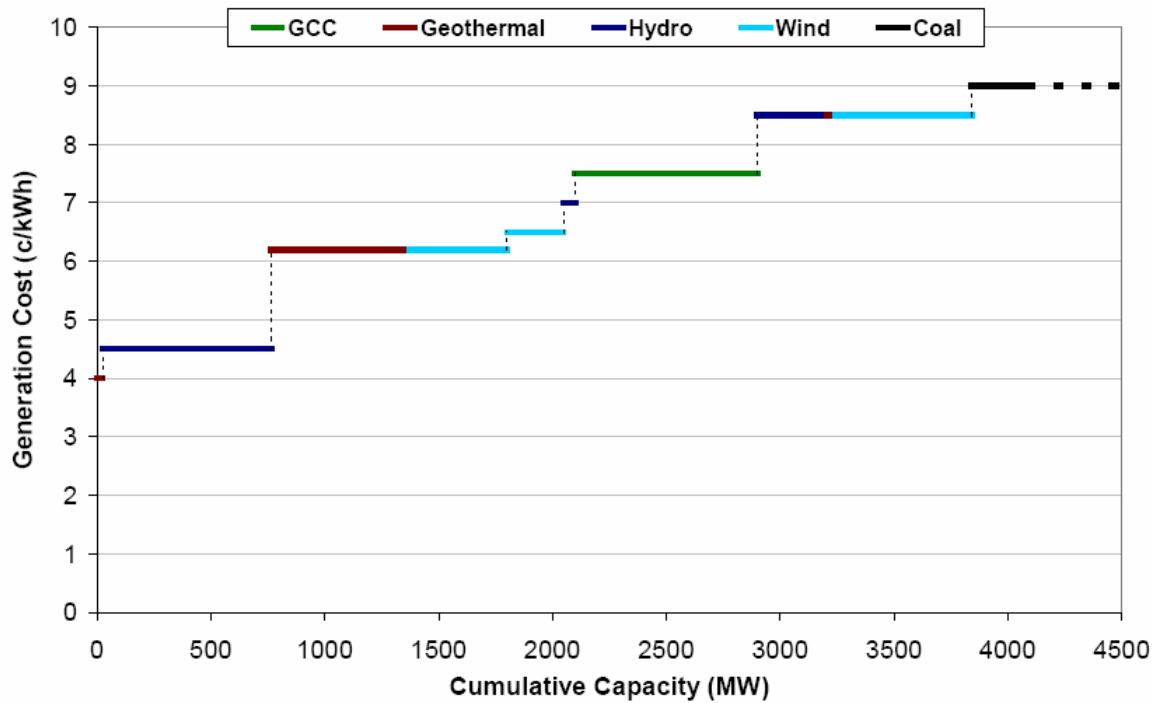
■ **Figure 7 Electricity consumers prices expressed 1984-2005 (Real year end March 2005 prices) (MED, 2006)**

The concern for New Zealand and other developed countries is that rising energy costs may lead to a decrease in energy demand and this, combined with already high labour costs, will reduce economic competitiveness and soften economic growth.

However, one of the key barriers to greater uptake of renewable energy has been cost, particularly upfront capital costs for electricity, which have typically been higher than comparable costs for fossil fuels. However, this situation changes as international prices for oil, coal and gas continue to increase.

Increasing electricity costs will mean that more renewable projects should be economically feasible as the market price of electricity exceeds their cost of generation (see for example Figure 8 from MED’s Energy Outlook to 2025 published in 2003). That MED prediction indicated that renewable energy could in fact dominate the new generation market given suitable market electricity prices.

Similarly, it is expected that biofuels will increasingly become mainstream if high oil prices are sustained.



■ **Figure 8 Indicative quantities of new generation sources viable at a range of prices. (MED 2003) NB: GCC stands for Gas Combined Cycle**

2.5 Security of Supply

A diversified portfolio of renewable energy supply can improve the resilience of the New Zealand economy to future energy supply problems and price shocks. This is recognised as one of the main goals of the National Energy Efficiency and Conservation Strategy (NEECS).

In general, energy sources present some form of risk, including:

- Continuity of supply, either through exposure to international markets or limited indigenous energy reserves
- Limitations for future growth
- Exposure to international price increases

These are detailed in Table 1 for New Zealand's energy sources.



■ **Table 1 Supply risks to New Zealand's energy sources**

Energy Source	Risk
Natural gas	<p>Limited life of Maui field, some new discoveries have been made but there are not currently sufficient to replace Maui and confidently enable major expansion of longer term gas usage.</p> <p>Imported Liquefied Natural Gas (LNG) or Compressed Natural Gas (CNG) is a possible supplement or replacement for indigenous gas reserves. It requires additional infrastructure and presents full exposure to international pricing and supply.</p>
Coal	<p>Supplies of low-sulphur, low-ash coal are presently sourced internationally. This has exposure to international pricing and supply.</p> <p>New Zealand has large reserves of lower grade coal that could form a longer term energy supply if and when barriers to its extraction and use are resolved.</p>
Oil and petroleum liquid fuels	<p>There is limited indigenous production of liquid fuels. Over 80% of liquid fuels are imported, presenting exposure to international pricing and supply.</p>
Hydro	<p>New Zealand's relatively low lake storage volumes mean that available water flows are strongly affected by weather variation. In addition, hydropower's long term generating capacity could be affected by climate change.</p> <p>New hydropower generation projects have been identified for a number of years and several have recently been progressed. However, these projects have faced major barriers in securing water use consents.</p> <p>Resource consents have no automatic right of renewal and are periodically exposed to public review and objection.</p>
Geothermal	<p>Not exposed to climate change. Resources will change under extraction and require some on-going investment to maintain production. Cost of capital for new developments is linked to international commodity prices (steel, generation plant).</p> <p>Barriers to securing resource consents for new projects.</p> <p>Resource consents have no automatic right of renewal and are periodically exposed to public review and objection. Concern over subsidence has affected one consent renewal.</p>
Wind	<p>Some exposure to climate change.</p> <p>Major barriers to securing resource consents for new projects.</p> <p>Resource consents have no automatic right of renewal and are periodically exposed to public review and objection.</p>

Diversification into a wider range of indigenous renewable energy sources could help mitigate these risks in two ways: reducing dependence on international fuel markets; and reducing dependence on a single form of indigenous renewable resource (*i.e.* hydropower). On the latter issue, since encountering several very “dry” years with consequent low levels of electricity reserve (1992, 2001, 2003) and with little new generation capacity being added to the New Zealand system, the government and major generation companies have recognised the need for additional diversified electricity generation. The generation companies have been making substantial effort to



develop new power generation from hydro, wind, geothermal, gas and coal but this has had limited success. Section 2.9 highlights the key barriers for renewable energy.

2.6 Local Benefits

The NEECS recognises the potential benefits for regional economic development that can arise from the development of renewable energy projects. Renewable energy projects (with the exception of biomass plant, where location is an economic consideration) need to be located close to the natural resources upon which they depend and this is usually away from the main urban centres. It is also recognised that for sources such as wind, there is value in having a good geographic spread of projects to increase the likelihood of having a well-balanced system. For the regions, this can mean increased economic activity associated with energy developments and the associated improved strength of local electrical network and supply. Biofuel resources require sustained agricultural activity to grow and harvest fuels, offering a long term and alternative form of economic activity. In addition, some renewable energy sources such as biofuels and geothermal can have secondary benefits in terms of direct heat use for agriculture or industrial processes, and some hydro projects can enable agricultural irrigation schemes.

During the course of the project, a number of councils highlighted pressing energy-related issues in their region, which could be at least partially addressed by a greater uptake of renewable energy.

- Transmission / distribution constraints leading to supply disruptions and associated loss of economic activity or the potential for supply disruption which could limit future growth and inward investment.
- Uncertainties surrounding the future of local energy sources (*e.g.* gas reserves) or local large-scale power generation plants (*e.g.* coal-fired units) which may lead to a supply shortfall, particularly in combination with distribution constraints.
- Liquid fuel and electricity costs which have the potential to cause a serious economic downturn, particularly in those regions where the local economy is largely dependent on agriculture, forestry and other sectors which are large consumers of liquid fuels.
- Regions where there is a substantial renewable resource, which can be used through the application of mature, cost effective technologies with environmental impacts that are broadly acceptable to the community.
- Regions where there is substantial renewable resource, which could be harnessed using emerging technologies over the next years and which have the desire to become regional, national or international technology leaders.
- Regions where there is considerable expertise of new energy technologies, which would benefit from the development of a regional market for their applications.



- A further factor to consider is that in 2013 lines companies will no longer be obligated under Regulation to continue supplies to (uneconomic) rural customers.

2.7 Climate Change

New Zealand has ratified the Kyoto Protocol, which entered into force on February 16, 2005. New Zealand's target is 100%, which means that New Zealand is required under the Protocol to reduce its greenhouse gas emissions back to 1990 levels on average during the First Commitment Period (CP1 or 2008-2012), or otherwise take responsibility for any excess emissions. It was envisaged that for New Zealand this target would be able to be met through a combination of domestic emissions reductions and increases in carbon sinks. It was also anticipated that more significant emission reductions would need to be negotiated for future commitment periods.

In May 2005, an estimate of New Zealand's CP1 emissions position relative to the target was projected to be about 32 million units (tonnes of carbon dioxide equivalent). In December 2005 the net emission deficit was increased to just below 51 million units, reflecting updated information about deforestation intentions. The decision to cancel the carbon tax is expected to increase the deficit to about 64 million units, although no account has been made of any replacement policies currently under consideration.

Renewable energy will significantly assist New Zealand to meet its obligations under the Kyoto Protocol whilst helping to meet New Zealand's growing electricity demand without increasing the use of thermal generation, whose greenhouse gas emissions contribute to climate change.

2.8 Resource Management Act

The Resource Management (Energy and Climate Change) Amendment Act 2004, introduced three new matters into section 7 (Other Matters) of Part II of the Resource Management Act 1991 (RMA), requiring all persons exercising functions and powers under the Act to have particular regard to:

- (ba) the efficiency of the end use of energy
- (i) the effects of climate change
- (j) the benefits to be derived from the use and development of renewable energy; and

To support the section 7(j) amendment, section 2 of the RMA was amended to define "renewable energy" as "energy produced from solar, wind, geothermal, hydro, biomass, tidal, wave, and ocean current sources".



The law relating to these matters has been refined to some extent by the Environment Court in its decision on *Genesis Power Ltd and The Energy Efficiency and Conservation Authority v Franklin District Council A148/2005*. This decision related to a resource consent application to establish a wind farm on the Awhitu Peninsula, south of Auckland.

The Court identified the benefits to be derived from renewable energy to include:

- Security of supply
- Reduction in greenhouse gas emissions
- Reduction in dependence on the national grid
- Reduction in transmission losses
- Reliability
- Development benefits
- Contribution to the renewable energy target.

The Court also gave considerable weight to the positive effects of renewable energy in its consideration of the decision and also found support for the project in its general assessment of Part II of the Act.

The 2004 amendment also removed the regulatory means for controlling greenhouse gases, as at the time when the Amendment Act was being developed, fiscal measures (namely the carbon tax) were being introduced to have the same effect. As a result, councils now cannot make rules which control the discharge of greenhouse gases on the basis that they contribute to climate change, nor can they consider climate issues in relation to resource consents. Rules relating to the control of greenhouse gases for climate change purposes made prior to enactment no longer apply. However, historic resource consent decisions still stand.⁵

In 2005, the Act was further amended by giving additional powers to councils to:

“the strategic integration of infrastructure with land use through objectives, policies, and methods:”

The amendment also provided a wide definition of infrastructure which includes:

“(a) pipelines that distribute or transmit natural or manufactured gas, petroleum, or geothermal energy:

⁵ A Private Members Bill is currently before Parliament that will have the effect of reversing these particular provisions.



“(d) facilities for the generation of electricity, lines used or intended to be used to convey electricity, and support structures for lines used or intended to be used to convey electricity, excluding facilities, lines, and support structures if a person—

(i) uses them in connection with the generation of electricity for the person’s use; and

(ii) does not use them to generate any electricity for supply to any other person:

These powers may be implemented by providing objectives, policies and methods in regional policy statements that will provide greater direction as to the locations and co-ordination of such infrastructure.

The 2005 amendment to the Act also changed the status of Regional Policy Statements. Previously District Plans were required to be not inconsistent with a Regional Policy Statement. The 2005 amendment altered this so that District Plans are now required to give effect to a Regional Policy Statement. This gives Regional Policy Statements additional powers to direct what provisions are included within District Plans.

Overall recent amendments to the RMA both require and empower Councils to have a greater role in the encouragement of renewable energy generation.

2.9 Barriers to Renewable Energy

There are a range of barriers that have slowed the uptake of renewable energy. These largely relate to the need for individual projects to secure their own “fuel” supply from natural resources while also still having to construct an energy conversion facility (*i.e.* power plant). The locations where these natural resources are found often have other intrinsic value (such as wind resources found in areas of high landscape value, or hydro opportunities in dramatic catchment areas) or the resource itself has other competing uses (such as recreational use of rivers, geothermal features as tourist attractions).

Some of the major barriers to renewable energy are identified in Table 2, along with a brief indication of where councils may have some influence on those barriers:

■ Table 2 Major barriers to renewable energy projects

Barrier	Description	Council Influence
High capital cost	Projects include the cost of “fuel” gathering as well as energy conversion and hence tend to have high capital cost. Some technologies are new and do not	No influence



Barrier	Description	Council Influence
Intensive “fuel” investigation	yet have the economies of scale in plant construction compared to conventional energy sources. Intensive investigation is required for determining resource potential. This is very high for geothermal but less for wind and hydro.	Consents for wind measurement towers, geothermal drilling and river weirs
Low energy density	Many renewable projects have a low energy density – requiring large areas for the collection of fuel and for energy conversion plant. However, some types such as wind and geothermal do not preclude continuation of other uses such as farming.	Land use that is allowed within human and natural land zonings.
Long development time	Most have several stages of development, from resource evaluation, consenting and construction. There are associated development risks at each stage.	Consenting process
Wide consultation Community attitude to natural resource uses	The use of natural resources and construction of plant in natural areas demands a high level of consultation often in the face of significant public opposition.	Planning environment Consenting process
Resources associated with natural features or areas of intrinsic or cultural value	Renewable energy can be associated with natural features that have high intrinsic value, such as wind in outstanding landscapes and hydro in natural waterways. These areas may also have special cultural value to Maori.	Landscape planning, natural area identification. Balancing effects of development against amenity values in consent process.
Competing uses for the same resource	Recreation use of rivers and irrigation competes with hydro power. Geothermal surface features have a range of uses.	Balancing effects and benefits from competing uses Resource consents to take water
High “mitigation” fees	Due the fact that objectors can impede the consenting process, many affected or interested parties now expect substantial fees in return for their agreement to a development. Consent requirements have resulted in a secondary mitigation fee market that is a barrier particularly for smaller projects.	Planning environment Consenting process
Non-firm nature	Some renewable resources such as solar, wind and marine are periodic or intermittent in nature. This limits their ability to meet peak demand requirements and hence tend not to secure highest market prices.	No influence
Transmission requirements	Most renewable energy projects need to be located close to the energy resource and so are dependent on transmission networks to carry the energy to where it is required.	Consents and designations for transmission upgrades or new lines



Barrier	Description	Council Influence
Environmental considerations	<p>Weak transmission networks limit positioning of projects.</p> <p>Developers may be required to build new transmission lines to service their projects.</p> <p>Councils may find it difficult integrating increased interest in renewable energy alternatives with local environmental concerns, already identified in existing or operative legislation.</p> <p>For example the use of biomass as an alternative to electricity could be viewed as an air quality problem, rather than an energy supply solution.</p>	<p>Planning environment</p> <p>Consenting process</p> <p>Non-regulatory</p>

Fossil-fuelled projects face few of these obstacles. For example two gas-fired power plants currently (2006) under construction did not require notified consents. The 1,000 MW⁶ Huntly plant has been reverted to being fuelled by coal so that the gas it would have otherwise used can be redirected to a new efficient CCGT gas-fired plant under construction. However, the conversion of the Marsden B plant to coal is subject to appeal on conditions by the developer and on environmental grounds by environmental groups opposed to the project.

Recent successful renewable energy projects have included an expansion to the Tararua wind farm and an expansion to the Mokai geothermal plant. These projects were located at existing power development sites and as such were readily able to obtain resource consents.

However, “green-field” projects tend to face greater difficulty within the RMA processes. The proposed expansions of the geothermal projects at Ngawha and Kawerau have been declined or face appeals because of perceived effects. Developments planned at new locations have had to follow a more difficult path. The hydro project “Aqua” was reportedly abandoned due to a perception of major public opposition, and several wind farms have faced similar opposition.

Developers report that small renewable projects are no longer viable to consider for development as the costs and delays associated with the consenting processes and the “mitigation” fees can be as great as for large projects. However, if fossil fuel costs and wholesale electricity prices continue to

⁶ The unit for measuring power is the Megawatt (MW). Power is the rate at which energy is generated / consumed, i.e. 1MW means that one million joules of energy is generated / consumed every second. As crude approximations: a full petrol tank in an average size car contains one million joules of energy; a single wind turbine has a 1MW capacity



increase in line with recent trends then the higher market return possible for alternative energy sources will tend to enable the development of more renewable energy projects.

