

Bay of Connections

One region. One goal. One future

Report for Bay of Plenty Regional Governance Group



Bay of Plenty Regional Energy Strategy : Technical Report

Wealth and wellbeing via energy

September 2009

Preface

Energy - what we can achieve

The Bay of Plenty, our region, is uniquely rich in primary energy resources; solar, geothermal and biomass which can be developed to complement its existing economic strengths in horticulture, forestry, wood processing and agriculture. The availability of these energy resources puts the region in the position that it can look to a future as a national leader in development of renewable energy opportunities. In addition it has good networks distributing electricity and gas, and substantial existing hydro generation though this is seen as essentially fully exploited.

This long-term energy strategy identifies the potential for these energy resources to be developed as an engine of future regional economic growth, and a platform for enhancing the wellbeing of our people. Potentially the investment of more than \$4 billion in sustainable energy-related developments is seen as turning the region from a net importer of electricity and liquid fuels into a net exporter of both while creating substantial employment requiring a range of skills.

Additionally the region's geothermal resources can be a basis for extending its regional tourism activity based on the model provided by Rotorua geothermal spas.

The region is also fortunate in the high levels of qualified people within existing centres of teaching and research excellence to assist the development of skills in specialist areas, particularly the trades. The region can become a leader in filling the current national shortages of energy-based trades and specialist providers.

To achieve the regional objective of becoming a leader in energy, and to secure the required investment, there is a need for a structured and co-ordinated approach to the development activities and a range of enabling developments, including for skills and training institutions, as outlined in this regional energy strategy.

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Bay of Plenty Regional Energy Strategy

1 Summary

The Bay of Plenty region is rich in untapped and underutilised energy resources that have significant potential to increase economic growth and community well-being. The energy resources of the region include those that can be developed and used locally and a number of opportunities of a national scale; offering the potential for significant investment, employment growth, and export from the region.

Forestry, wood processing, tourism and agriculture are the activities that currently dominate the economic landscape of the region and provide a foundation for energy-based investment. Major energy development opportunities include the further exploitation of the region's geothermal resources for large-scale electricity generation and direct heat supply, and the use of the region's abundant forestry resources as a basis for liquid-fuel or wood-fuel manufacturing; building on the research underway by Scion and other regional researchers. These are sustainable energy opportunities, with a very low carbon footprint.

Further energy-related opportunities are seen in the use of geothermal heat to extend the range and quality of the geothermal health spa industry, in solar energy for home heating and in the medium to long-term electricity generation. Some incremental hydro development is available while a number of measures are proposed to foster security of electricity supply and mitigate potential electricity price increases to business.

The strategy sees the regional primary energy resources as an engine for both investment and economic growth, with more than \$4billion of investment potential available, and for improving the wellbeing of the people of the Bay of Plenty. This personal or community wellbeing that can flow from the strategy includes: increased employment, skill development, increased local spend as a result of the economic development, flow on business opportunities with multiplying effects, and warm and healthy homes.

Key points from this Regional Energy Strategy

The Bay of Plenty is rich in sustainable energy resources, but

To exploit these resources a paradigm shift in our thinking is required

- Focussing on wealth creation not preservation
- Thinking energy, not just electricity
- Addressing the development of resources collectively

While addressing wise use and security of supply issues to achieve business and personal wellbeing

The opportunity is to create regional wealth out of energy; potentially attracting investment of more than \$4 billion in sustainable energy initiatives

2 Introduction

Energy is essential to all our lives. It is the fuel that powers our modern society and a vital input to our agricultural, commercial, industrial, household and transport activities. And it will become increasingly valuable and costly in the face of increasing demand, limited hydrocarbon resources and pending responses to climate change.

To promote economic growth and enhance our standard of living, the Bay of Plenty region needs access to secure and reliable supplies of energy at affordable prices. However more than just this is possible given the region's abundant geothermal, wood and solar energy resources which mean that sustainable energy production and use can become a driver of growth in its own right.

2.1 Regional Economic Growth Strategy

This Regional Energy Strategy picks up the key themes and objectives of the Bay of Plenty Regional Strategy, an "Economic Growth Strategy for a Sustainable Future", offering a key contribution to the achievement of its growth and sustainability goals.

Bay of Plenty Regional Economic Growth Strategy: Vision Statement

The Bay of Plenty: the most dynamic and progressive region where we work together to achieve economic prosperity, a sustainable environment and improved well-being for all people.

The regional economic growth strategy provides an alignment between sub regions, and suggests investigation of sustainable energy options for the future. In this Strategy, energy is seen primarily as an enabler; however energy can be a growth-engine in its own right.

The research and consultation carried out in the course of developing the Regional Energy Strategy identified that the region is rich in energy resources, but currently “energy poor” in that it imports electricity, gas and all liquid fuels. This Energy Strategy shows how the region can attract very substantial investment to become, over time, a net exporter of sustainably produced electricity and liquid transport fuels, while creating economic growth and significant employment, including in a range of skilled jobs.

2.2 The importance of the Regional Energy Strategy

The increasing importance of energy in our lives and in our economy requires a long term (30-50 years) Regional Energy Strategy, aligned with national strategies, which addresses both local energy supply and demand and also the development of the regions potential as a basis for economic development and a solution to national energy issues. This Strategy provides solutions which are specific to the needs, capacity and potential of the region while pointing to a range of new and exciting energy-related initiatives.

Local government has an important role to play in meeting the region’s energy needs, as district and regional councils are involved in working with electricity generators, electricity and gas transmission and distribution companies, industry and communities in the development of new projects including those relating to energy infrastructure. Local government also has a direct influence on supply and environmental considerations as it is responsible for much of the planning and delivery of local and regional infrastructure including the integration of transport modes such as transmission lines, road, rail and shipping.

The forms of energy used, and their method of sourcing and generation are often interchangeable depending on availability, cost and investment required in utilisation. This Regional Energy Strategy considers the three energy forms of electricity, heat and liquid transport fuels as equal opportunities for wealth creation despite their different values according to specific location of use.

2.3 The purpose of the Strategy

Purpose: Regional Energy Strategy

- To advocate for energy conservation and efficiency within the community by fostering partnerships at the national and local level and sharing knowledge and experience.
- To ensure a framework for the maintenance of security of energy supply to enhance business.
- To facilitate access to, and development of, sustainable energy sources and innovative energy technologies within the region by identifying and addressing barriers to development.
- To raise public awareness of the crucial role of energy in the regional and national economy.
- To assist development of economic business opportunities based on the region’s renewable energy resources.
- To assist achievement of employment and personal wellbeing via the wise use of energy and the development of available resources.

This Regional Energy Strategy has been developed by the Regional Governance Group supported by Environment Bay of Plenty and guidance from sub-region growth leadership groups (Priority One, Bright Economy, Toi-EDA) to provide the direction, co-ordination and leadership for the many interested parties who are involved in the energy sector in the region.

The energy sector involves or impacts on everyone within the region and yet there has to date been no mechanism for co-ordination of effort, or resolution of energy supply issues.

The strategy covers the whole of the Bay of Plenty Region and all energy forms including electricity, heat and liquid transport fuels and demand-side energy management, but priority is given to the energy-related drivers that the region can influence or respond to, and which offer the greatest benefits for the region’s economy and people.

The Energy Strategy includes specific action plans with delivery to be led by appropriate local or regional entities, this including:

- Generic delivery within sub-regions by Economic Development Agencies
- Specific delivery by local support groups e.g. Maori Authorities
- The establishment of special interest cluster groups (refer Actions, Section 8):
 - “Rotorua is geothermal”
 - Rotorua geothermal health spa centre
 - Geothermal heating for horticulture
 - A focused warm and healthy homes programme

- Territorial authority leadership/ demonstration programmes
- Government entity procurement policies

The Strategy also includes monitoring and review processes including:

- Monthly monitoring reports from Economic Development Agencies with these:
 - Collated by Environment Bay of Plenty
 - Issued to all interested parties
- Annual review of the Energy Strategy and Energy Infrastructure Plans by the Governance Group, including review of achievement of targets and objectives, and re-setting as appropriate

2.4 Energy in the region – what we can achieve

Over the next 15-50 years our region could attract more than \$4 billion in sustainable energy-related developments including:

- Extensive geothermal direct heat supply to processing industries
- Geothermal electricity generation (\$2b plus investment)
- Transport fuel manufacture from forest resources including forest wastes, and potentially fuel crops (up to \$1b in investment)
- Enhanced tourist related activities based on geothermal resources
- Warm and healthy low energy homes and commercial buildings based on solar space and water heating initiatives or on geothermal heat pumps
- Increased use of wood-based fuels for industrial, institution and residential heating
- Investment in energy efficiency and health/wellbeing projects such as home insulation
- In the longer-term significant solar electricity generation

This investment would be based on the utilisation of the region's abundant sustainable resources: geothermal, wood and solar, potentially leading to:

- The generation of more than 10% of NZ's electricity demand (the region becoming a net exporter)
- The production of more than 10% of NZ's liquid transport fuels (ethanol & biodiesel)
- Significant growth in energy-intensive processing industries and tourism activities
- Major reductions in carbon emissions

These developments would secure r benefits in terms of jobs, skill development and lifestyle, including Maori as owners of many of the geothermal resources, and many of the forests.

2.5 An integrated strategic approach

The Regional Energy Strategy covers an integrated focus across a range of areas; to utilise and develop the available resources to achieve a range of economic and social objectives. The key areas are illustrated in Figure 1.