2.10 Potential Role for Local Government

While development of renewable energy resources can have benefits that are of national and regional value, these benefits apply to a variety of sectors and are often not manifested in a way that is tangible and of direct value to the individual developer. In the absence of direct financial or other enabling incentives, the wider national and regional benefits therefore may not surmount the barriers to most forms of renewable energy development.

This is the reason that central government has engaged in strategies to promote renewable energy. Some of the barriers to renewable energy development are manifested in the regions and districts, and the councils have a key role in the process for approving or declining these projects and more fundamentally, for establishing policies and plans that proactively support greater uptake of renewable energy. The Councils and their policy and planning instruments can therefore have a significant effect on the future uptake of renewable energy in New Zealand.



3. Technologies

This section provides a summary of technologies which are used to use renewable energies. Renewable energies are defined by the RMA as:

- Solar
- Wind
- Hydro
- Geothermal
- Biomass
- Tidal
- Wave
- Ocean Current

Of these, hydro and geothermal are relatively mature technologies, solar, wind and biomass are new and to some extent still developing, while tidal, wave and ocean current are still at the development stage.

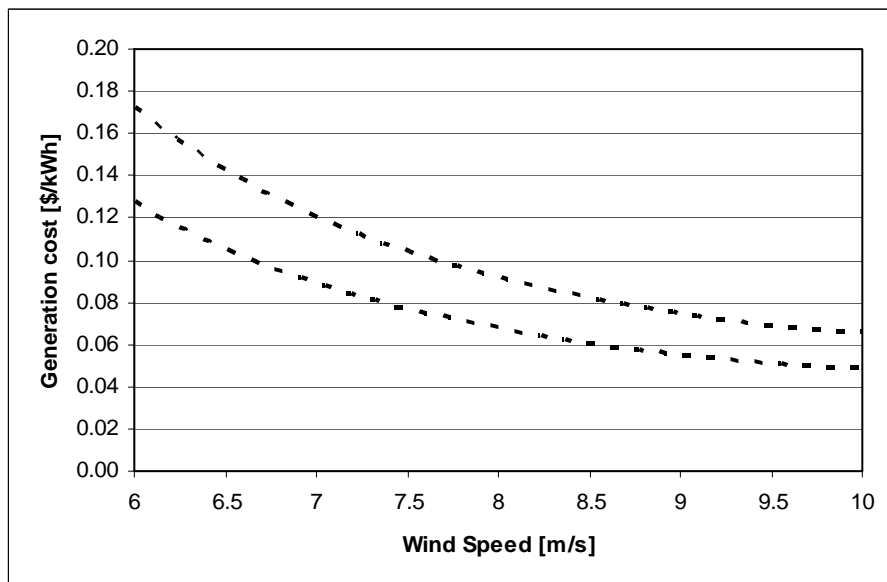
3.1 Technical and Economic Considerations

The following paragraphs comment on some issues that affect cost estimates for renewable energy projects and future price trends. All the listed values in Table 3 for capacity factor and cost are indicative only. Renewable energy projects have generally very project specific cost components and need to be assessed on a case by case basis.

3.1.1 Wind power generation

Figure 9 shows the dependency of the generation costs from large scale wind farms on the average wind speed. Note that this graph is only an indication of likely costs for typical projects. Costs can vary significantly between projects, depending on complexity of the terrain and resulting higher costs for access roads or long distance to the grid with high investment needed for the grid connection. The graph shows that currently the electricity prices require average wind speeds of around 8 m/s for projects to be economically viable. A future increase in electricity prices will make areas with lower wind speeds attractive for developers also.

Wind turbine prices have dropped considerably over the last decade due to a large increase in manufacturing rates/capacities and technology enhancement. However, this trend is not expected to continue. Last year saw a general increase in turbine prices, which was partly due to higher steel prices. Furthermore, some manufacturers were forced to increase prices to avoid financial losses and make the business more profitable. Profit margins have been very small in the past due to a very competitive market.



■ **Figure 9 Indication of wind energy generation costs**

3.1.2 Solar PV generation

Solar PV system costs have been dropping significantly over the last decade. Furthermore, the efficiency of solar cells is constantly improving. This trend is expected to continue with further production capacity lowering the costs, and further technology developments increasing the efficiency.

3.1.3 Solar thermal conversion

Technology used in solar thermal conversion systems continues to advance, reducing production cost and increasing system performance. Ongoing improvements to solar conversion surfaces and effective reductions in convection losses ensures solar thermal conversion efficiency continues to improve. It is believed that this technology will remain as the most economic solar conversion system available for installation in both new and existing houses.

3.1.4 Hydro generation

The wide range of cost of generation comes about because of the very site specific nature of projects. The necessary project components and their scale (for example diversion and water conveyance works, environmental mitigation works and choice of equipment) depend very much on the location and the intensity of the potential. Additionally site specific aspects such as topography and geology drive construction costs while local hydrology determines the energy available from the site. Whereas low head schemes have proportionally large (and slow speed)



generating units and relatively low civil works investments, the opposite is the case for high head opportunities where the (small, high speed) machine cost tends to be low, but with a relatively high investment in the diversion works and pipeline. The scheme's proximity to electrical grid, access to site and necessary transportation work (new roads vs. existing) can also affect the project cost substantially, as can the cost of capital (own or borrowed from the market) in the prevailing market conditions.

3.1.5 Geothermal power generation

Geothermal development costs have been relatively stable for some time, although drilling costs in particular have risen over the past year. Many of the recent geothermal power developments in New Zealand (*e.g.* Mokai, Rotokawa and Ngawha) have used wells that were drilled by the government many years ago, thus removing a significant cost and risk component. Similarly, expansion of those projects can draw on a production history that allows greater certainty as to the size of the resource and its capacity to sustain the expanded operation. For example, addition of a binary power plant at Wairakei did not require any additional wells to be drilled, and cost much less than the estimated costs in Table 3, which are for a stand-alone binary plant. Costs are significantly higher for green-fields developments where there are no existing geothermal wells, compared with expansion of an existing development.

The energy in ground at ambient (non-geothermal) temperatures (10-15°C in New Zealand) represents a significant energy resource which can be used with ground source heat pumps (GSHP). This technology is used on a large scale in North America and Europe where the climate, high electricity prices and subsidies make this technology economic. These drivers are largely absent in New Zealand and as a result there has been little use of GSHP's in New Zealand. Use of geothermal heat using ground source heat pumps can save up to 60% on electricity heating costs in a typical New Zealand homebut, because of the high installation cost (approximately NZ\$12,000), may only be economic in larger commercial buildings.

3.1.6 Marine power generation

Marine power generation costs are expected to drop considerably over the next decade. It is expected that the cost curve will be similar to the wind power generation. However, it must be noted some cost components, especially Operation & Maintenance, can only be estimated with high uncertainty at this stage.

■ **Table 3 Renewable energy technologies**

Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
Wind					
Wind turbine	Extraction of kinetic energy from the wind flow Horizontal axis wind turbine 2 or 3 blades Direct drive or gearbox AC generation	Well established Commercially available	Large scale Typical modern turbine size 2-3 MW Wind farms up to 300+ MW Intermittent generation Capacity factor: 35-45% Difficult to forecast	Visual impact Noise Shadow flickering Electromagnetic interference	1,700-2,100 \$/kW (installed) approx. 8 c/kWh see comments above
Micro wind	Extraction of kinetic energy from the wind flow Horizontal or vertical axis turbines 2 or 3 blades Direct drive DC generation	Well established Commercially available	Small-scale (<10 kW) Electricity generation or direct drive of water pumps Intermittent generation Difficult to forecast	Minimal visual and noise impact	7,000-10,000 \$/kW 30-40 c/kWh
Solar					
Solar Thermal System	Solar radiation transformed into heat System consisting of solar collector and storage Active systems use a pump whereas passive systems rely on gravitational forces	Well established Commercially available	Small-scale, heat	Minimal visual impact	3,000-6,000 \$ per domestic system 11-17 c/kWh _{th}
Solar Photovoltaic	Solar radiation transformed into electricity Solar cells consisting of semiconductor material (either thick or thin technology) Silicon most common semiconductor material	Well established Commercially available	Small-scale, electricity Intermittent generation	Minimal visual impact	grid connected (incl. inverter): 13,000-20,000 \$/kW approx. 80 c/kWh

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Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
Hydro					
General	Water passing through a turbine rotates the runner which is harnessed to a generator to produce electricity.				
Run of River	A proportion of river flows are diverted to a power plant via a small barrage or a weir. The weir provides submergence but little storage at the diversion. Instantaneous power available dependent on river flow.	Well established technologies commercially available	Small to medium, electricity, baseload	Water diversion - visual and ecological effects also impacting recreational activities	3,000-4,500 \$/kW 4-7 c/kWh
Storage	A dam creates substantial water storage which is drawn upon to generate power on demand. Energy and plant load factor determined by reservoir inflow.	Well established Commercially available	Medium to large scale electricity, peak load Capacity factor 50-70%	Land inundation, effect on aquatic ecosystems (change in habitat, fish migration), changed opportunities for recreational activities	3,500-5,000 \$/kW 7-10 c/kWh
Pumped Storage	In addition to storage at the diversion area upstream, storage is also provided at the downstream end. Power is generated at time of high electricity price and pumped for re-use at times of low electricity price.	Well established Commercially available	Medium to large scale electricity, peak load	Land inundation, effect on aquatic ecosystems (change in habitat, fish migration), changed opportunities for recreational activities	2,500-4,000 \$/kW generation costs: N/A (net consumer)
Biomass					
Direct heat	Biomass (such as woodwaste etc) is burnt to generate heat, either directly or as steam or hot thermal oil.	Well established Commercially available	Available from the smallest domestic scale (wood stoves etc) to NZ's largest industries (pulp & paper).	Air quality may be affected by the smaller-scale developments. Large installations will have sophisticated emissions control systems. Fuel transport will have adverse effects.	Woody biomass: 4 \$/GJ

Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
Electrical generation	Biomass is burnt to generate steam for a power plant.	Well established Commercially available	Economics favours the larger-scale developments, typically greater than 25 MWe, but limited by harvesting and transport costs. Capacity factor: 90%	Power plant developments will have sophisticated emissions control systems. Fuel transport will have adverse effects.	20 MW class woody biomass plant: 3,400 \$/kW 13 c/kWh
Liquid fuels	Very wide range of options for the production of liquid fuels, including hydrolysis and fermentation to ethanol, oil and tallow esterification to biodiesel, gasification and synthesis to methanol and hydrocarbons, pyrolysis etc).	Some technologies are well-established and commercially available (ethanol, biodiesel, etc), others are at prototype and/or early commercial stages (gasification and synthesis, pyrolysis, hydrolysis etc).	Economics favours the larger-scale developments, largely due to technical sophistication, but limited by distributed nature of the resource and the harvesting and transport costs.	Process plant developments will have sophisticated emissions and effluent control systems. Raw materials transport will have adverse effects.	Tallow and oils to biodiesel Plant capacity 120,000 t/year. Plant capital cost \$50 million. Feedstock cost \$460/t, product cost \$0.45/L. Biomass to Methanol Plant capacity 250,000 L/day. Plant capital cost \$250 M. Product cost \$1.1/L, \$61/GJ Biomass to Ethanol Plant capacity 100,000 L/day. Plant capital cost \$128 M. Product cost \$1.75/L, \$75/GJ
Gaseous fuels	Biological degradation (anaerobic digestion, fermentation etc) to generate methane gas.	Well established Commercially available	Available from the smallest domestic and/or farm scale bio-digester to municipal effluent treatment for NZ's largest cities.	Process plant may need sophisticated effluent control systems. Raw materials transport may have adverse effects.	
Geothermal					
Conventional geothermal power plant (steam turbine) possibly with binary plant for steam condensing.	Fluid self-discharges from wells. Steam and liquid water flows are separated. Steam is passed directly through a turbine to generate electricity. Binary plant	Well established Commercially available, applicable to high temperature (typically >200°C) geothermal fields	Medium to large scale electricity (base load), plus downstream direct heat potential. Capacity factor 90-95%	Air quality (especially H ₂ S odour), impact on surface thermal features, shallow aquifers and ecosystems, noise, visual, subsidence,	2,500-3,000 \$/kW 5 - 8 c/kWh

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Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
	possibly used for condensing steam and heat recovery from hot water. Waste fluids mostly reinjected into the ground.			resource depletion	
Binary power plant on medium to low temperature resources	Wells may self-discharge or require pumping. Geothermal fluid heats a secondary (binary) fluid in a closed cycle that is vaporised, drives a turbine, is cooled and condensed.	Well established Commercially available, most applicable to low temperature (120 to 200°C) geothermal fields. Applied in many USA fields usually with pumped wells. In NZ, binary plant presently only used for heat recovery from water on geothermal projects.	Small to large scale electricity (base load), plus downstream direct heat potential Capacity factor 90-95%	Air quality (especially H ₂ S odour), impact on surface thermal features, shallow aquifers and ecosystems, noise, visual, subsidence, resource depletion	5,000-7,000 \$/kW 7-10 c/kWh
"Enhanced" Geothermal systems (including Hot Dry Rock – HDR)	Geothermal reservoirs that have heat but insufficient water or permeability for conventional extraction. Multiple wells required for stimulating fractures and circulation of a fluid through injection-production well couples. Energy converted to electricity Potential on margins of existing NZ fields.	At developmental stage in USA, Europe and Australia. Large heat reserves in some geological environments, hence there is technology development effort.	Projects are likely to be large to enable economy of scale	Effects expected to be minimal compared to conventional geothermal. Some thermal contraction effects (v minor subsidence)	High cost
Direct use of heat: many potential uses, including:	Paper manufacture Timber drying Other industrial processes Space heating Space cooling Horticulture Aquaculture Bathing, spas	Well established Commercially available technology exists for most applications.	Range from very small scale (domestic heat pumps) to large scale industrial plants Capacity factor 90-95%	Depending on the scale of the operation, effects range from negligible to similar to a geothermal power plant	300-400 \$/kW _{th} 1-2 \$/GJ

Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
Ground source heat pumps	Heat pump using the ground or groundwater as a heat source or sink. Can achieve very high efficiencies compared to conventional heat pumps using atmospheric heat sinks. Typically used to heat or cool buildings.	Well established Normally some measure of custom design in NZ, as there are few suppliers. Wider application in USA, Europe, Japan and China.	Range from domestic to commercial building scale.	Minimal effects. If using groundwater, then affects water temperature.	NZ\$12,000 estimated installation cost is higher than standard heating-cooling systems. Electrical input ~25-30% of output. Viable for commercial buildings if long term efficiency is considered.
Tidal (Kinetic Energy) Ocean Current	Exploitation of velocity component of tide. Flow of water passing turbine blades cause aerodynamic lift. Blades are connected via shaft to electrical generator				
Technology a1	Similar operating principle to vertical axis wind turbine. 2 or 3 blades mounted on a monopole seabed foundation	Large scale 300KW prototype demonstration 3 year sea deployment nearing completion. 1000KW grid connected demonstration prototype planned 2006-2007	In the order of 1MW per installation Electricity production Base load contributor – Energy BUT source intermittent but highly forecastable (years in advance) Capacity factor 40-50%	Yet to be fully understood but generic issues with: Sub sea noise especially in piling operations Marine mammal collision Risk to marine navigation and associated pollution risks Underwater cabling -Seabed and habitat disturbance -Electromagnetic interactions with elasmobranchs	Based upon estimates rather than track record: Early full scale prototypes 14,000 to 23,000 \$/kW Cost of energy range of 28-43 c/KWh Early production models 5,000 \$/kW Cost of energy approx. 22 c/KWh
Technology a2	As above but floating Vertical axis rotary device on mooring. Either fully submerged or surface piercing.	Number of 500KW grid connected demonstration prototypes planned 2006-2007	In the order of 1MW per installation Electricity production Base load contributor – Energy BUT source intermittent but highly	As above minus piling issue	as above

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Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
			forecastable (years in advance) Capacity factor 40-50%		
Technology a3	Ducted turbine mounted on seabed via concrete foundation	1MW grid connected prototype demonstration planned 2006-2007	In the order of 1MW per installation Electricity production Base load contributor – Energy BUT source intermittent but highly forecastable (years in advance) Capacity factor 40-50%	As above minus piling issue	as above
Technology a4	Reciprocating aerodynamic foils convert mechanical motion into hydraulic rams power take off device.	100KW grid connected demonstration planned 2007	In the order of 1MW per installation Electricity production Base load contributor – Energy BUT source intermittent but highly forecastable (years in advance) Capacity factor 40-50%	As above minus piling issue	as above
Tidal (Head)	Exploitation of head differential between high and low tide.				
Technology b1	Impoundment (dam) of estuary. Gates within the dam allow water to pass upstream of structure. Closure of gates at high tide creates head height differential across dam as tide falls on downstream side. Operation reversed at low tide. Low hydro	Well established Commercially available technology exists for most applications.	In the order of 100MW per installation Electricity production Base load contributor – Energy BUT source intermittent but highly forecastable (years in	Profound and irreversible change in estuary eco-system	Existing plants are broadly comparable with the upper end of fossil fuel based generation costs Costs are expected to be much higher in NZ due to the lower tidal range