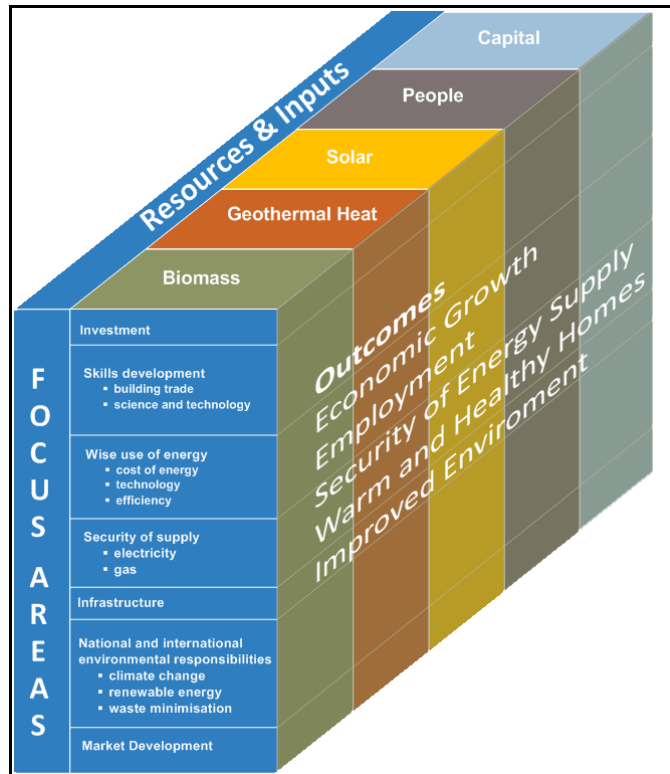


Figure 1: An integrated approach to economic wealth + wellbeing via energy

3 National energy issues

3.1 Energy demand

New Zealand is relatively rich in energy resources and has until recently enjoyed low-cost energy which has been attractive for business, and in particular primary industrial processing. Total national energy use, by fuel, is shown in Figure 2, with the relatively steep increases in the consumption of electricity and oil being notable. Costs for all forms of energy have risen, in particular for transport fuel (oil), and this trend is expected to continue once the world's economies recover and world oil supplies peak.

The growth in electricity and transport fuel usage and cost provides significant opportunities for the region.

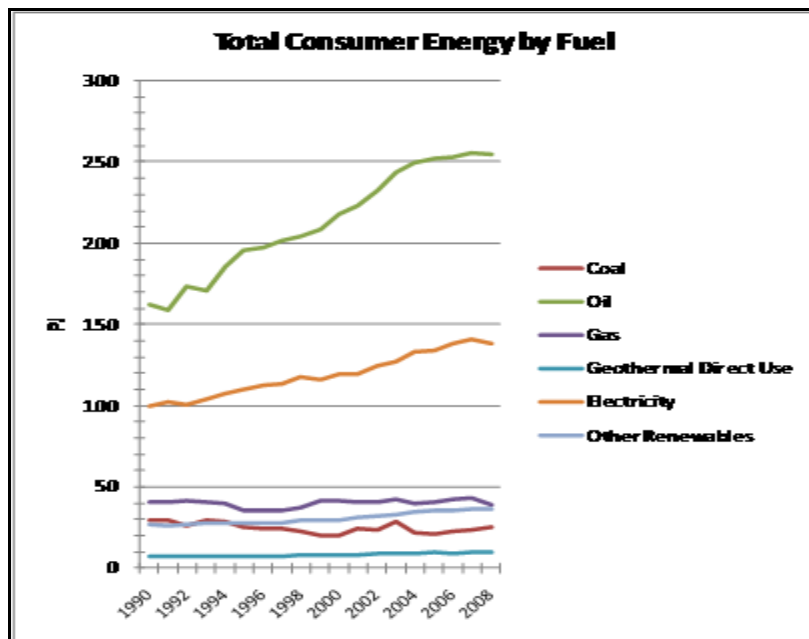


Figure 2: Total national annual energy consumption, by fuel
Source MED

To put these trends in a regional perspective, the Bay of Plenty's energy consumption is around 7% of that used nationally, with the variations in use shown in Figure 8.

Around two thirds of New Zealand's electricity supply is met by renewable energy, and new power station developments over the next few years seem likely to be based largely on wind and geothermal resources. Electricity prices have now increased to levels that also support generation from sources with lower environmental impacts. In this mix, total potential geothermal generation from conventional and consentable resources is seen as approximately 1,600 MW, or 13,000 GWh per annum, this being equivalent to around 30% of current national consumption.

The bulk of petroleum fuel is used for transport (with most of this imported), while gas supplies are seen as adequate to meet demand for at least the next 12 years, with proven reserves of 2200 PJ and exploration activity at record levels. Coal reserves are extensive but it seems unlikely that its use in New Zealand will increase significantly unless carbon sequestration, which is being investigated, can be achieved.

The timber industry uses wood processing wastes extensively for heat production and some electricity generation while energy crops are grown in Canterbury for biodiesel production and are being investigated for planting in other areas. A Scion study concluded that purpose-grown energy forests, if planted today throughout New Zealand, could meet all of New Zealand's future transport fuel and heat energy needs.

The over-riding goal of the Government's energy strategy, which is still being developed, is seen as economic growth, with a focus on security of supply, affordability and environmental responsibility. These priorities fit well with the region's energy resources and development opportunities.

3.2 Climate change policies and renewable energy

In 2002 New Zealand ratified the Kyoto Agreement and since then successive governments have been developing policy initiatives to reduce national greenhouse gas emissions; with the current government's policy expected to be released shortly. Climate-related initiatives are expected to put a price on carbon emissions and thus provide a bias towards low carbon fuels, in relation to fossil fuels.

Because of the finite amount of fossil fuel, particularly oil, in the world and the increasing focus on climate change, there is a strong international trend towards the increased use of renewable energy and intensive work on the development of new "green" technologies, and reductions in the costs of their exploitation. Geothermal, biomass and solar are natural renewable resources with low carbon emissions which will continue to be a focus for this investment.

The large amount of existing and potential renewable energy in the region puts the Bay of Plenty in a good position to capitalise on such measures and to play a key role in New Zealand's low carbon future, potentially becoming the "renewable energy region" of New Zealand.

3.3 Wise use of energy

Energy is a valuable commodity and a direct and increasing cost to business, households and other users. It also has other, often intangible, impacts and costs when finite resources are used up or there are external effects during the energy conversion or transmission process. An underlying principle of all national and regional energy strategies is conservation and the efficient use of energy.

The government has programmes via the Energy Efficiency and Conservation Authority for the promotion of conservation and to assist energy users to adopt efficient energy use technologies. Through the adoption of such technologies business can often reduce their production costs and homeowners can achieve warm and healthy homes, with improved wellbeing. However adoption of energy efficiency technologies generally leads to an increase in energy use as they are used as a basis for increased production, or as homeowners increase their comfort levels by keeping their homes warmer.

4 The regional energy context

4.1 Bay of Plenty's energy profile

The region's economy is based primarily on forestry, wood processing, tourism, horticulture and agriculture. Each of these sectors provides a sound base for development of energy based initiatives. The region is:

Resource rich in:

Sunshine and rain: Creating opportunities in hydro generation and longer-term solar energy

Geothermal, with:

- Numerous underdeveloped geothermal resources
- Heat resources essentially under every part of the region
- World-leadership in industrial use at Kawerau

Forest resources: With extensive forestry plantations and around 20% of the wood, in the form of residues, currently wasted either at harvest or during processing, and much of the wood produced exported as low value log and chip

But currently energy poor:

- With some hydro and geothermal electricity generation, cogeneration and geothermal and biomass heat production, but
- The region imports all gas and transport fuels, and is a net importer of electricity

People rich, with:

- A pool of people from which to develop energy skills
- Two well established trades training providers
- Scion, an international centre of wood-energy research

With existing energy-related strengths including:

- Industry, i.e. Kawerau, (the world's largest industrial geothermal heat site)
- Hydro and geothermal electricity generation
- Tourism, Waiora Health Spa, QE Health
- Forest harvesting, collection, chipping and transport of wood chip

Underutilised opportunities include heat and electricity generation and utilization, geothermal heating for hot house food production and aquaculture and Rotorua's latent potential to become yet again an international geothermal health spa location.

4.2 Regional energy drivers and trends

Supply, price and utilization of energy in the region will be driven by a range of issues:

Economic growth

- Forecast (pre-recession) at 3.5% pa over next 5-years
- Population growth expected overall (0.8% pa), particularly in the western regions

Increasing prices

- For hydrocarbon fuels (gas, liquid and coal), and for electricity
- As a result of the pending carbon charge

Security of supply

- Issues with the electricity networks feeding parts of the region
- Issues with (single circuit) electricity supplies to sparsely populated areas
- Gas availability constrained by pipeline locations

Demand growth

- Driven by population, pricing and economic growth:
 - Heat demand depends on industry type/use
 - Electricity demand expected to grow 14% in next 10-years

Regional energy resource development will be driven by

- Demand growth and price rises; regional and national
- National need for new sources of electricity generation
- Availability of sustainable resources and their improved relative economics
- Responses to environmental drivers and carbon taxes
- Fuel switching - moves to use of sustainable (and cheaper) energy sources
- Distributed energy initiatives

4.3 Electricity demand

Bay of Plenty's peak electricity demand is expected to grow as illustrated in Figure 3; at around 1.3% pa (note the reduction due to in part to the economic crisis) driven by the factors outlined in 4.2 above.

There is no shortage of electricity supply to the region as the region is part of the national electricity supply grid. There will be however over time the need for new sources of electricity generation in New Zealand and where these

can be developed within the region the proximity of the generation will improve the reliability of supply and reduce the nodal cost of electricity by the minimisation of transmission losses.

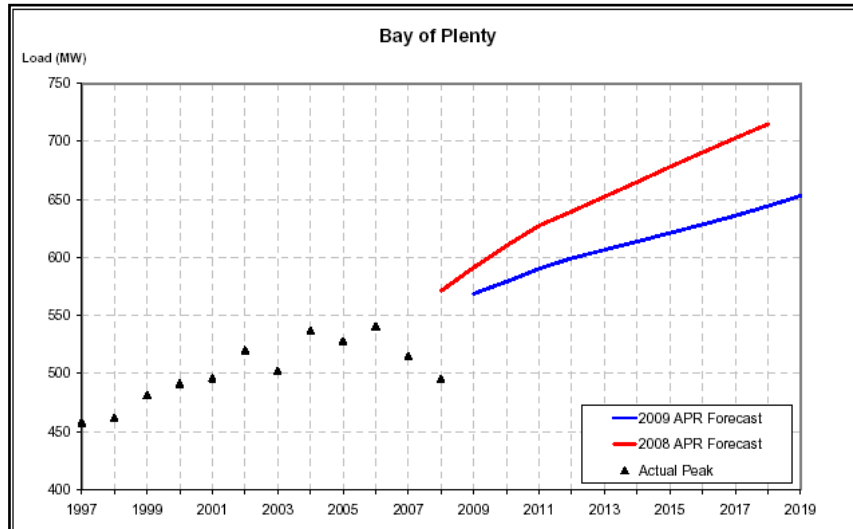


Figure 3: Projected Bay of Plenty electricity demand
Source Transpower Annual Planning Report 2009

* APR – Annual Planning Report

4.4 Electricity distribution networks

Electricity is generated locally and also imported into the region via Transpower’s national grid from national generators. It is distributed within the region by three regional network companies; Powerco in Western BOP, Horizon in Eastern BOP, and Unison in Rotorua and southern BOP from grid exit points at 13 substations.