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Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
	turbines may then be used to release head and generate electricity.		advance)		
Technology b2	Narrow headlands create 'nature' impoundment as head height can vary across the sides of the land mass. The introduction of piping containing water turbines exploits head driven flow.	Yet to be demonstrated at meaningful scale	In the order of 100MW per installation Electricity production Base load contributor – Energy BUT source intermittent but highly forecastable (years in advance)	Hazard to fish life passing through pipe. Estimated to be little eco-system impact	unknown
Wave					
Technology a	Oscillating water column: Conversion of wave energy into pneumatic energy, channelled through bi-directional air turbine connected to rotary electrical generator. Can be configured as floating structure, seabed fixed or fashioned into cliffs or breakwaters	Demonstrated at 500KW grid connected site. Presently with 4 year of operational service	Intermittent energy source. Forecast ability better than wind, but good reliability only based on future time period estimates of 6-8 hrs. Electrical generation 500-1500's KW size range per installation Capacity factor 40%	Yet to be fully understood but generic issues with: Marine mammal collision Risk to marine navigation and associated pollution risks (less if deeply submerged Changes in sediment transportation patterns Underwater cabling: -Seabed and habitat disturbance -Electromagnetic interactions with elasmobranchs	Based upon estimates rather than track record: Early full scale prototypes 11,000 to 26,000 \$/kW 63-72 c/KWh Early production models 7,000 \$/kW approx. 29 c/KWh
Technology b	Point Absorber: Conversion of wave heave motion into mechanical relative displacement between floating buoy on sea surface and other reference point. Variety of PTO	Demonstrated at up to 100(?)KW power level in open sea	Intermittent energy source. Forecast ability better than wind, but good reliability only based on future time period estimates of 6-8 hrs. Electrical generation + high	Yet to be fully understood but generic issues with: Marine mammal collision Risk to marine navigation and associated pollution risks (less if deeply	as above

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Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
	options including; Fluid pumping (water or oil) Hose Pump Direct drive linear generator		pressure water pumping/desalination opportunities 100's KW size range per installation Capacity factor 40%	submerged Changes in sediment transportation patterns Underwater cabling -Seabed and habitat disturbance -Electromagnetic interactions with elasmobranchs	
Technology c	Overtopping: Use of wall to focus wave energy into central location. Waves of certain size break over head wall and fill floating reservoir. Low head hydro turbines in floor of reservoir are connected to rotary electrical generator(s)	Demonstrated at up to 100KW level in open sea. Advance plans in place to deploy MW size device in 2007	Intermittent energy source. Forecast ability better than wind, but good reliability only based on future time period estimates of 6-8 hrs. Electrical generation 10's MW size range per installation Capacity factor 40%	Yet to be fully understood but generic issues with: Large mammal collision Risk to marine navigation and associated pollution risks (less if deeply submerged Changes in sediment transportation patterns Underwater cabling -Seabed and habitat disturbance -Electromagnetic interactions with elasmobranchs	as above
Technology d	Attenuator: Semi-submerged, articulated structure of sections linked by hinged joints. The wave motion on these joints is resisted by hydraulic rams, which pump high-pressure oil through hydraulic motors which drive electrical generators	750KW pre production prototype deployed. Commercial order placed for several devices for Portuguese deployment 2006.	Intermittent energy source. Forecast ability better than wind, but good reliability only based on future time period estimates of 6-8 hrs. Electrical generation 10's MW size range 1-2MW size range per	Yet to be fully understood but generic issues with: Marine mammal collision Risk to marine navigation and associated pollution risks (less if deeply submerged Changes in sediment	as above

Resource / Technology	Technology Description	Technology Status	Type of Application - size - heat / electricity - peak / base / capacity	Environmental Effects	Costs*
			installation Capacity factor 40%	transportation patterns Underwater cabling -Seabed and habitat disturbance -Electromagnetic interactions with elasmobranchs	

*Sources: General experience of SKM and NaREC gained in a number of different renewable energy projects
EHMS 2005 for solar thermal costs



4. Renewable Energy Potential

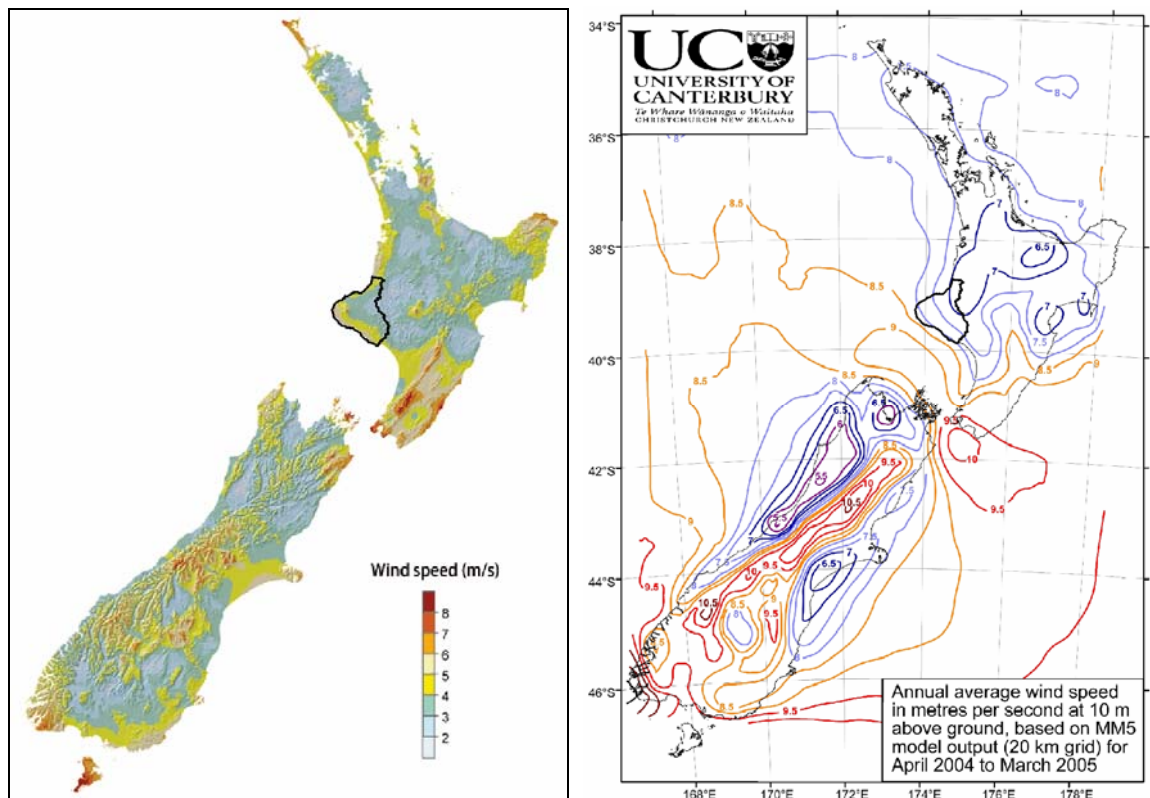
4.1 Introduction

This section reviews the existing and potential future renewable energy potential of the Taranaki Region, looking in turn at wind, solar, hydro, biomass, geothermal and marine energy.

4.2 Wind

4.2.1 Wind Resource

Overall, New Zealand has good wind resource due to its location in the roaring forties, but wind speeds vary considerably around the country (Figure 10). Both wind resource maps in Figure 10 have limited accuracy but provide a good indication of high wind areas. The NIWA map is derived from met station data whereas the Canterbury map is based on weather model data.

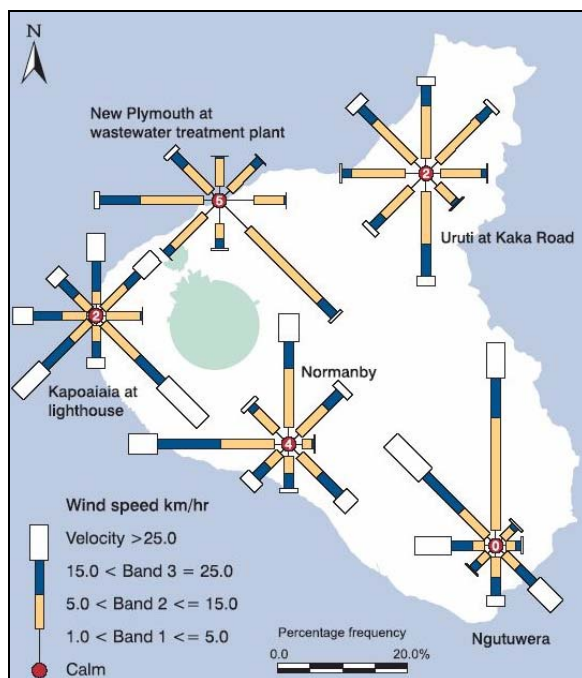


■ Figure 10 Median and average wind speed at 10 m height (NIWA 2005a, Canterbury 2005)



The wind speeds in the Taranaki region are not among the highest in the country, which are generally found in the southern part of the North Island. However, some areas in the Taranaki region are likely to have average wind speeds of above 8 m/s, which is currently the approximate minimum wind speed required for economic wind farms. For comparison, wind speeds in the Tararua Ranges are about 10-11 m/s.

Earlier studies (EECA & CAE 1996, EECA 2001a) identified the Taranaki coastline as an area with sufficient wind speeds. The wind speeds were estimated to be around 7 m/s at 50 m above ground. Based on the more recently published wind maps and wind roses (Figure 11) it is estimated that there is generally more wind at the western and southern Taranaki coast than at the northern coast. The wind speeds along the west and south coast are estimated to be around 8-9 m/s at 60-80 m height (this is the hub height range for modern large wind turbines).



■ **Figure 11 Wind roses (Taranaki Regional Council 2003, based on data from NIWA)**

4.2.2 Potential Electricity Generation from Wind

Wind power generation has become a significant contributor to electricity generation in many regions around the world, especially Europe and US. There is currently 60,000 MW of wind power installed worldwide. Germany alone has almost 18,000 installed wind turbines with a total capacity of around 18,500 MW. The development of wind power in New Zealand has been

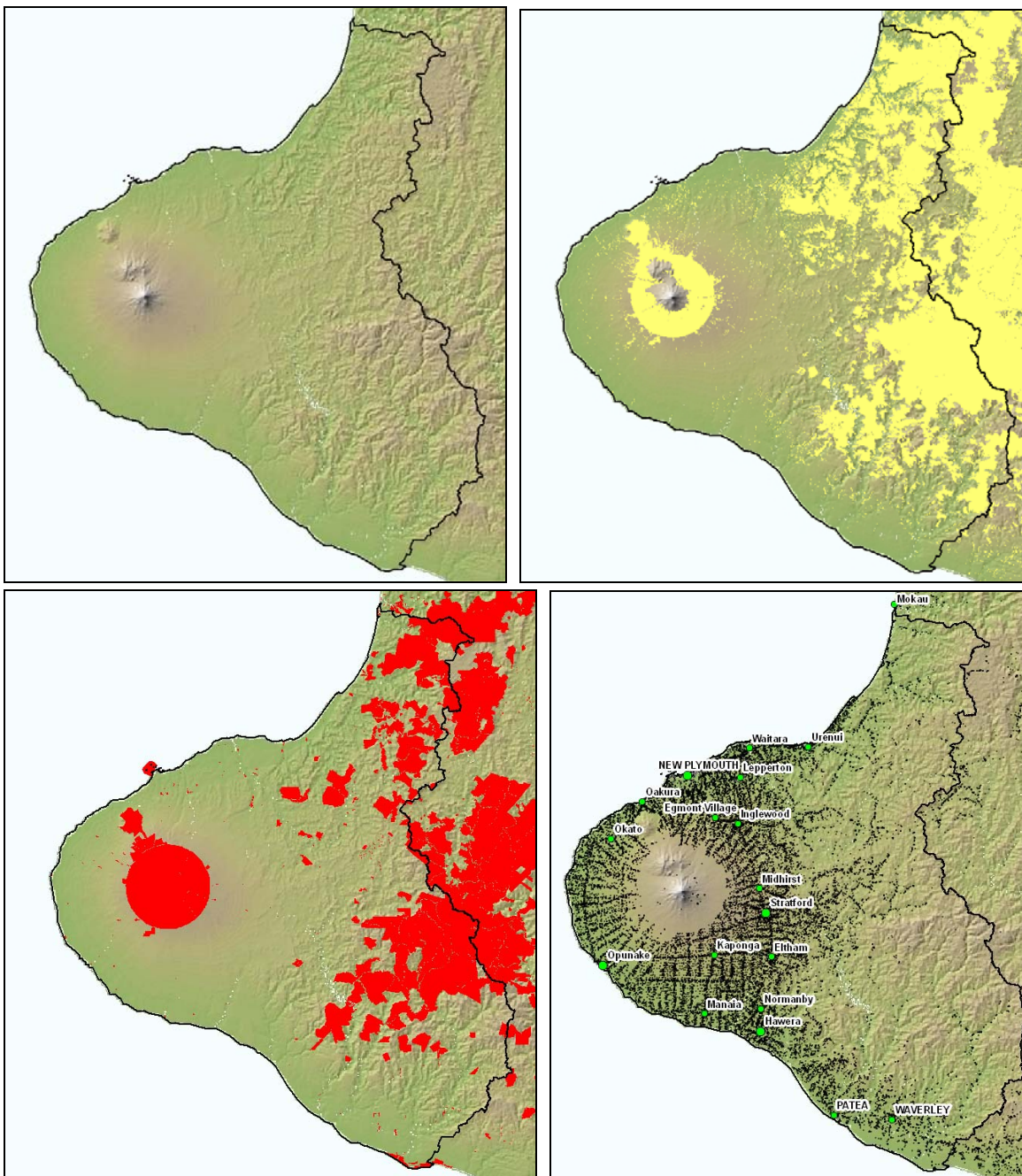


delayed for many years because of very low electricity prices, which made it uneconomic to install wind turbines. Rising electricity prices during the last few years have changed this, and wind farms are now competitive with other forms of electricity generation. However, New Zealand's total installed wind power capacity of 170 MW is still very low when compared with other countries.

There are currently no wind farms in the Taranaki region, but some wind farm developers have mentioned that they are active in the region. No details on exact project locations or planned capacities have been made public though. Due to the highly competitive market situation, those projects will only be made public once all landowner agreements have been signed and when there is high confidence about the viability of the project.

It is not only the wind speed that determines suitable areas, but a range of other factors including location of important natural features, proximity to population, site availability, topography, access and distance to electricity network or grid.

Figure 12 shows areas that will require careful and sensitive planning by wind farm developers. Native forest and Department of Conservation (DoC) land can lengthen and complicate the consent process - most of these areas are currently perceived as unsuitable for wind farms. The relatively even distribution of buildings, and therefore population, across the coastline makes development of large scale (>100 MW) wind farms difficult. The southern coast around Waverley and Patea seems to be less populated and might hold enough space for one or two large scale wind farms.



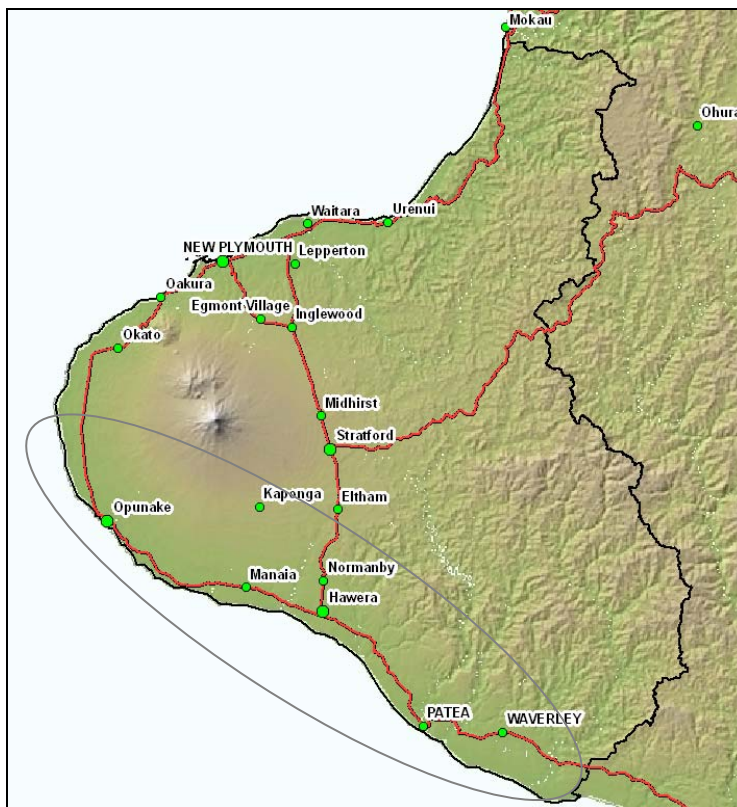
■ **Figure 12 Elevation, native forest (yellow), Department of Conservation land (red) and buildings (black dots)**

Very large wind farms (300+ MW) are unlikely to be developed due to the region’s population density. There are no large ridgelines which could be used that are comparable to the Tararua Ranges or the Te Waka/Maungaharuru Ranges (Hawke’s Bay), where the accumulation of wind



farms can potentially lead to cumulative environmental effects. The wind farms in the Taranaki region are expected to be in the 25-150 MW range and located some distance from each other so that cumulative effects are less likely. Three to five wind farms of that size could potentially be developed based on an initial screening of the region taking into account wind resource, topography, population density, distance to grid, accessibility and environmental factors (e.g. native forest and DoC land). However, the development of wind farms in the Taranaki region is likely to cause some controversy as it does in other regions of the country.

If carefully planned, approximately 300 MW of wind capacity could be installed over a number of years with environmental impacts that were broadly acceptable to local communities, focused in the areas shown in Figure 13. It is to be denoted that the technically available wind potential is much greater.