The Bay of Plenty connection to the rest of the national grid is predominantly through the 220 kV Whakamaru–Atiamuri and Ohakuri–Wairakei circuits, with lower capacity 110 kV circuits through Kinleith. There are 220 kV interconnecting transformers at Tarukenga, Kawerau and Edgecumbe. Transpower’s transmission lines are shown in the figure 4.

Single line supply to some areas diminishes security of supply and this will require significant investment to overcome. The new generation at Kawerau has reduced the loading of the circuits into the Eastern Bay of Plenty, but constrains maximum output from the Matahina and Aniwhenua hydro stations.



Figure 4: Schematic of the transmission grid in the Bay of Plenty
Source Transpower

A range of current and forecast regional network related issues with potential to impact on supply have been identified and electricity increased demand over the next decade will need to be addressed, but these regional issues are not out of the ordinary. They are identified in the Asset Management Plans of the network companies while transmission and grid exit point supply related issues are referred to in Transpower’s Annual Planning Report. Issues include:

- The absence of long-term infrastructure plans and processes for developing these
- Growth, especially in the Tauranga area putting stress on the system, and requiring a co-ordinated planning approach
- Areas where supply security is at risk, i.e. single line supply

The action plan, section 8 identifies a range of initiatives designed to ensure a coordinated regional approach to planning and development associated with regional networks.

4.5 Electricity generation

Total regional generation of over 400MW compared with peak demand close to 600MW. Installed hydro capacity within the region is currently 173MW, with an additional 185 MW of geothermal power at Kawerau, and 60MW of thermally fuelled generation and cogeneration at Edgumbe, Mount Maunganui and Rotorua.

Some 13.5 MW of new hydro capacity is currently under study by Bay of Plenty Energy and up to 150MW of further geothermal generation is planned for Kawerau.

4.6 Electricity pricing

Regional electricity pricing is relatively high, and volatile, in comparison with other areas of New Zealand. This reflects the national supply situation and constraints in the regional supply system leading to high nodal prices. Pricing by consumer group and network area is shown in Figure 5.

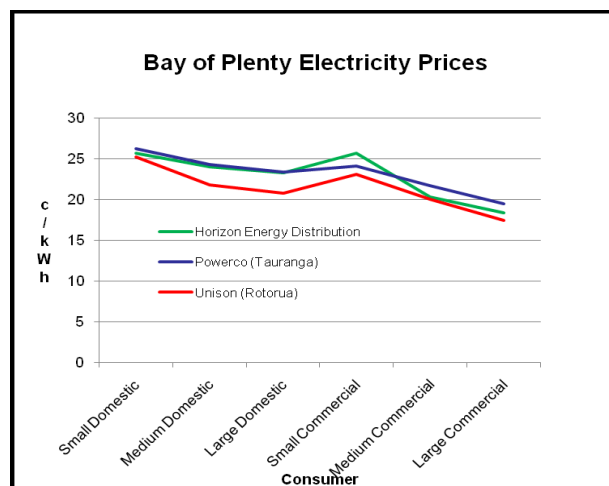


Figure 5: Bay of Plenty electricity prices
Source MED

Figure 5 shows that the price of electricity is similar in each of the subregions. It also shows that the larger the site electricity load then the cheaper the price for electricity indicating that there may be opportunities for businesses to aggregate demand so that lower prices can be negotiated.

4.7 Gas distribution

The region is supplied with natural gas through an extensive distribution network owned by Vector Ltd. This system is generally underutilised, though the main supply compressors at Pokuru (near Te Awamutu) are close to capacity. Bottled LPG is supplied by On-Gas, a subsidiary of Vector, and Nova LPG, a subsidiary of Todd Energy and is used extensively in the area.

The availability of gas for direct use for heating and cooking is a valuable source of energy for business and home owners and the underutilised network offers potential for industrial exploitation.