■ **Figure 13 Elevation map with potential wind farm areas**

The development of wind farms in the Taranaki region needs also to be looked at in a nationwide context. Due to the intermittent nature of wind power there is a limit to how much wind power can be connected to the national grid. A recent study investigated the wind power integration limit



(Energy Link & MWH NZ 2005). It was found that 20% of the nation's annual electricity consumption could potentially be met by wind generation. This leads to a potential wind power capacity of around 2,000 MW (based on today's consumption). There is currently only 170 MW of wind power installed in NZ but a number of large projects totalling more than 1,000 MW are under way or are being planned.

Small scale wind turbines (<10 kW), which are used for remote power supply, can successfully be operated in areas with lower wind speeds also. However, the lower hub heights (approx. 10-20 m) of these smaller turbines means more care needs to be taken when siting near local obstacles (*e.g.* trees and buildings). Small scale wind turbines will not play a significant role in future electricity generation, but they can become important for remote farms and settlements.

4.3 Solar

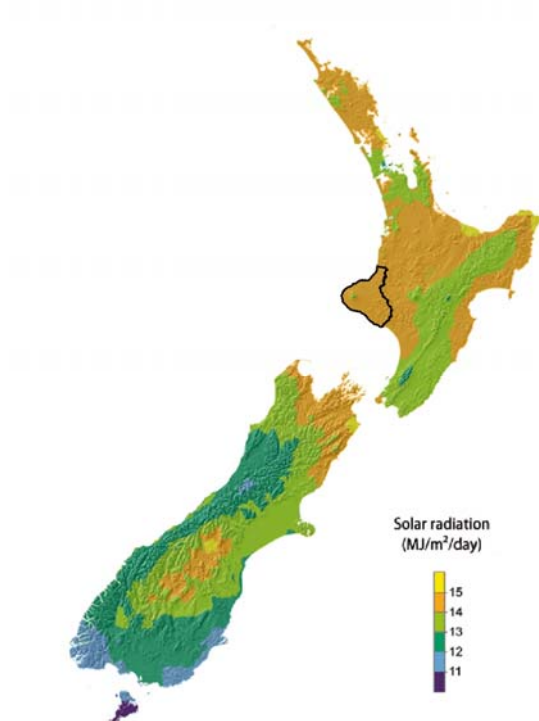
4.3.1 Solar Resource in the Taranaki Region

Solar radiation across New Zealand is similar to that at many sites in Australia and higher than most areas in Europe (Table 4). Solar radiation for the Taranaki region is approximately 1500 kWh/m² yr, with no large variations across the region (Figure 14).

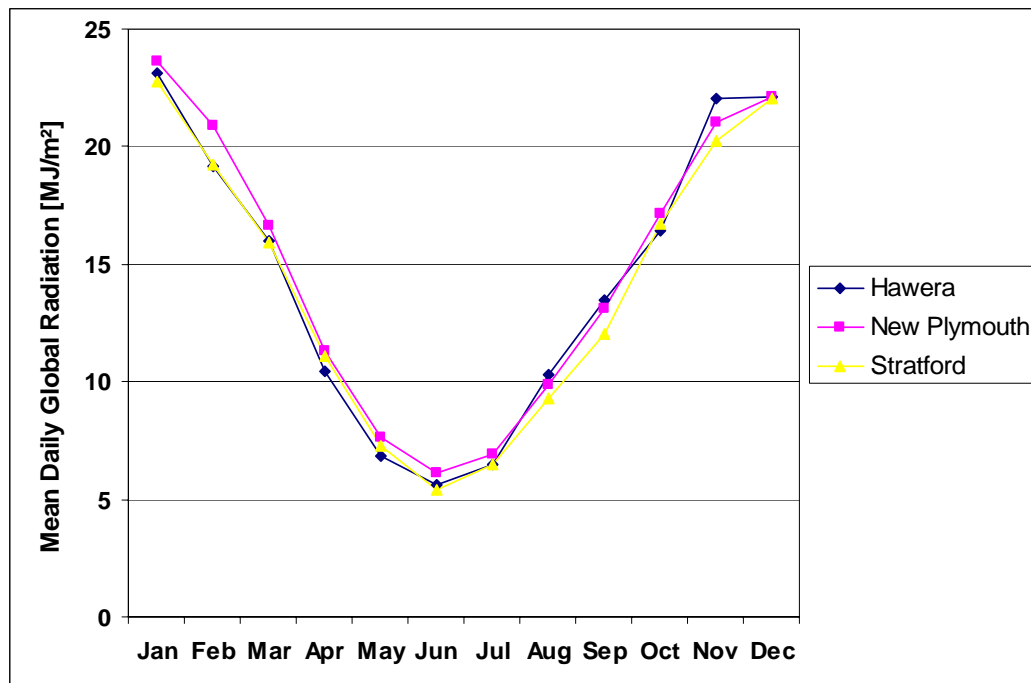
The solar radiation varies greatly over the year. Figure 15 shows the variation at 3 weather stations in the region. The given radiation data is valid for horizontal surfaces. The gain of solar systems can be easily enhanced by tilting the system towards north. Optimum tilting angle is the value of the latitude of the site. For example, an increase in the performance of a solar system in New Plymouth of around 11% can be achieved by tilting the system by 39° towards north.

- **Table 4 Typical values of total global solar radiation for several sites (EECA 2001b, NIWA 2006a)**

	MJ/m ² yr	kWh/m ² yr
Sydney	6150	1708
Melbourne	5302	1473
Kaitaia	5288	1469
New Plymouth	5347	1485
Gisborne	5386	1497
Paraparaumu	5035	1403
Christchurch	4898	1360
Invercargill	4652	1292
Germany	3609	1003



■ Figure 14 Solar radiation distribution (NIWA 2005b)



■ Figure 15 Monthly variation of solar radiation (NIWA 2006a)



4.3.2 Potential for Solar Thermal

Households account for 32% of electricity demand in the Taranaki Region (EECA, 2004). Of this, about one third is usually for water heating (BRANZ 2004). A standard solar thermal system can produce around 55% of a household's water heating. Hence, the installation of solar thermal technologies has the potential to address some of the regions overall supply issues.

Solar thermal systems are most economic when installed in new buildings. Population growth in the Taranaki Region has been a moderate 0.9% for the 2001 to 2006 period (Statistics NZ 2006). The number of occupied dwellings increased by app. 1,000 with the largest growth occurring in the New Plymouth District. The areas with high demand for new housing are best suited for the promotion and installation of solar thermal systems.

Overall, *there is potential for a substantial increase in the uptake of solar thermal use in the Taranaki region.*

4.3.3 Potential for Solar Photovoltaic

The biggest barrier for the large scale uptake of PV is the high cost of the technology. Consequently, uptake has predominantly been for remote power supplies, enthusiast users and commercial developments where renewable energy has additional value as a corporate strategy or image statement. *The current high costs of solar photovoltaic means that large scale grid connected uptake in the region is unlikely, however small scale applications, particularly for remote power supply are expected to become more popular.*

4.3.4 Potential for Passive Solar Building Design

Solar space heating can significantly reduce the amount of energy use in new buildings. With solar space heating, the building is designed to maximise the absorption of solar energy. This can be applied to any building regardless of size or use (domestic/commercial). The building design considers building placement and orientation on the site and design features to capture, store and release solar energy in the building. Solar building design not only reduces the energy use, but it also can reduce moisture and condensation, improve sound insulation and provide a generally more comfortable and healthy living environment.

4.4 Hydro

4.4.1 Previous Hydropower Capacity Studies

The potential for developing the hydro-electric potential of New Zealand has been the subject of study for more than 100 years, the milestone reports being:



- 1) **The Hay Report (1904):** The earliest full assessment of New Zealand’s hydro-electric resource was conducted in 1904, when North and South Island reports were tabled in the House of Representatives. Nearly all of the schemes which have so far been developed were identified in these original reports.
- 2) **Ministry of Works and Development (1982):** The Ministry of Works and Development (MWD) undertook a comprehensive assessment of the country’s small and medium scale hydropower potential in the period 1978 to 1985, establishing a consistent assessment methodology to look for sites with a potential installed capacity in the range 500 kW to 50 MW assuming a typical plant factor of around 50 %. The work involved a review of maps, gauged river flows and topography to identify opportunities for harnessing water power. Local features of the most promising sites were then assessed and preliminary concepts were devised. In 1985 Beca Carter Holling and Ferner Ltd made an assessment of the areas included in Taranaki and concluded a potential total installed capacity of around 80 MW from approximately 13 sites in the 500 kW to 50 MW range. The potential schemes and their scheme parameters are tabulated by catchment area in Appendix A. The locations of the previously identified potentially attractive schemes in the region are shown on Map 1.
- 3) **WORKS (1990):** This study concluded the Taranaki region had the potential of additional 45 MW from three schemes. The study considers two 10 MW schemes – one consists of generating from Waitara River and discharging into Kokohiko and the second consists of generating from Manganui flows and releasing into Waitara. The third scheme is 25 MW on Patea River upstream near Mangamingi.
- 4) **Ministry of Economic Development (2004):** In their ‘Waters of National Importance’ report, East Harbour Management Services considered the hydro-electric resources of New Zealand. A ‘publicly known’ nationwide future hydropower potential of around 2,500 MW is considered, recognising also that there are possibly a significant number of opportunities not publicly identified. In the Taranaki region, only one scheme of 18 MW capacity was considered in the ‘high’ and ‘medium’ confidence category, equivalent to 0.73% of the national potential.
- 5) **EECA Renewable Energy Industry Status Report (2005):** On behalf of EECA, East Harbour Management Services went on to report on the nationwide potential for additional renewable power generation. On a national basis the report estimated an additional annual hydro potential of some 4,260 GWh (equivalent around 900 MW with a typical plant factor of 50%). Cost estimates were based on escalating the MWD data from the 1980’s. In the Taranaki region, four schemes below 16 c/kWh (@10% weighted average cost of capital (WACC)) were considered having a combined capacity of 22 MW at medium confidence level.
- 6) **Ministry of Economic Development (2005):** East Harbour Management Services reported on the overall scope and cost ranges for generating electricity and heat from renewables. In the



Taranaki region an additional five hydro schemes were identified with total installed capacity of 25 MW at the medium confidence level.

- 7) **Electricity Commission (2005):** As part of the Electricity Commission's Statement of Opportunities, a report was compiled by Parsons Brinckerhoff which provided a summary of all previously identified schemes – large and small. The report included cost estimates escalated from the MED report and developed ranges of possible cost (on a theoretical basis only) for schemes not previously estimated. The report summarised the schemes from previous References. There are no schemes in the Taranaki region.

The Taranaki region covers 4,600 km² and includes Mt. Taranaki (2,518 m), Fanthams Peak (1,962 m) the associated lower slopes and ring plain together with the foothills of the eastern hill country. The Matemateaonga Range in the east rises to about 750 m. The geology of the region consists of alluvial deposits in the lower lying flat areas that are associated with the major rivers and coastline while the areas underlain by lahar deposits are undulating and rolling. The sandstone/siltstone sequence to the east has a sharp steep topography, particularly where harder interbedded limestones are found.

The region is exposed to the weather systems from Tasman Sea. The lower altitude area of the region is temperate with snow falling on the higher slopes of Mt Taranaki. Mt Taranaki affects the rainfall in the area markedly, with high rainfall in the western region compared to low rainfall in the eastern hill country. Rainfall is well distributed throughout the year, with winter peaks in June and July and a seasonal low over the November to March period.

Storm rainfall intensities are higher on the west coast than on the eastern lowland and southern coastal areas. Stream flows reflect the pattern of high rainfall in the Mt Taranaki region, with rivers and streams in the northern and western regions experiencing flash floods. However, compared to rivers in other parts of New Zealand, the flows in the two major rivers, the Waitara and the Patea are not high, probably due to their smaller catchments.

The Taranaki Regional Council is responsible for managing the coastal, air, freshwater and land resources of Taranaki. The Council carries out a range of monitoring activities.

For this hydro assessment the region has been divided into 6 areas that combine several catchments within them. The major rivers and lakes in these zones are given in Table 5.



■ **Table 5 Taranaki – Catchment Areas, Major Rivers and Lakes**

	Catchment Area	Major River(s)	Lakes
1.	Northern Coastal Rivers	Mohakatino, Tongaporutu, Mimi, Urenui, Onaero, Waiau	
2.	Waitara River	Waitara, Manganui	Ratapiko, Ngangana
3.	Northern Mountain Streams	Stony River, Oakura, Mangarei, Waiwhakaiho, Waiongana, Ngatoro, Manganui	Mangamahoe, Rotomanu
4.	Western and Southern Mountain Streams	Stony, Warea, Waiaua, Otakeho, Kaupokouni, Kapuni, Inaha, Waingongoro	Opunake
5.	Patea River	Patea, Mangaehu	Rotorangi
6.	Southern Coastal Rivers	Tangahoe, Manawapou, Waikaikai, Mangaroa, Kaikura, Whenakura, Wairoa, Waitotara	

4.4.2 Developed Hydropower Resources

Taranaki has four existing hydroelectric generation schemes as listed in Table 6.

■ **Table 6 Developed Hydro-Electric Schemes in Taranaki**

Scheme	Catchment Area	Scheme Rating (MW)	Owner/Operator
Patea	Patea	30.7	Trustpower
Opunake	Western and Southern Mountain Streams	7.0	Opuha Dam Ltd & Alpine Energy
Mangorei	Northern Mountain Streams	4.5	Trustpower
Motukawa	Northern Mountain Streams	4.8	Trustpower
	TOTAL	47.0	

4.4.3 Possible Future Hydropower Potential

The following sections describe the hydro potential in the different catchments.

Northern Coastal Rivers

The area covers small rivers in the north that have their headwaters in the eastern foothills and drain down towards the coast. Rivers in the area are the Mohakatino, Tongaporutu, Mimi, Urenui, and Onaero Rivers and the Waiau Stream.

In previous studies, no potential schemes had been identified in the region, mainly because of the small river flows and the lack of topographical features where substantial head could be gained or sites that would allow diversion of flows to neighbouring catchments. Also significant areas in the



region are Department of Conservation land or Native Forest area. However there may be some opportunities for micro and mini hydro generation in the lower reaches of the rivers if there are locations with steep river reaches or local drops.

Waitara River Catchment

At 1,470 km², the catchment is the largest in the region and consists of two major tributaries – the Waitara River and the Manganui River, which rise to 1,700 m above sea level. The Manganui River drains around 292 km² but contributes proportionately higher flows to the lower Waitara River because it drains the high precipitation from the slopes of Mt Taranaki. The existing Motukawa scheme diverts the Manganui River into Lake Ratapiko and into the Waitara River approximately 3 km upstream of Tarata.

Water use in the area consists of a variety of commercial and recreational uses. Horticulture, dairy farms and petro-chemical industries are the major commercial users of the water in the area. Recreational uses include canoeing, fishing, whitebaiting, water skiing, yachting, rafting and rowing. While most of these are non-consumptive users, the river regime changes that hydro schemes cause will affect them to some extent and may be one of the major issues in consenting future schemes.

Previous studies have identified three potential diversion schemes and four storage (dam) schemes. There are several potential low level storage schemes on the middle reaches of the Waitara River. They are a 5.8 MW scheme 2.5 km downstream of its confluence with the Makino, a 9.75 MW scheme some 7 km downstream of Tarata township or an alternate 4.1 MW scheme without the diversion to the Onaero River and a 7.3 MW scheme 3 km upstream of Bertrand Road that uses the additional Manganui inflows.

Northern Mountain Streams

The waterways in the regions comprise numerous streams in the area bounded by the Stony River in the west and the confluence of the Manganui and Waitara Rivers in the east.

There are many current consumptive users of the water in the region comprising of agricultural, urban and rural water supply and other industrial water supply commitments. The lower part of Waiwhakaiho River is also used for a wide range of recreational activities.

Earlier studies have identified five diversion type schemes in the region with four meriting additional study.

On the Manganui River there is a potential for a 12.3 MW scheme by exploiting a fall of 65 m gained by diverting water from Everett Park and discharging into the Waitara River downstream of the Waitara/Manganui confluence. Augmentation of the existing Taraki hydropower scheme by



diverting flows from rivers east of the Manganui River into the Ratapiko Lake to supplement the current generation was another identified potential but may not be economic. This is because to convey the added flow to the powerhouse, additional canal and penstocks would be necessary.

Two schemes have been considered in conjunction that would allow the existing Mangorei Power Station to augment its output. The first scheme consists of diverting flows from the Mangaoraka River and Korito River and discharging into Mangorei Stream to gain a head of 100 m and generate 5.9 MW. A diversion downstream of the tailrace discharge would then convey flows to Lake Mangamahoe. This addition of the inflow to the lake would increase generation from the Mangorei power station. The Mangorei power station generation can also be increased by supplementing inflows into Lake Mangamahoe by diverting flows from the Waiwhakaiho River into the Mangamahoe Stream which feeds into the lake.

Western and Southern Mountain Streams

The waterways within this region comprise of the rivers and the streams that drain radially from the slopes of Mt Taranaki, bounded by Stony River in the northern flanks and by the Waingongoro River in south. These waterways derive their flows from the high rainfall (up to 8,000 mm) on the upper slopes, which results in uniformly graded rivers that have cut shallow valleys and occasional gullies (up to 10 m deep) with reduced gradients as they flow to the coast.

There are several consumptive water uses in the region. The major ones include industrial abstraction for various purposes such as by urea plants, urban water supply and agricultural uses. Various rivers and streams have recreational uses such as canoeing in the Waingongoro River, the scenic appeal of Stony River and fishing.

Earlier studies have considered the nine potential schemes and studied four in more detail, discarding the rest as potentially uneconomic.

Two potential diversion type schemes were identified in the mid and lower reaches of the Waingongoro River. The first scheme would consist of diversion of the Waingongoro River to a power station located upstream of Mawhitiwhiti Road to generate 2.4 MW. The second scheme would consist of diversion from the Waingongoro River to a power station located either on its bank 7 km upstream of the river mouth or discharging into the river mouth area to generate 1.9 MW or 4.3 MW respectively.

Another option identified in 1974 is the potential augmentation of the generation of the existing Opunake power station by 0.5 MW by diverting the Mangahume River into the Waiaua River.



Patea River Catchment

The Patea River originates from the eastern slopes of Mt Taranaki and flows through Stratford and into the inland hill country where its major tributary the Mangaehu Stream meets it. The combined river then flows southeast, and then south to the coast. The catchment of the system experiences high rainfall on the Mt Taranaki slopes to moderate rainfall in the lower reaches.

The consumptive water use in the area comprises horticulture, agricultural uses (cereal, root and green fodder crops) and urban water supply. Major recreational uses of the rivers in the areas include trout fishing, scenery and canoeing.

Earlier studies have identified 3 potential schemes on the Patea River – two storage type and one diversion type. A potential for a diversion type scheme is possible diverting Patea flow downstream of Stratford to a powerhouse located on the right bank of the Patea to generate 2.6 MW. However, this scheme may prove uneconomical due to its requirement for significant earthwork, tunnel and long penstock. Another scheme on the river is a storage type dam 1.7 km upstream of the Mangamingi Bridge that can potentially generate 9.7 MW to 25 MW, depending on the height of the storage dam. Another scheme involves using the existing abandoned power station near Normanby Road and re-lining the existing tunnel to use the head generated over a series of sharp loops in the river.

Southern Coastal Rivers

The rivers in this area consist of rivers and streams to the east of the Patea River and those that drain to the coast. The major river systems in the area are Whenakura and Waitotara Rivers and their tributaries. Significant areas in the region in the upper reaches of the rivers are Department of Conservation land/Native Forest area. Earlier studies have identified no potential schemes in the area.

The headwaters of the Waitotara River originate in Matemateaonga Range which rises above 740 m and experiences reasonable rainfall (2,400 to 1,200 mm annually), with a high portion of the rain coming in the winter. There may be some potential for micro and mini hydros in lower reaches of the tributaries where localised drops may present feasible sites for sufficient head gain over short reaches.

4.4.4 Other Possible Hydropower Options

Having assessed the potential for conventional new hydro installations (developing head and diverting flow to generate electrical power by conventional water turbines), other means of increasing the contribution of hydropower include:



Rehabilitation and/or Uprating of Existing Plant

Modernisation and refurbishment of the water turbines and generators at existing hydropower schemes can typically realise an increase in output of 10 to 20% and/or (depending on their relative value in the power market) additional energy across the operating envelope of typically 2 or 3%.

Alternative Technologies

There are some experimental technologies that in the future may become viable to harness hydro potential. Helical turbines for example (for 'ultra low head' applications) are a reaction crossflow machine, developed between 1993 and 1995 at Northeastern University in Massachusetts. The turbine operates in the streamflow and extracts energy from the stream velocity. Steep reaches in rivers with water velocities >1.0 m/s can provide potential sites for machines in series.

Other new technologies evolving, intended to reduce the complexities and capital costs of small hydro schemes, and for 'modular' applications, include siphon type turbines, variable speed and PMG generators and plastic pipelines. For the very small schemes, waterwheels with gearboxes or belt-drives can still have a place.

4.4.5 Summary

In summary:

- Approximately 13 'mini' or 'small' scale projects are believed to be possible in the region with a combined capacity of approximately 80 MW. Among these 2 schemes (with an installed capacity of around 18 MW) are within or close to the Department of Conservation land or Native Forest areas with remaining schemes with a total of around 60 MW available from other schemes.
- Although TRC has recently undertaken an assessment of micro hydro potential in the region, the results have not yet been published. .

Additional potential hydro sites can be identified through the use of modern GIS techniques using updated geographical information. GIS techniques can be used to isolate reaches of rivers with reasonable slopes and to estimate flows to determine the theoretical energy potential of the site. This will be especially relevant in determining small, mini and micro hydro sites where this type of screening approach would potentially be very useful.

The installed hydro capacity within the Taranaki Region is almost 47 MW. The remaining hydro potential from schemes outside the Department of Conservation land and Native Forest areas is about 60 MW in mini, small, and medium scale projects .



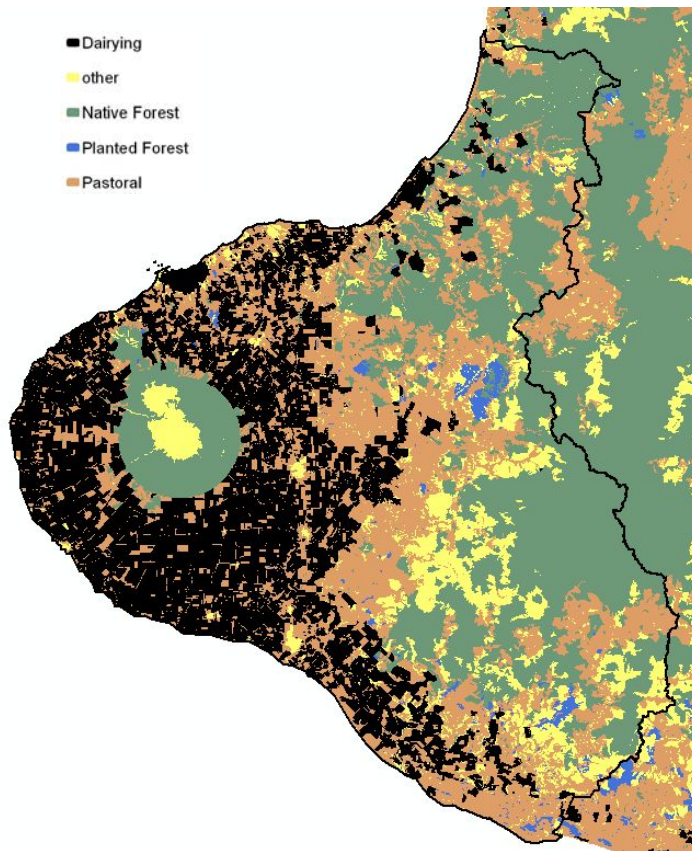
4.5 Biomass

4.5.1 Biomass Resource in Taranaki Region

The resources for the production and use of biomass as a renewable energy resource include agricultural crops, dairy and livestock farming, forestry and the residues associated with production and processing of these.

The Taranaki region, despite its generally good soils and well-distributed rainfall, does not have a particularly suitable climate for intensive cropping and is not likely to be a major source of crop-derived biomass. More than 400,000 ha of land is currently used for high intensity pastoral farming but less than 200,000 ha could be considered suitable for energy cropping (EnConsult, 1981), which compares with more than 300,000 ha in the Waikato Region and 525,000 ha in Canterbury.

Taranaki's agriculture is characterised by livestock production, particularly dairy, and the region is more likely to remain a major pastoral farming area, as indicated in the regional land use map (Figure 16).



■ **Figure 16 Taranaki land use map**



4.5.1.1 Agricultural Crops for Energy

A wide range of crops can be grown in New Zealand that are suitable for renewable energy production, including both thermal and electrical energy and transport fuels. These include:

- grain crops - maize, wheat, oats and barley
- root crops - fodder beet, sugar beet, potatoes
- oil-seed crops - rape, linseed,
- herbaceous crops – kale, sweet sorghum, grass and lucerne

New Zealand produces around 950,000 t/year of grain and seed crops (Statistics NZ, 2002) with barley, wheat and maize grain being the leading components. Peas and other pulses contribute an additional 33,000 t/year. The starches in grains and pulses are readily converted to sugars and then fermented to produce ethanol. These crops are the basis of the very large “corn-based” fuel alcohol industry in the US. Blends of up to 10% ethanol in gasoline, known as “gasohol”, are widely available throughout much of the US.

Oil seed production in New Zealand is much smaller, at around 5000 t/year, and also highly variable. Most of the oil-seed production is based in the lower South Island. Vegetable oils are attracting increasing interest as a raw material for the production of transport fuels, especially “biodiesel”.

The Taranaki region is a very modest producer of maize grains, just 1,800 t/year, and nearly 1,600 t/year of barley in 2002 (Statistics NZ, 2005). This production was derived from only 540 ha, indicating that the level of production could be increased significantly using just a portion of the available 200,000 ha of arable land in the region. The current level of grains production could provide for the manufacture of less than 1 ML/year of ethanol.

The climate and soils of the Taranaki region are well suited to root crops and somewhat higher yields, averaging around 10 ODt/ha, may be achieved with beet crops in particular, i.e. sugar beet and fodder beet. The manufacture of transport fuel from beet crops grown on just 10% of the available 200,000 ha of arable land could deliver around 85 ML/year of ethanol.

Oil seed cultivation is not common in the Taranaki region, presumably because of production economics rather than an adverse climate or unsuitable soils. Yields of oil-seed rape in Southland are typically in the order of 1.8 ODt/ha, equivalent to nearly 700 L/ha yr for biodiesel from this crop, and a similar level of production could be anticipated from the Taranaki region

4.5.1.2 Forestry and Wood Processing Residues

Forestry has the potential to be a very major supplier of biomass for several types of renewable energy, although not specifically in Taranaki. New Zealand has around 1.75 million hectares of



planted production forestry which is being harvested at a rate of 50,000 ha/year, producing around 22 million cubic metres of timber.

At April 2004 the Taranaki region included 18,700 ha of planted production forestry with a relatively young area-weighted average age of 12 years (MAF, 2005). More than 3,000 ha of this area is classified as “unpruned and without production thinning”, indicating that it would be valued at the lower end of the scale, suitable for pulping, fibre-based manufacture (MDF *etc.*) or for energy.

Production of liquid fuels from just the “unpruned and without production thinning” forestry resource in the Taranaki region, without recovery of the harvesting residues, could result in around 20 ML/year of methanol and over 9 ML/year of ethanol. Use of this woody biomass material in a “dendro-thermal” power plant for electrical generation could support a generation plant capacity of less than 5 MW_e and generate some 40 GWh/year.

4.5.1.3 Short Rotation Woody Biomass for Energy

In some countries where areas have been identified as suitable for the supply of woody-biomass, and where generation from renewables is subsidised, it is increasingly common to find the cultivation of fast-growing, coppicing species such as willow, poplar *etc.* This is usually grown as fuel for dendro-thermal power plants, but may also be used as a cellulose feedstock for the production of ethanol via hydrolysis, fermentation and distillation.

Small-scale cultivation trials of *Salix* (shrub willow) are currently underway in parts of New Zealand (although none in the Taranaki Region that we are aware of) with the expectation that the production would form the basis of fuel ethanol and possibly bio-polymer industries. The suitability of such fast-growing and machine-harvestable sources of woody biomass, and the relative economics of production, will not be known for several years.

4.5.1.4 Livestock Farming – Dairy and Meat

As indicated in Figure 16, the Taranaki region includes large areas of pastoral farming.

Dairy processing residues

Taranaki is a significant dairy region in New Zealand, second only to the Waikato, with around 2,100 dairy farms and an aggregate dairy herd of more than 650,000. The region produces and processes around 2,300 ML of raw milk per year and much of the milk from this region, as well as from the Manawatu and Rangitikei regions, is processed at the Whareroa site in south Taranaki.

This milk is converted to products such as butter, cheese, whey proteins, skim-milk and full-milk powders. Products such as cheese and whey protein concentrate result in a lactose-containing



wey, but virtually all of the lactose streams from the Whareroa site, as well as some from the Waikato region, is processed to lactose at the Kapuni site.

Residual lactose streams of appropriate quality may be fermented and the ethanol recovered by distillation. Ethanol is produced at three sites in the Bay of Plenty and the Waikato, but none within the Taranaki region.

Dilute dairy effluent streams, some containing residual biodegradable materials, may also be amenable to anaerobic digestion, producing biogas. Although of relatively low calorific value, this biogas may be used directly for heat-raising or electrical generation. No sites in Taranaki region are known to be recovering biogas from anaerobic digestion of effluent.

The remaining effluent streams, some of which may contain lactose, but for which recovery or processing are regarded as uneconomic, are disposed of to local waterways or spray-irrigated onto adjacent farms.

Meat processing by-products

New Zealand produces almost 150,000 t/year of animal fats (*i.e.* tallow) from meat processing plants. In past years much of New Zealand's tallow production was used locally for soap manufacture, but most is now exported. Tallow may be used in the manufacture of biodiesel by way of a relatively simple esterification process.

Of New Zealand's 150,000 t of tallow produced in the year ending March 2006 (J O'Connell, pers. comm., Statistics New Zealand), some 147,800 t was exported. Of this tonnage, more than 400 t was edible grade tallow with an average value of around NZ\$1,300/t FOB. The balance of nearly 147,400 t consisted of inedible grades with an average value of NZ\$500/t FOB.

There are several meat processing plants and abattoirs in the Taranaki region, some of which have rendering plants to recover tallow. Accurate figures are difficult to obtain, but 33,000 t of inedible grade tallow was exported through Westgate Port, New Plymouth, in the year to March 2006.

Municipal Solid Waste

Municipal solid waste (MSW) is included in this investigation and report on the basis that a proportion, the organic portion in particular, may be regarded as a renewable resource. The population of around 103,000 in the Taranaki region generates around 60,000 t/year of household and commercial waste (excluding cleanfill waste).

Anaerobic digestion

The anaerobic digestion of wet organic wastes (other than plastics) produces biogas, typically a mixture of methane and carbon dioxide with the methane content ranging from about 45% to 60%



(CAE, 1992), sometimes as high as 80% by volume (dry basis) (East Harbour, 2005) and a calorific value between 12 and 30 MJ/m³.

No New Zealand councils or waste disposal contractors are known to be using bacterial digestion processes for disposal of solid wastes, although the technology is now available.

Anaerobic digestion of MSW occurs naturally in landfills where it is a by-product of bacterial action. Relatively few of NZ's older landfill facilities were set up specifically to produce biogas, to contain it or to provide for its recovery and use. Although a few of the older landfill facilities have been developed for landfill gas production, the recovery rates are modest and much of the methane is lost to the atmosphere.

As older landfill facilities are closed, however, the newer and larger landfills are required to comply with the National Environmental Standard which was introduced in 2004. Under this standard, there must be provision to destroy the methane, either by flaring the gas or using it as an energy source.

Combustion

Waste combustion is widely used in many other parts of the world, Europe in particular, where landfill disposal of waste is becoming increasingly unacceptable.

Of the more than 60,000 t/year of MSW generated in the Taranaki region, over 35,000 t/year is combustible material with an average calorific value of around 10 MJ/kg. Despite the relatively low calorific value, combustion of this material would produce around 20 GWh/year of electricity.

4.5.1.5 Sewage

Domestic sewage and liquid industrial wastes are collected from almost all municipal areas and reticulated to central plants for treatment and disposal. Typical quantities of domestic wastewater amount to 200 L/person-day, equivalent to a volumetric flowrate of 13,000 m³/day for the city of New Plymouth.

Total (dissolved and suspended) solids in the wastewater are expected to be in the range of 700 to 1000 mg/l, amounting to as much as 13 t/day of total solids.

Anaerobic digestion

Treatment of sewage typically involves a flocculation and sedimentation stage to increase the solids concentration and then sludge digestion by aerobic and/or anaerobic processes. Anaerobic digestion produces between 0.75 and 1.12 m³ of biogas for every kg of volatile sewage solids



destroyed, amounting to as much as 14,000 m³/day for New Plymouth City. This biogas will have a methane content of between 65 and 70%, by volume.

Sewage sludge drying and combustion

Sewage solids have been segregated, dried and burnt for over 100 years and modern sewage treatment plants around the world are routinely disposing of sewage solids in this manner. Where sewage solids are recovered from treatment plants in New Zealand they are usually disposed of to landfill, although New Plymouth is one of only two cities in New Zealand where sludge drying and alternative disposal options are currently available. Sewage sludge drying and combustion trials are understood to be underway in both Hamilton and Auckland with the objective of reducing the high costs of transport and landfill disposal.

Combustible solid recovered from New Plymouth's digested sewage sludge is expected to have a calorific value of around 16 MJ/kg (bone dry basis). Despite the apparently high calorific value, the net recoverable energy from the combustion of sewage solids is relatively low, mainly due to the high energy demand associated with drying, sterilisation of the emissions and odour control.

4.5.2 Technology

4.5.2.1 Transport Biofuels

A range of transport fuels may be produced from biomass sources. These include:

- Biodiesel – from oil-seed crops, oil-bearing crops such as *jatropha*, and animal fats, via transesterification
- Ethanol – via direct fermentation from grains and root crops as well as via hydrolysis and fermentation from cellulosic material such as wood, straw *etc.*
- Methanol – via gasification of almost all biomass and catalytic re-combination of the resulting synthesis gas
- Biogas – via anaerobic digestion of almost all biomass
- Pyrolysis oil - by the pyrolysis of biomass material and the subsequent separation and refining of the produced liquid.