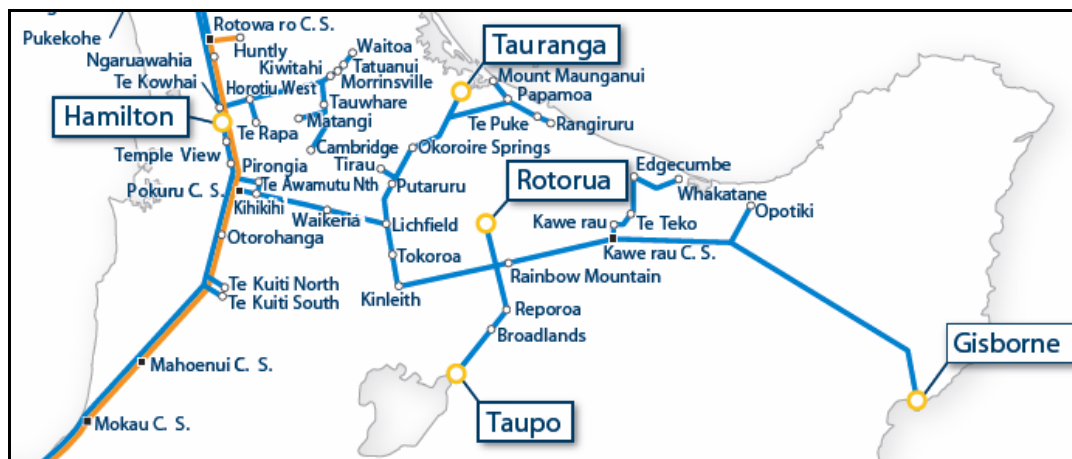


Figure 6: Bay of Plenty regional gas distribution system
Source Vector

4.8 Use of energy for business

The energy use for the region is shown in Table 1¹ from which it can be seen that business, commerce and agriculture use 71% of the regions energy with industry being the major energy user.

Table 1 Regional energy end use

Region	Energy used (PJ)	% energy used by sector				
		Agriculture	Commerce	Household	Industry	Transport & storage
Bay of Plenty	35.36	7.4	8.4	29.0	42.6	12.6
New Zealand	487.07	7.2	11.2	32.4	34.1	15.0

Note: Household includes household transport. Data sourced from the Energy End Use Database, EECA.

4.9 Commercial and industrial energy use

The three highest end energy uses for each business sector in the region and the percentage of the total regional energy use for business are shown in Table 2. It can be seen that industry and transport and storage are the predominant business energy users in the region. Process heat is the largest regional energy end use followed by land transport.

Table 2 Business energy end use

Sector	End Use	% Sector	% of total regional energy use	TJ
Agriculture	Motive power, mobile	33.0%	0.9%	443
	Transport, land	28.7%	0.8%	386
	Pumping	12.0%	0.3%	161
	Total	73.7%	2.1%	990
Commerce	Transport, land	24.5%	0.9%	431
	Low temperature heat (<100 C), space heating	20.3%	0.8%	356
	Refrigeration	18.7%	0.7%	329
	Total	63.5%	2.4%	1,115
Industry	Intermediate heat (100-300 C), process requirements	81.7%	46.8%	22,124
	Motive power, stationary	5.9%	3.4%	1,587
	Motive power, mobile	2.5%	1.4%	669
	Total	90.0%	51.5%	24,380
Transport and storage	Transport, land	78.4%	9.1%	4283
	Transport, sea	11.1%	1.3%	609
	Transport, air	7.8%	0.9%	428
	Total	97.4%	11.2%	5320

Note: Data sourced from the Energy End Use Database, EECA. The data for Table 2 was collected in July 2009 and the components making up the sector may be grouped differently from the earlier values obtained in Table 1. The total end energy use for New Zealand is 544.44 PJ.

¹ Source: "TARANAKI - WHERE WE STAND Taranaki State of the Environment Report 2009" Chapter 10, Energy, Taranaki Regional Council

4.10 Residential energy use

New Zealand has generally cold homes (by international standards), with poor insulation, poor draught-proofing and poor design for both the capture of solar heating and the exclusion of excess heat during summer months. Health and wellbeing is directly related to the warmth of homes, and the associated energy costs.

The design of many current houses reflects previously cheap energy costs and demonstrates a lack of appreciation of the value of design in maximising use of insulation and solar energy for heating. Good design for energy conservation is often currently seen as a cost, not a benefit, by buyers or home owners, and retrofitting energy efficient elements such as underfloor insulation or solar water heating after the house is built can double the cost of those features; rendering them uneconomic or and often sub-optimally installed compared to their inclusion when the building is being built.

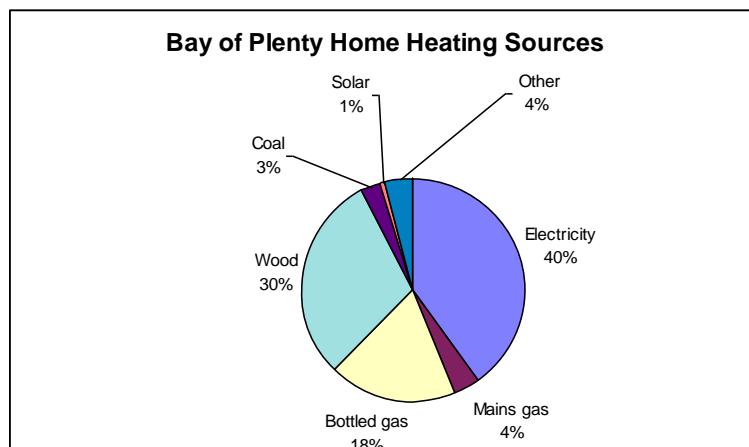


Figure 7: Current regional domestic heating sources

4.11 Transport energy

Transport energy use, driven by economic and population growth, improved fuel economy and increased fuel prices including a carbon charge is expected to remain nationally at around current levels and even decline until around 2016 when forecasts are that it will increase again. Light passenger travel demands are especially sensitive to fuel prices and vehicle ownership whereas commercial travel demands are more sensitive to economic growth².

The region is an importer and price-taker, though some influence on this may flow from initiatives to manufacture liquid fuels from the production from local forests (refer section 5.2).

As technologies for the production of alternative fuels develop and become commercially viable they will play a more prominent role in the mix used by the transport fleet. Over the next two decades there can be expected to be significant changes in the type of fuels used for transport. It can be assumed that there will be a greater use of liquid biofuels (ethanol and biodiesel blends), and electric vehicles.

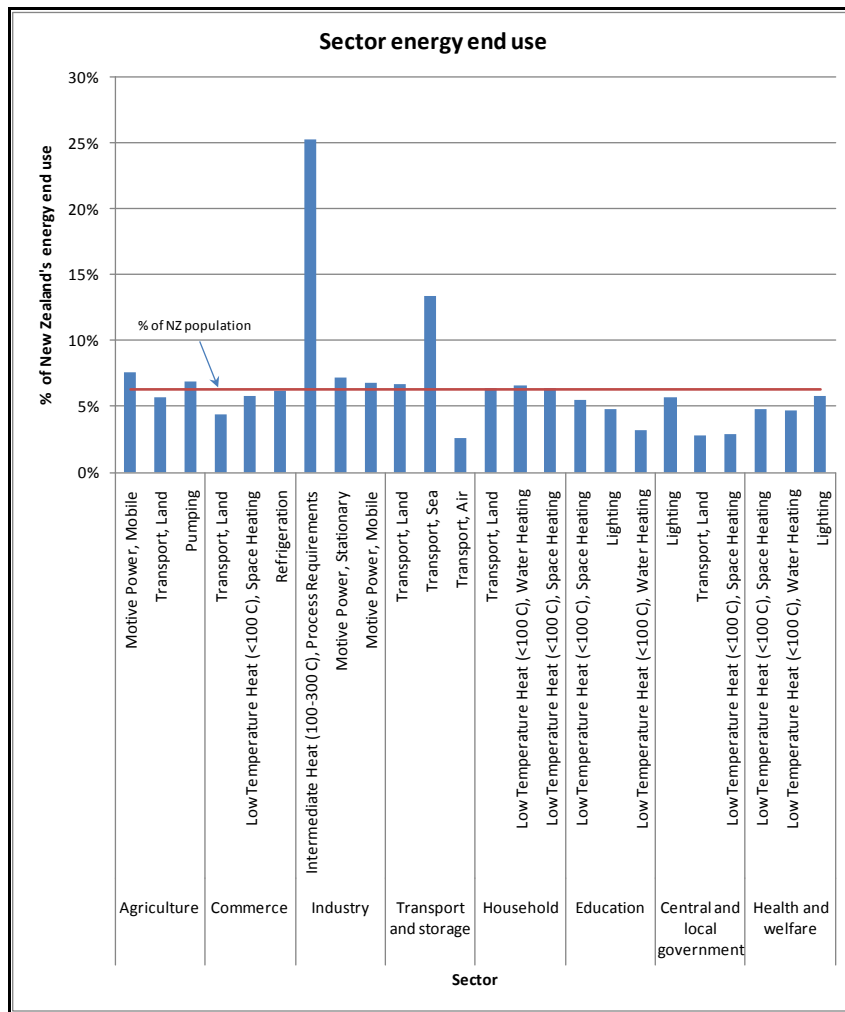
In 2040, it is envisaged that biofuels will be used throughout both light and heavy vehicle fleets. The composition of the light fleet is expected to be one third diesel, one third petrol and one third electric or hydrogen (or both). This change in usage will reduce CO₂-e emissions from transport by about 26 percent per capita.

Increased use of electric vehicles will also result in an increased demand for electricity within the region and the changes will have an effect on infrastructure development, fuel storage and distribution of liquid biofuels, and require a means of recharging electric vehicles.

4.12 Regional sector energy end use

The three highest energy end uses for each sector in the region, as a percentage of New Zealand's energy use, are shown in Figure 8 with, for comparison, a line showing the region's percentage of New Zealand's population. Two energy end uses stand out; process heat reflecting the industrial base of the region and sea transport reflecting the importance of the port of Tauranga. Energy end uses for other sectors appear to be more in line with what would be expected on a population basis with some local variations.

² S. Donovan, J. Genter, B. Petrenas, and N. Mumby McCormick Rankin Cagney, T. Hazledine University of Auckland, T. Litman Victoria Transport Policy Institute, G. Hewison, T. Guidera, L. O'Reilly, and A. Green Brookfields Lawyers, G. Leyland Incremental "Managing transport challenges when oil prices rise" NZ Transport Agency Research Report 357



Note: Household includes household transport
 Data sourced from the Energy End Use Database, EECA

Figure 8 Bay of Plenty sector three highest energy end use in comparison with New Zealand

5 Energy resources

5.1 Solar energy potential

Solar radiation levels for the Bay of Plenty are approximately 1450 kWh/m²/yr, with no large variations across the region, as shown in Figure 9. This is relatively high on an international scale, meaning that this is a good regional resource, though it is strongly summer-weighted as shown in Figure 10.

Solar energy, excluding general and agricultural benefits, has essentially three practical uses: space heating of homes and other buildings, water heating and electricity generation. It can also cause excess heating in buildings over summer, driving the installation of air conditioning and increasing electricity loads and consumption.