Biodiesel

Biodiesel is a clean burning transport fuel produced from renewable resources including oil-seed crops and animal fats. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend that can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to manufacture, biodegradable, non-toxic, and is free of sulphur and aromatics.



The technical definition for biodiesel (NZS7500:2005) is “a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Typically these are methyl esters or ethyl esters, however higher alkyl groups can be used.” The New Zealand standard appears to follow the US standards (ASTM D 6751 in particular) reasonably closely.

A biodiesel blend (Bx) is a blend of biodiesel with mineral diesel fuel, where “x” represents the volume percentage of the biodiesel component in the blend. Biodiesel blends in New Zealand are presently limited to no more than 5% biodiesel by volume.

Ethanol

The production of ethanol from agricultural biomass is well developed technology. Very large quantities of ethanol are currently manufactured from cane sugar (cf. Brazil) and grains (cf. the USA) specifically for transport fuels.

Starches in grains and pulses (and even potatoes) are readily converted to glucose and then fermented to produce ethanol. Sugars may be extracted directly from crops such as sugar cane, sugar beet etc. Ethanol is currently produced largely from wheat in Australia (EECA, 2006) and sugar cane is expected to become more widely used also. Sugar cane does not grow well in New Zealand although root crops, such as sugar beet, could be grown in most areas of New Zealand and extraction of the sugar is straightforward.

Cellulose, which is the major component of wood, straw, corn stover etc, may also be converted to pentose sugars by hydrolysis. Much of the early work on the hydrolysis of woody-biomass relied on cooking at high temperature and pressure with a dilute mineral acid. This relatively energy-intensive process has been partially replaced by enzymatic hydrolysis, which requires expensive enzymes but takes place under less aggressive conditions.

Dilute sugar solutions are fermented using typical brewery technology to produce ethanol. The dilute ethanol solution is usually concentrated to around 94% by distillation. Ethanol must have a very low moisture content if it is to be used for blending with petrol and it is therefore distilled again with a ternary component to produce fuel-grade ethanol

The distillation stage is very energy-intensive and several processes, including membrane separations, are under development.

Bioethanol is the basis of the very large “corn-based” fuel alcohol industry in the US. Blends of up to 10% ethanol in gasoline, known as “gasohol”, are widely available throughout many states.

Methanol

Methanol was originally known as “wood alcohol” as it was obtained by the destructive distillation (similar to pyrolysis) of wood. This process is not used in the manufacture of methanol on an



industrial scale. The most common route to methanol is from natural gas via the production of synthesis gas and the catalytic reforming of that to form methanol.

Synthesis gas: $2\text{CH}_4 + \text{H}_2\text{O} + \text{O}_2 = \text{CO}_2 + \text{CO} + 3\text{H}_2$

Gas shift: $\text{CO}_2 + \text{H}_2 = \text{CO} + \text{H}_2\text{O}$

Methanol synthesis: $2\text{H}_2 + \text{CO} = \text{CH}_3\text{OH}$

Synthesis gas may be produced by the combustion of almost any biomass under appropriate conditions. Clean woody-biomass is very well suited to the production of synthesis gas as it has a very low ash content.

Methanol is not being proposed as a transport fuel in New Zealand (EECA, 2006), despite extensive vehicle trials in the 1980's, but is a component in the manufacture of biodiesel.

Pyrolysis Oil

Many forms of biomass will produce a mixture of hydrocarbon-based liquids and gases when pyrolysed, *i.e.* heated to high temperatures under oxygen-starved conditions. The liquid may be further refined and separated to provide a range of potentially useful streams including fuels, solvents *etc.* The technologies require relatively severe processing conditions, and are at an early stage of development relative to the process routes identified above, and are not discussed further.

Biogas

Biogas is generated as almost any biomass is broken down by biological processes.

4.5.2.2 Electricity generation

The generation of electrical energy from biomass is widely practised around the world and the technologies and economics are well understood. Biomass – typically woodwaste, grain husks, bagasse or straw – is burned to generate steam which is used to power an electrical generator. The combustors range from simple “dutch ovens”, through reciprocating and vibrating grates, to bubbling and circulating fluid bed boilers. Biomass is also increasingly co-fired with coal in stoker and pulverised-fuel boilers.

We are not aware of any examples of electrical generation based on renewable fuels in the Taranaki region.

4.5.3 Summary of Resource Potential

Overall, *there is limited potential for production of both transport fuels and energy from biomass in Taranaki Region.* This comprises less than one million litres per year of ethanol for transport



fuel from grain crops currently grown in the region. About 10 million litres per year of ethanol or 40 GWh per year of electrical energy from woody biomass derived from lower-grade forestry.

4.6 Geothermal

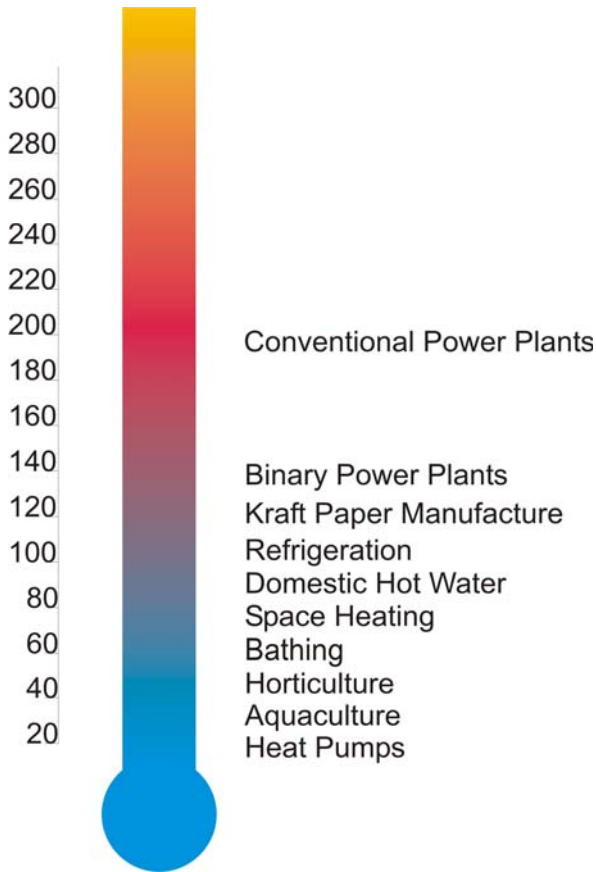
4.6.1 Power Generation

The Taranaki region does not contain any of New Zealand's high temperature geothermal fields, which only occur within the Taupo Volcanic Zone and in Northland. However, it is the location of recent volcanism (Mt. Taranaki last erupted about 1755), and higher than average heat flow, particularly in the vicinity of New Plymouth (Allis *et al* 1995), where the geothermal gradient is over 30°C/km. With temperatures over 150°C in some deep oil and gas exploration wells, it may be possible to generate electricity (GNS 2006), at least in theory. Elsewhere in the world, power can be generated from geothermal fluids at temperatures as low as 80°C using binary power plant technology, though in New Zealand, power is only generated in binary plants from geothermal fluids at more than 120°C, for economic reasons.

It is necessary to have large volumes of fluid, and not just adequate temperatures, for power generation. Furthermore, that fluid would have to be water, rather than hydrocarbons, since oil (which is found at depths of about 2000 m) will be too cool for power generation, and gas, which is deeper (around 3500-4000 m) and thus hotter, does not have appropriate thermal properties for the extraction of heat. So if there are abandoned deep onshore wells that penetrate an overpressured water-filled aquifer at depth (>4000 m), they could potentially be used for electricity generation. However, it is more likely that the temperatures and flow rates obtained would be too low for power generation, and be more appropriately used for direct heat applications.

4.6.2 Direct Use

Low temperature geothermal fluids (<150°C) can be used for a range of direct heat applications (Figure 17). Such fluids can be obtained from low temperature geothermal systems, or from deep within the earth. Warm water reaches the surface at two locations in Taranaki: an area of warm springs about 12 km NNE of Opunake, and from the abandoned Bonithon-1 oil exploration well in New Plymouth (Table 7).



■ **Figure 17 Temperatures (°C) required for some direct use geothermal applications**

A large number of deep oil and gas exploration wells have been drilled in the Taranaki region, and although downhole temperatures were not always reported, exceed 130°C in at least three onshore wells (Table 8). Most of these wells are either plugged and abandoned, or still used for oil/gas production, but the plugged wells could be reopened so that heat could be extracted from them. The data in Table 8, obtained from a quick search of the MED website, indicates that there are at least a dozen onshore wells with measured downhole temperatures of up to 144°C. These temperatures are more than adequate for a range of uses, provided an adequate flow rate can be maintained.



■ **Table 7 Warm springs in Taranaki (from Mongillo & Clelland 1984)**

	System	Flow l/s	Max. T °C	Notes
1	Arawhata		30	Springs both sides of Arawhata Road over about 100m ² near the junction with Wiremu Rd
2	Bonithon-1 well		28	Artesian flow from an abandoned oil exploration well

■ **Table 8 Temperatures in some onshore Taranaki oil and gas wells (from MED 2006)**

	Well name	Depth (m)	Max. T °C	Well status
1	Bonithon-1	916	28	plugged and abandoned, reopened in 1940s for warm water supply
2	Kaimiro-1	5000	132	production
3	Manganui-1	3975	93	plugged and abandoned
4	Manganui-2	3753	109	plugged and abandoned
5	Mokoia-1	3750	76	plugged and abandoned
6	Ngatoro-1	4126	135	plugged and abandoned
7	Rotokare-1	3233	64	plugged and abandoned
8	Stratford-1	4975	104	production
9	Te Kiri-1	4710	144	plugged and abandoned
10	Urenui-1	2940	106	?
11	Waihapa-1	4477	58	plugged
12	Wharehuia-1	3595	55	plugged and abandoned

There is other evidence of high temperatures at relatively shallow depths. Allis *et al* (1995) reported: “a mysterious heating-up of the soil and the dying of plants in the backyard of a New Plymouth residence was reported during 1993 (Craig Evans, Taranaki Regional Council, *pers. comm.*). The Taranaki Regional Council measured 45°C at <50 cm depth, and these conditions apparently persisted for several months before gradually disappearing.”

To date, the only use of the geothermal resource in the Taranaki Region is the Bonithon-1 well, which is used for bathing. This is one of the coolest (28°C) and shallowest of the abandoned onshore oil wells, and is used because it is artesian (*i.e.* the water flows without pumping), and it is close to a population centre (New Plymouth). Even so, the water from this well is not hot enough for bathing, and it is heated further with gas prior to being used in the Taranaki Mineral Pools (Jackson 2001).

Horticulture (greenhouse) geothermal heating systems have been developed in many countries, including at Mokai and Kawerau geothermal fields in New Zealand.



Aquaculture projects include the Wairakei prawn farm, which uses waste hot water from the Wairakei power plant.

A range of **industrial applications** can make use of geothermal fluids over a wide temperature range. These include timber drying, pulp and paper manufacture, dairy processing, and many other applications.

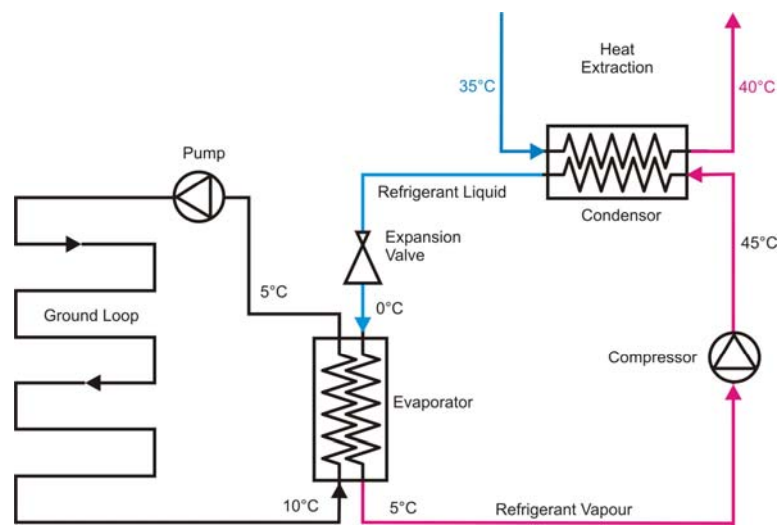
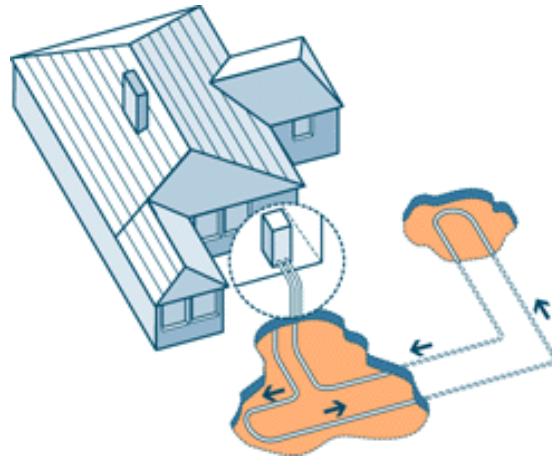
Geothermal **space heating** is common where high temperatures are present at shallow depths (*e.g.* in parts of Taupo), though ground source heat pumps may be more practical in Taranaki.

Elsewhere in the world, **ground source heat pumps** (GSHP) have become widely used since the 1980s. Heat pumps permit the extraction of heat from warm ground or groundwater, in a similar way to standard air conditioning, only instead of using ambient air for the heat source (or sink), warm ground or groundwater is used (Figure 18). Ground source heat pumps are much more efficient than standard air conditioning units because in winter, when heating is required, the ground is warmer than the air (even away from thermal areas), and in summer, when cooling is required, the ground is often cooler. The only energy required is that needed to pump the circulating fluid through the system. This technology is used on a large scale in North America and Europe where the climate, high electricity prices and subsidies make this technology economic. These drivers are largely absent in New Zealand and as a result there has been little uptake of the technology here.

All other factors being equal, GSHP's are most cost effective in areas with climatic extremes (cold winters and hot summers) because the pump provides both heating and cooling and is used for longer periods and at high rates. As a result, the capital investment can be recovered in a relatively short time.

Thain *et al.* (2006) provide estimates of annual costs for space heating and assisted water heating using GSHP in New Zealand. For a typical household with an electricity price of 12c/kWh, and space heating for 800 hours per year, the annual heating cost (space and water) is \$520 compared to \$1320 for electricity alone, i.e: a saving of \$800 per year (~60%). However, this is not a sufficiently high saving to compensate for the initial high capital cost (about \$12,000). On this basis, it is unlikely that GSHP's will find favour for domestic heating in the Taranaki, particularly if natural gas is available.

For larger commercial buildings which often require heating and air-conditioning, economies of scale may make GSHP's economic, particularly where there is a source of water to improve efficiencies (*e.g.*: river-side developments).



■ **Figure 18 Schematics of a ground source heat pump system.**

By far the most widespread use of low temperature geothermal resources in New Zealand, including Taranaki is for **bathing**. Hot baths and spa complexes have been developed at many of the high and low temperature systems throughout the country, including at the Taranaki Mineral Pools.



4.6.3 Summary of Resource Potential

Temperatures in some abandoned oil and gas exploration wells are sufficient for a range of direct use applications, provided adequate flows could be obtained. Ground source heat pumps constitute a largely untapped resource, and can be used throughout the entire region, not just in the thermal areas.

4.7 Marine

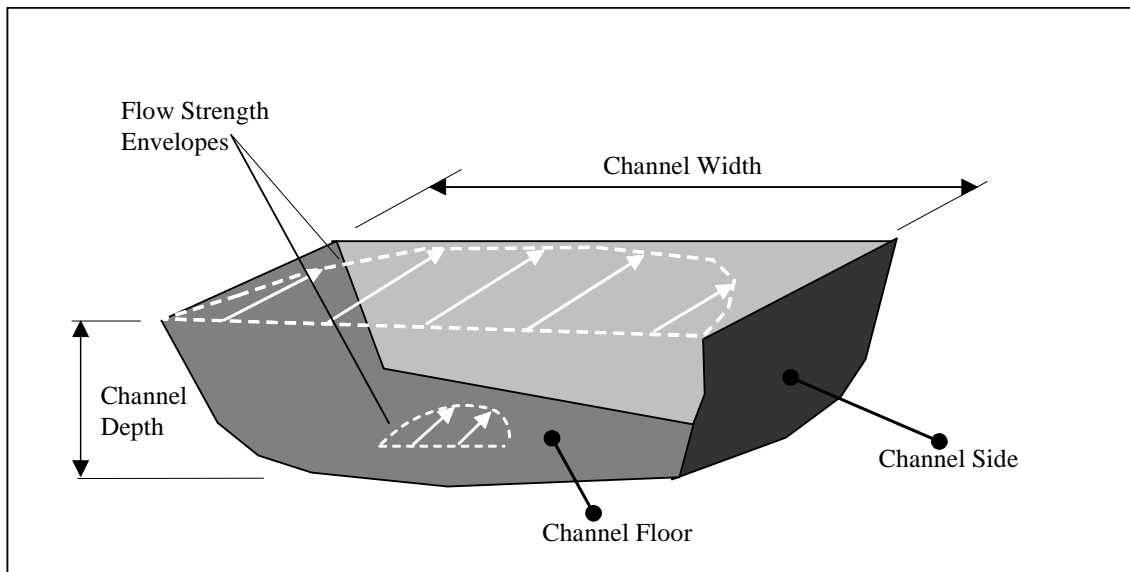
4.7.1 Tidal Resource

Tides are the periodic rise and fall of large bodies of water caused by the gravitational interaction between the astronomic bodies within our solar system. This may be simplistically understood as the gravitational attraction of the moon causing the oceans to bulge. Another bulge occurs on the opposite side, since the Earth is also being pulled toward the moon (and away from the water on the far side). Since the earth is rotating while this is happening, two tide cycles occur each day. At periodic 28 day intervals the alignment of the moon, sun and earth causes an additive effect creating stronger tides and conversely at other times weaker tides. Although the influence of these effects is generally diffuse, localised bathymetry concentrates tidal flows in certain regions into areas of highly energetic activity.

A number of factors come into play when estimating and assessing the extent of the resource and its 'harvestability'. These can be grouped into two categories: 'site' and 'technology'. Site assumptions are focussed around the extent of the resource itself while the technology group is focussed around the technical issues of harnessing the resource. A critical decision in determining the extent of the resource is based around estimating the flow velocity and its variability dependant upon the lunar cycle. As a complete set of detailed data for every site of potential interest is seldom available, certain assumptions or extrapolations must be made.

Typically these will concentrate upon:

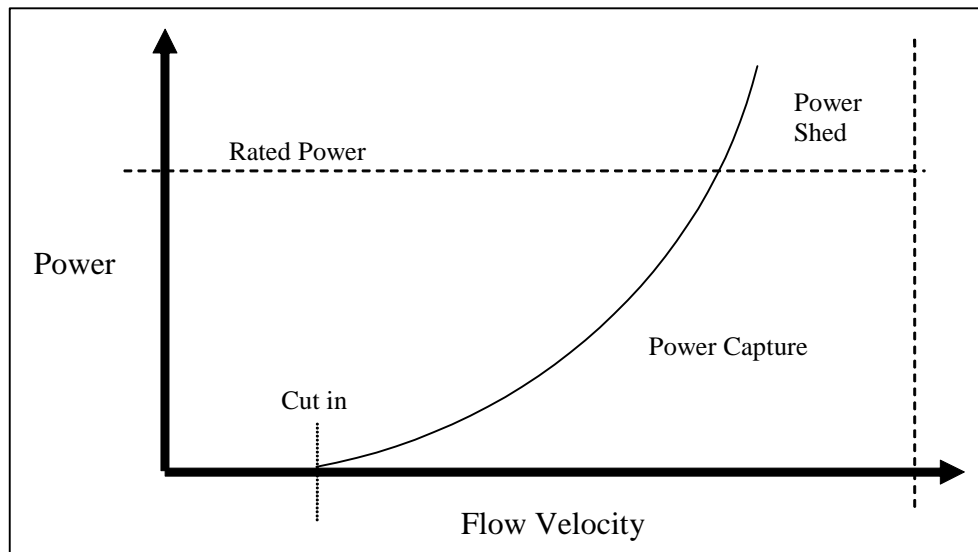
- Influence of the boundary layers on flow rates (both seabed and channel sides) and the effect they have on flow through the channel cross section between 'mean peak spring velocities' and 'neap' flows (Figure 19)
- Variance of flow within tidal 'ebb' and 'flood'
- Presence of bathymetry oddities that cause 'hot' and 'cold' spots
- Thresholds of energy extraction beyond which tidal flow pattern will change in response to the extraction itself (*i.e.* channel blockage effects)



■ **Figure 19 Cross sectional view of tidal channel**

Factors influencing ‘harvestability’ are largely technology dependant:

- Efficiency of devices to capture energy and convert it to electrical power (Figure 20). As devices operate in flow environments that are far from constant, design compromises result in the device being designed to only operate across a selected range of conditions. Typically the device will have a ‘start up’ flow velocity, below which it does not operate, and a ‘rated power’ beyond which it does not operate. Below the cut in and above the rated power, the device will ‘shed’ power.
- Reliability of the device and the speed with which repairs can be executed
- The density of device deployment or spacing within an array
- The location of the device relative to boundary layers
- The transmission efficiency of the electrical connection relative both to land and the end user proximity
- Needs of other maritime users



■ **Figure 20 Generic device power capture graph**

The tidal range in New Zealand is low (2 to 3 m) compared to many other places around the world (up to 10 m in the UK). Nevertheless there are some sites around New Zealand with significant tidal currents. Most promising are the areas around headlands, together with Cook and Foveaux Straits and the entrances of some natural harbours. Maritime tidal atlases suggest that the maximum tidal current in those harbour entrances is approximately 2-3 m/s.

The information available regarding tidal flow patterns in the region is limited but indicates that the tidal flows seen within this region are insufficient for power generation.

Generation capacity

The two key geographical factors determine the suitability of a site for the deployment of tidal stream extraction technologies are flow rates and water depths:

- 1) Flow rate is highly significant as the power is proportional to the cube of the flow velocity. This may be illustrated by understanding that the power increases by a factor of 8 every time the flow doubles. Therefore tidal developments in the short to medium term are only likely to be economically viable in sites of higher flow. Discussion with existing technology developers suggests that sites where spring peak flows exceed 5 knots are required. In the context of the areas covered within this study this is greater than the available resources.
- 2) As water channels are generally much greater in width than depth, water depth acts as the constraining factor in available energy capture. This factor is compounded by the seeming convergence in the development of horizontal axis twin bladed turbine type technologies, whose power capture is determined by a swept circular cross section. Full sized machines



have a blade diameter of typically 20 m and are situated in 30-40 m of water if mounted on a mono-pile foundation, with options for greater than 40 m if based upon floating - sea bottom tethered configurations. In the context of the areas covered within this study, the technology presently being developed is not suitable for deployment in the relatively shallow waters found within harbour regions.

To summarise, the sites considered within this study are not well suited to tidal technology developments, with insufficient tidal flow velocities meaning that these sites are not well suited to exploitation in the short to medium term.

4.7.2 Wave Resource

Ocean waves are created by the conversion of kinetic wind energy acting across the surface of an area of open water, where the energy within the wind acts upon the surface friction of the water such that with time it creates an orbital water particle motion. The open space expanse over which the wind and water have opportunity to interact is referred to as the fetch. The interaction between the wind and sea is such that the energy transfer between the mediums will continue until such a point that either equilibrium is reached (this is known as a fully developed sea) or that the fetch length is such that the waves enter shallow waters and break. Wave energy additionally has a directionality component related to the wind direction driving the fetch.

As wave energy propagates nearer to coastal regions, it experiences several physical changes, whose additive effect is to reduce the levels of energy resource found in shallow coastal waters as compared to their deep water ocean counterparts. The driving factor in this transformation is water depth. As deep water waves enter coastal waters (deep water is where the water depth is greater than half the wave length), a transition in the wave characteristics occurs. Whilst the wave frequency remains the same, three factors change:

- The wave length shortens
- The wave amplitude increases
- The wave velocity reduces

The above changes are underpinned by the fundamental mode change of the wave's water particle velocity path from circular to elliptical. This is caused by the influence of the seabed and its friction acting upon the wave propagation. At a point where the wave has grown in height by around 1.3 times, its steepness will be such that it topples over and can be visually seen as surf.

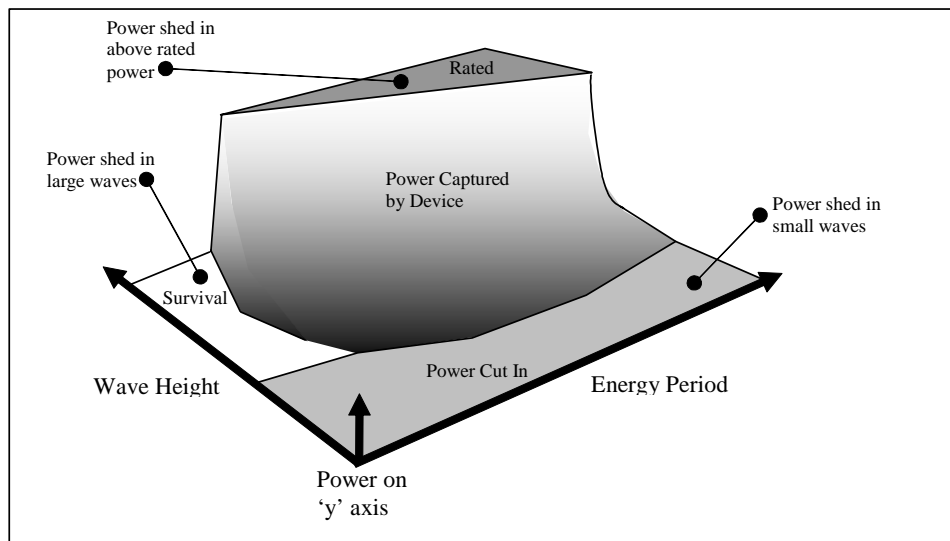
As with the tidal case study, the estimates of both the total and attainable wave resource are based upon a set of assumptions that significantly impact the overall results. These assumptions are summarised:

- Distance to land mass for grid connection



- Single device capture efficiency
- Device availability
- Device spacing within array
- Transmission efficiency
- Minimum allowable site area
- Site survey data
- Needs and rights of other maritime users

Many of the above are directly analogous with the tidal situation. However wave device power capture efficiency is somewhat different. Unlike tidal, where the dominant variable in the power calculation is velocity, with waves, power capture is a combination of wave period and height (Figure 21), thus creating a 3-D scenario. Typically a device will be designed such that below a certain threshold or 'cut in', the device will shed power. Above a certain threshold associated with its rated power, the device will also shed power, and in high energy storm conditions the device may shed power as a survivability strategy.



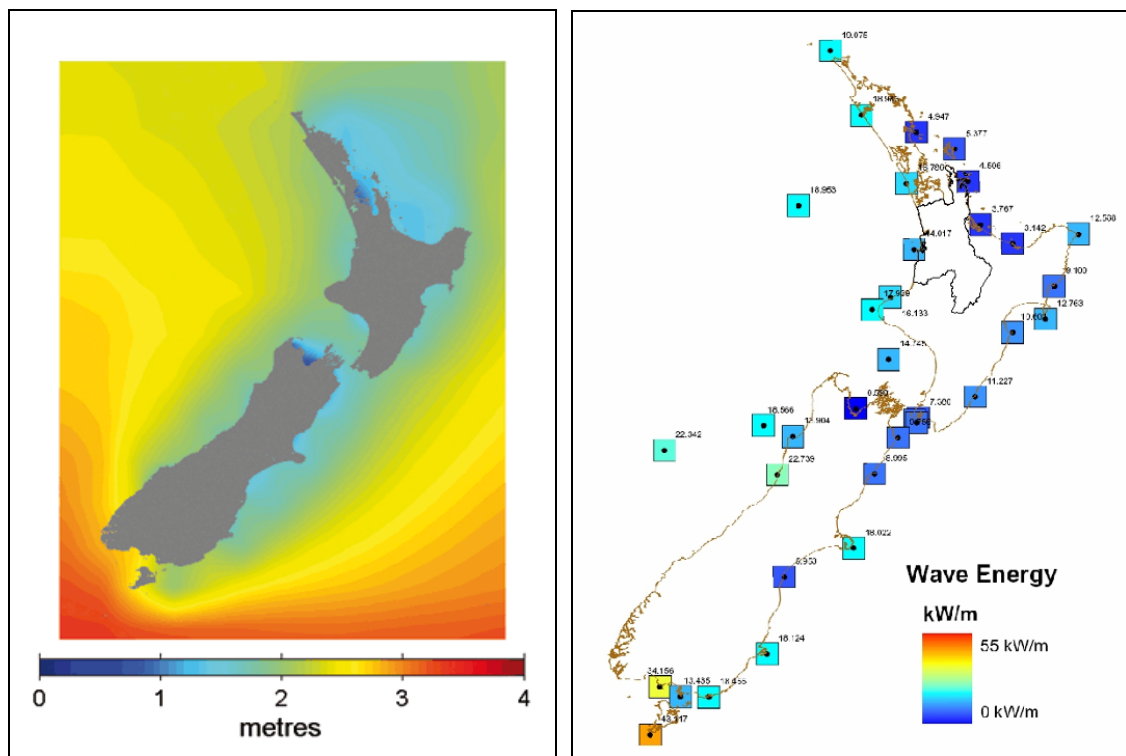
■ **Figure 21 Typical wave device power capture**

In New Zealand, the weather systems that are driven up from the southern ocean play a major influencing role. It follows that offshore and coastal regions exposed to these influences will contain a greater abundance of wave energy than more sheltered areas. Accordingly, reports show that the annual average wave power around the New Zealand coast varies from 8 kW/m at East Cape to 99 kW/m near Stewart Island. A typical value is around 30 kW/m, which is favourable in terms of global energy potential. Figure 22 shows average significant wave height for coastal areas



of New Zealand for the period 1979-93. The presentation is given in terms of ‘Significant Wave Height’ (a simple statistical tool of averaging the height of the highest one third of the waves in a given sea state). As a guide, areas with greater significant wave height have better potential for wave power electricity generation.

Another study provides an annualised average wave energy atlas for selected locations around the New Zealand coastline and offshore deep waters (Figure 23). This information is provided in kW/m. Relative to this region, data is provided 13 km due west of the region. This information states that resource potential power levels of 16.1 KW/m.

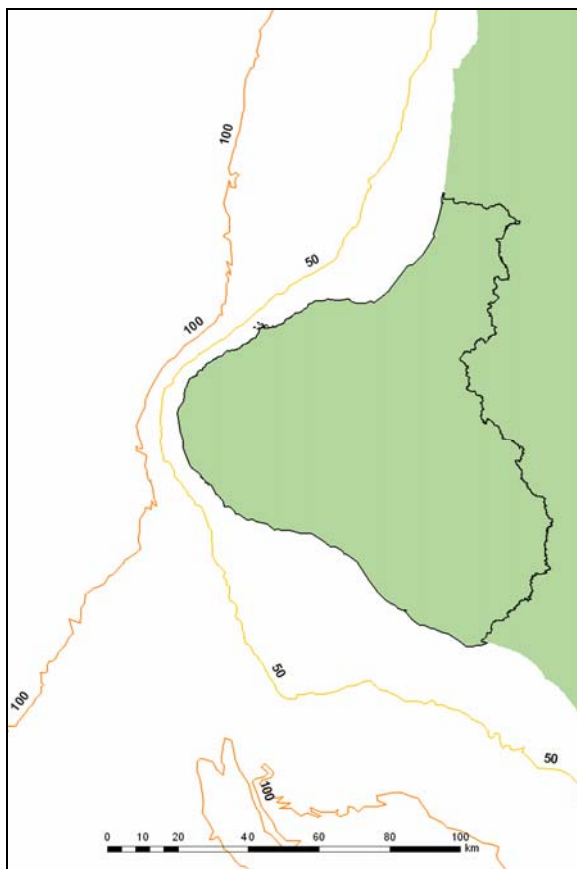


■ **Figure 22 Mean wave height from 1979 to 1998 and wave energy (NIWA 2006d, East Harbour Management Services 2005)**

To illustrate the attainable power potential, a simple case study based upon resource potential and Pelamis-deployed technology may be considered to demonstrate the wave power extraction viability. Operating in the 16.1KW/m wave climate environment, each unit would produce around 180KW for significant wave heights of 2.2m and a wave period of 8 seconds. With units spaced 150m apart, a farm array of 14 devices would have a footprint of 2100m by 150m. Assuming the developer-quoted load factor of 40%, the annual energy production would be 8.86GWhr per farm.



Several practical issues must be borne in mind. A wave farm further from a shoreline connection point will have a more significant subsea electrical cabling connection cost burden than one nearer. Locating wave farms closer to the shore will reduce connection costs but will also reduce energy resource availability as shallower water depths (<50 m) are encountered (Figure 23). Additionally, depending on the strength of the local shoreline electrical transmission systems, upgrade measures and hence additional costs may be necessary.



■ **Figure 23 Water depth contours along the Taranaki coastline (depths in metres)**

Based on these numbers, it is estimated that about 8 MW/km² of wave energy devices could be installed. With a coastline length of around 250 km, this equates to a capacity potential from wave energy in the thousand megawatt range, ignoring environmental constraints and conflicts with other maritime users.



5. Enabling Assistance

5.1 Introduction

Although the focus of the current study has been to assess renewable energy resources and regulatory approaches at the regional level, there are a variety of non-regulatory methods (referred to here as ‘enabling assistance’) which could also be developed to encourage greater renewables uptake. This chapter presents a number of such approaches for consideration by councils, particularly for those regions where there is a clear and pressing energy issue such as those outlined in Section 2.6.

It was noted during the preparation of this report that neither the Taranaki Regional Council, nor its predecessors, has been involved in energy planning, nor has it considered the possibility of doing so to any extent in the future. During the preparation of the current Regional Policy Statement it was noted that issues around energy supply and investment were considered by the Council to be outside the scope of the Resource Management Act 1991, and council functions as regulator, and that energy supply and investment is appropriately addressed at a national level. Consideration by the Council of energy planning would require a change to its current policy and core functions in this area.

5.2 Renewable Energy Expertise

Renewable energy can be viewed as a development activity with potentially adverse local environmental impacts but with national energy benefits (*e.g.* security of supply) and international environmental benefits (*e.g.* climate change). As such, the inclusion of renewable energy in the Resource Management Act (RMA) needs to be recognised as a departure from the norm for councils who have primarily been responsible for managing regional environmental resources. At the same time, the inclusion of renewable energy in the RMA is consistent with the councils’ role in the meeting of national and international objectives on issues such as biodiversity.

As such, with a number of notable exceptions, the majority of councils have limited in-house expertise on issues relating to energy and renewable energy. This is perhaps unsurprising given councils’ core functions under the RMA, the relatively recent limited inclusion of renewable energy in the RMA and the rapid development in renewable energy technologies. However, it is clear that if the councils are to play a role in the greater uptake of renewables through either regulatory or non-regulatory approaches, then additional expertise is required. This should be such that a council’s capacity with regard to renewable energy is commensurate with that of its other functions, *e.g.* soil conservation or water quality. This would assist the high-level resolution of how proposed renewable energy developments might affect aspects of the regional environment.



Whilst the requirements for renewable energy expertise will vary between councils, it will largely be determined by the region's and council's aspirations and the renewable resources available in the region.

5.3 Renewable Energy Plans / Strategies

The urgency and type of energy issues varies substantially between regions. For those regions with one or more pressing energy issues, such as those outlined in Section 2.6, councils may wish to consider the development of an energy plan / strategy. This would typically be positioned as an economic development or infrastructure plan / strategy rather than an implementation mechanism under the RMA. Such an approach would provide for design flexibility, speed of implementation and the ability to consider wider, non-renewable energy issues. A preliminary indication of this regional approach is provided by the Southland Regional Energy Strategy (2004).

5.4 Resource / Constraint Mapping

The issue of developing spatial representations of renewable energy resources overlaid with information relating to development constraints (*e.g.* outstanding landscapes, areas of high cultural value) was raised at a number of discussions with councils. Whilst Section 4 provides an indication of the magnitude and location of renewable energy resources in the region, more detailed information would be required to prepare resource maps of value to regional policy statements and plans. This type of more detailed information is likely to be held by a disparate group of organisations including renewable energy developers, research organisations and regional / district councils. For instance, with regard to wind resources, extensive field studies have been undertaken by developers and historic records are held by meteorological departments. The most detailed and reliable information is commercially sensitive and as such, is unlikely to be made available to councils. However, broad-scale resource maps could be developed in a cost effective manner by combining information held by public institutions with commercially available numeric models or numeric modelling capabilities.

It is to be noted that mapping also presents a potential new constraint to greater renewables uptake in that broad scale resource mapping may overlook small high potential areas. Furthermore, constraint mapping without adequate consultation with the renewable energy sector may inadvertently screen out areas of medium or high potential. As such, decisions on whether and how to develop resource / constraint maps requires careful consideration. Developers also express concern that once detailed resource maps are available, landowners can demand much higher access or "mitigation" fees, presenting a secondary barrier to renewables. Section 6.2.1 provides a further discussion on the identification of suitable sites for renewable energy developments.



5.5 National Renewable Energy Forums

In order to promote good practice on both regulatory methods and enabling assistance and develop a deeper appreciation of the issues associated with renewable energy, a programme of forums involving selected councils from across New Zealand could be established. Alternatively, renewable energy could be brought into existing forums, such as those for the Chief Executives of councils.

5.6 Economic Instruments

RMA financial contributions are to be taken, and used, for a purpose specified in the relevant plan. These could be used to charge a greater contribution to energy generation methods that create the greatest environmental damage. For example non-renewable generation that creates air discharges could be charged on the basis of the volume of type of discharges produced.

The rules providing for such contributions would have to be written into a Plan and would be a requirement on resource consents. There are a number of issues with such financial contributions.

Firstly the process of placing the required rules into a District Plan is complex and may take a considerable effort and time. The environmental effects that the financial contribution relates to will need to be fully justified and defined accurately in terms that can be translated into monetary terms.

There is also a case that can be argued that the environmental effects of emissions are national in nature and reducing such emissions creates national benefits. It may therefore be that any economic instruments are better justified at a national level rather than at the local level, a route the Taranaki Regional Council considers more appropriate.

Other economic instruments such as carbon taxes, tax incentives for renewable energy projects and variable electricity pricing (giving advantages to renewable energy) are not available to councils and will rely on Central Government implementation. Councils may have an advocacy role in respect of these matters.



6. Regulatory Approaches

6.1 Current Regulatory Approaches

The main regional policy and regulatory document in the Taranaki Region is the Regional Policy Statement. The Regional Policy Statement (RPS) was made operative in September 1994. The Policy Statement is currently under review which is at the preliminary draft stage.

The RPS contains a section on energy with the objectives and policies being;

OBJECTIVE

To achieve, as far as is practicable and appropriate, efficiency in the use and production of energy without compromising the sustainable management of natural and physical resources.

POLICY

Policy One: Energy efficiency

Efficiency in the use and production of energy by users of natural and physical resources will be encouraged in relation to:

- energy requirements of urban form, subdivision patterns and lot alignment;*
- the design, location and operation of buildings and other structures;*
- transport modes and patterns;*
- use of appropriate energy saving technologies in industrial, commercial and residential situations;*
- waste management including the minimisation, recovery, re-use and recycling of solid wastes and other contaminants, provided that the energy required to carry out these measures is less than that required to produce new products or materials.*
- research into, and development of, alternative energy sources and more energy efficient methods (both traditional and alternative) of producing energy.*

The RPS lists a number of implementation methods including advocacy, education and having the opportunity to use water for hydro electric power generation in the management of the region's water resources and in the preparation of regional plans. It also encourages energy efficient urban forms through appropriate provisions in district plans.

The RPS does not appear to consider the 2004 amendments to the Act which is assumed to be largely due to the age of the document.



The Council is currently reviewing its Regional Policy Statement. Advanced drafts of the new Regional Policy Statement make specific provision for renewable energy. Proposed methods for implementation include the use of regional plans where there are opportunities to use renewable energy resources for power generation.

The Taranaki Regional Council has the following regional plans;

- Regional Coastal Plan – Operative 1997
- Regional Air Quality Plan - Operative 1997
- Regional Fresh Water Plan – Operative 2001
- Regional Soil Plan – Operative 2001

While a number of these plans directly affect renewable energy, for example controlling use of rivers for dams, they do not explicitly promote renewable energy.

There are three Territorial Local Authorities within the Taranaki Region. The current regulatory approaches of the Councils are summarised below.

New Plymouth District Council

The New Plymouth District Plan became operative in 2005. The District Plan contains a section relating to the effects of utilities but the Plan appears to have no specific policies relating to renewable energy.

Stratford District Council

The Stratford District Plan became operative in 1997. The Plan appears to have no specific policies relating to renewable energy.

South Taranaki District Council

The South Taranaki District Plan became operative in 2004. The Plan appears to have no specific policies relating to renewable energy

6.2 Potential Regulatory Approaches

The following policy suggestions examine some ideas concerning how the Taranaki Regional Council may be able to provide for renewable energy use and generation through its Regional Policy Statement and Regional Plans.



6.2.1 Identification of Suitable Renewable Energy Locations

Regional Policy Statements and Plans can assist the provision of renewable energy by identifying the potential locations where forms of renewable energy generation that have specific locational constraints may be appropriately located. Resources that have potential locations that can be identified typically include wind-power sites, hydro, geothermal and marine based energy sources. These locations can be illustrated on maps within the Policy Statement or Regional Plan.

The development of this mapping should include the identification of any potential environmental effects that may limit or preclude the use of the resource in terms of sustainable management of natural and physical resources. For example, some areas suitable for wind generation may also be in areas of outstanding landscape value. Some rivers that may be able to be used for hydro electricity generation may have high environmental values that would preclude such development.

An alternative to mapping areas with particular energy potential (where this is not possible or desirable) is to identify broader natural area classifications where particular types of energy development is appropriate and provide for more permissive rules for development within those areas.

Following the 2005 amendments to the RMA, Regional Policy Statements can where appropriate direct District Plans to make suitable provision for the development of renewable energy in locations identified in such mapping. Alternatively the mapping can be used to give policy direction to resource consent processing at both regional and district levels. The maps can also be used to develop appropriate rule packages in the council's own Regional Plans concerning the use and taking of water and the coast etc.

While such locational based policy development has not to date been used extensively in Regional Policy Statements and Plans the approach is valid and is starting to be used more frequently. For example the Auckland Regional Policy Statement details the Metropolitan Urban Limits on a map. A mapping approach is also enabled via the 2004 amendment to the Resource Management Act that enabled the establishment of aquaculture management areas. A similar approach is also taken in the geothermal chapter of the Environment Waikato Policy Statement.

Recommendations

- (i) That where possible the Regional Policy Statement identify areas within the region suitable for renewable energy development including wind, hydro, geothermal and marine based generation. The location of these areas should be developed taking into account the potential effects of such generation facilities and the sustainable management of natural and physical resources.



- (ii) That District Plans should be amended to ensure that rules do not preclude renewable energy development in areas identified in the Regional Policy Statement. (For example landscape protection areas should not identify areas deemed suitable for wind power generation in the Regional Policy Statement.)
- (iii) That Regional Plans and District Plans provide for existing renewable energy generation facilities. For example specific zones may be provided for existing hydro stations.

6.2.2 Non-Locational Policy Development

Some renewable resources are not locationally constrained or there may be insufficient information about a resource and its effects available to develop a locational approach (*e.g.* biomass generation).

Regional Plans can assist the provision of renewable energy by developing conditions or controls on how “trade offs” between various resources can be made. It is considered that this approach is mandated by the changes to the Resource Management Act that requires Councils to have particular regard to the benefits to be derived from the use and development of renewable energy. This approach essentially considers the benefits of renewable energy and looks at various “trade offs” between the local and wider benefits of that development and the localised environmental effects that may result from renewable energy generation and transmission within the context of sustainable management of natural and physical resources. If direction on such decision making is not specified by the council, then it is difficult for Councils to balance the benefits of renewable energy against other environmental effects when considering consent applications. It is considered that these policies need to be as detailed as possible so as to give firm direction.

An example of this approach can be illustrated by policies concerning the provision for wind power. Policies can be developed that would give guidance concerning within which landscapes wind power generation turbines may be appropriately located after having considered the visual effects of wind turbines.

Recommendations

- (i) That the Regional Policy Statement include a series of objectives and policies on renewable energy, and that Regional Plans consider conditions or control on how “trade offs” between localised effects and the benefits of renewable energy should be made.
- (ii) That District Plans be amended to give effect to the Objectives and Policies developed in (i) above.



6.2.3 Consents

Discussions with industry players have indicated that consenting issues are a significant disincentive to the development of some forms of renewable energy. There are a number of consenting options that councils can investigate that would provide encouragement for the development of renewable energy.

Ways in which consenting can be modified include the use of incentives within the consenting processes to encourage the use of renewable energy. Incentives could include:

- greater air discharge thresholds for biomass energy generation (where this can be supported by appropriate ambient air quality), or
- reduced consent thresholds (types) when based on renewable resources, or
- longer consent periods before consent renewal for use of renewable resources than for non-renewable resources.

Codes of practice for renewable generation can be used within consenting processes. Such an approach requires the development of codes of practice, and compliance with these will be accepted instead of the need to comply with rules, or alternatively result in simpler forms of resource consent where compliance with the code of practice is achieved. This technique is reasonably common in Resource Management Act plans with some other issues. Regional Energy Strategies and Regional Energy Forums may be suitable avenues for developing codes of practice around a number of renewable energy resources. These will likely need development in association with generators, District Councils and other interested parties.

Recommendations

- (i) That Regional Plan rules be amended to provide greater air discharge thresholds for biomass energy generation where this can be supported by ambient air quality.
- (ii) That Regional Plan rules be amended to reduce consent thresholds for energy generation based on renewable resources.
- (iii) That Regional Plan rules be amended to provide longer consent periods for renewable energy projects.
- (iv) That the council work with energy generators, District Councils, Tangata Whenua and other interested bodies to develop industry codes of practice for renewable energy production.



6.2.4 Domestic or Small Scale Developments

The scale of potential renewable energy projects may also be considered by Councils in setting policy, consents thresholds and notification requirements within plans. In some cases it may be just as difficult to obtain consent for a small scale project that has a low level of local environmental effects as for a large renewable energy project, as plans do not always make distinctions between small and large scale effects. This tends to encourage large scale projects that may have more significant effects than a series of smaller scale projects.

For example, small scale hydro generation projects that do not use dams or do not divert significant volumes of water could be rendered subject to lower consent thresholds than large projects. For example, a wind farm with only one or two turbines will have less visual effects than a large wind farm, yet often a similar consent process is required for both. This situation could be changed by setting scale thresholds for resource consents whereby smaller scale projects are made subject to controlled or restricted discretionary activity consents whereas larger scale projects require fully discretionary resource consents. Domestic scale generation may be able to be a permitted activity.

At the District level for example, Franklin District Council makes specific provision for some small scale renewable energy generation as permitted activities in rural areas.

Recommendations

- (i) That the Regional Policy Statement, Regional Plans and subsequently District Plans be amended to make appropriate provision for various scale energy generation facilities.
- (ii) That the Regional Policy Statement, Regional Plans and subsequently District Plans be amended to allow small scale renewable energy production (including solar and wind) as permitted activities.
- (iii) That District Plan subdivision rules provide site orientation provisions in order to support solar heating and power generation.
- (iv) That District Plans rules should be amended to ensure that development control rules (*e.g.* maximum height rules) do not unreasonably preclude domestic scale renewable energy production (*e.g.* allows solar panels on roofs) and protect solar access to nearby properties.

6.2.5 District Plans

Section 75(3) of the Resource Management Act requires District Plans to give effect to a Regional Policy Statement. Councils are therefore able to give direction to the types of rules and policies



that the constituent District Councils are able to place in District Plans that directly control land use.

Good practice would dictate that this power should be used in conjunction with a collaborative approach to issues with District Council. Councils are well positioned to influence how District Plans in their region provide for renewable energy generation through specific policy direction within Regional Policy Statements. The nature of the energy resources within the region are such that each District has its own unique range of resources. The response of each District is likely to be different based on the nature of resources in each District.

Recommendation

- (i) That the council work closely with the District Councils within the region to ensure that District Plans reflect the renewable energy objectives and policies of the Regional Policy Statement.

6.2.6 Future Proofing Policy Statements and Plans

In developing the next generation of Regional Policy Statements and Plans, Councils should have regard to the potential developments in renewable energy that may occur in the region over the life of the Policy Statement or Plan.

For example, many regions have large areas of coastline that may be suitable for one or more forms of marine electricity generation through the life of a Regional Policy Statement or Regional Coastal Plan. Because this technology is still evolving, polices (and rules in Regional Coastal Plans) could consider how new technologies may be used in the future, what potential environmental effects may result and the circumstances in which such technology may be put in place. In effect polices may be developed in a way that future proofs the policy statement/plan by making provision for new technology to the extent possible under current levels of knowledge.

Recommendations

- (i) That the Regional Policy Statement and Regional Plans be amended to recognise potential future renewable energy technologies and make high level policy provision for such technologies.
- (ii) That the council monitor the state of technology development and make changes to the Regional Policy Statement and Regional Plans to make appropriate provision for developing technologies.



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Appendix A Previously Identified Hydro Schemes

Scheme No	Site	Head (m)	Output (MW)	Energy ⁽¹⁾ (GWh)	Remarks
Northern Coastal Rivers					
	Lower reaches of rivers in the area ⁽²⁾				Potential micro and mini hydro.
Waitara River Catchments					
T1 ⁽³⁾	Waitara River		5.8	25.4	d/s of Waitara/Makino confluence
T2 ⁽³⁾	Waitara River	22	12.5	54.8	7 km d/s of Tarata township divert water to adjacent Kokohiko Stream 9.75 MW with 10% mandatory release
T3 ⁽³⁾	Waitara River		4.1	18.0	Alternate to T2
T4	Waitara River		7.3	32.0	Below Waitara/Manganui confluence
Northern Mountain Streams					
T5	Manganui		12.3	53.9	Diversion type, release into Waitara
T6	Mangaroaka, Mangawarawara, Korito Streams	105	5.9	25.8	Consist of a tailrace canal to return water to Lake Mangamahoe
T7	Waiwhakaiho				Brings additional flow to Mangorei Scheme to increase its generation.
T8	Taraki Scheme augmentation				Augmentation of Taraki scheme
Western and Southern Mountain Streams					
T9	Waingongoro		2.4	10.5	2.75 if no compensation flow is considered
T10	Waingongoro		4.3	18.8	A. discharge into Waingongoro River 4 km u/s of the river mouth (1.9 MW) B. discharge at sea level
T11	Mangahume diversion		0.5	2.2	Upgrade of existing Opunake power station, Diversion of Mangahume into Waiaua
T12	Waingongoro		1.2	5.3	Recommission of existing power station
Patea River Catchment					
T13	Patea River		2.6	11.4	Diversion through tunnel to return flows to Patea 3 MW if no compensation flow is considered
T14	Patea River		25.2	110.4	Below Patea/Mangaehu confluence, 64 m high dam



Scheme	Site	Head	Output	Energy ⁽¹⁾	Remarks
No		(m)	(MW)	(GWh)	
					9.7 and 18 MW with 30 and 50 m high dams
Southern Coastal Rivers					
	Lower reaches of tributaries of Waitotara River in Matemateaonga River ⁽²⁾				Potentially several micro and mini hydros in the middle reaches of tributaries of Waitotara River

Notes:

- ⁽¹⁾ Energy estimated at 50 % plant factor.
- ⁽²⁾ Site location not known.
- ⁽³⁾ Within or near DoC land or Native Forest areas



Appendix B Resource Maps