Production of electricity from solar energy by use of photovoltaic (PV) cells is well established, with current New Zealand applications generally in off-grid situations where installing power lines to the site would be uneconomic. The cost of electricity generated by photovoltaic cell at small scale is in the range 105 to 150c/kWh which can be cost effective for isolated applications such as on farms.

Commercial scale electricity generation is being rapidly employed overseas, where tariff or other assistance is provided, and costs are reducing as technologies including photovoltaic and solar thermal improve. Costs for large scale photovoltaic generation are said to be currently around 4m Euro/MW (in Italy), while a 125MW solar thermal system in Abu Dhabi is said to have a cost of US\$8.3m/MW. Thermal efficiencies are quoted at 15-16% and 41% respectively

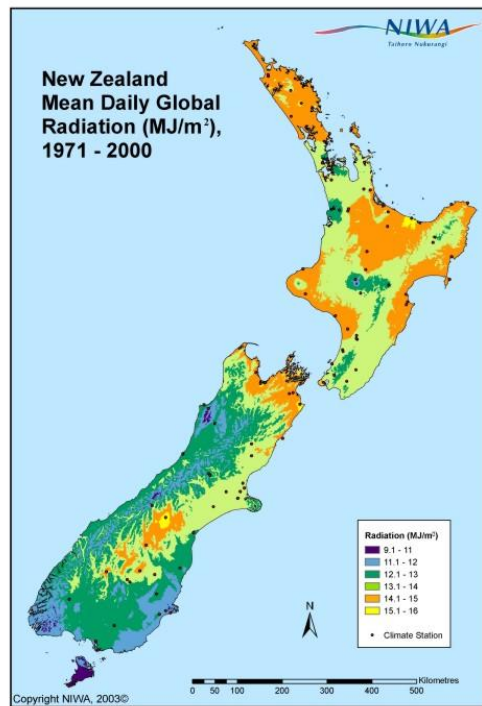


Figure 9: Solar radiation levels for New Zealand
Source NIWA

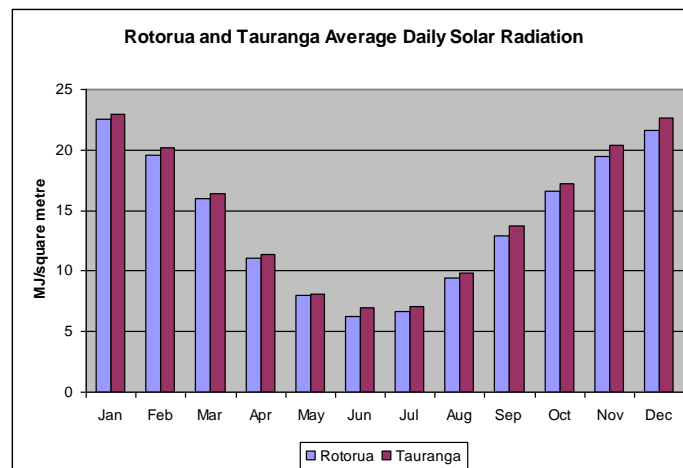


Figure 10: Comparison of Rotorua and Tauranga monthly solar irradiance
Data Source NIWA

In the context of this strategy electricity generation at significant scale is seen as a medium to long-term prospect while domestic/commercial use is discussed in section 4.8. In summary:

Solar space heating:

- Inclusion of solar design in new buildings can be the cheapest form of space heating and cooling.

Solar water heating:

- Inclusion of solar systems for heating water is most cost effective in new buildings
- Converting existing homes can be cost effective for large volume hot water users
- The cost of retrofitting solar heating to existing buildings could be reduced through economies of scale and reduced regulatory requirements.

Solar electricity generation:





- Is cost effective at present for off-grid applications
- Costs are fast reducing for larger-scale (on-grid) applications, and conversion efficiencies are improving
- Considered a potentially significant opportunity in the medium to longer term.

5.2 Geothermal energy

People commonly associate geothermal energy with hot springs and geysers, and the powerful signs of geothermal activity found in Rotorua and elsewhere. However, there are wider forms of geothermal energy and their application.

Development options associated with high temperature resources are found in restricted geographical areas, but there are other options based on both lower temperature resources and the natural temperature gradient of the earth which have potential essentially anywhere in New Zealand.

Table 3 Comparison of potential geothermal applications and associated resource location (from White, 2008)

	Heat pump applications	Enhanced systems for heat (or electricity)	Conventional heat applications	Electricity generation
Location				
Comments	<ul style="list-style-type: none"> • Potential national application • Best areas have not been defined 	<ul style="list-style-type: none"> • Potential applications nationally • Best areas have not been defined • Basic research is required 	<ul style="list-style-type: none"> • Localised application • Data is being collected • Resource size is being assessed under low temperature research funded by FRST 	<ul style="list-style-type: none"> • Narrowly defined resources • Some resources are effectively protected from large scale development

The Bay of Plenty is exceptional in that it is one of the few regions that has the opportunity to develop every type of geothermal application and resource.

Conventional geothermal

The region has extensive high temperature geothermal resources for conventional heat use and electricity generation, benefitting both economically and culturally from those developed or utilised to date. There is considerable untapped conventional geothermal development potential.

Large amounts of steam are used for process heat and electricity generation at Kawerau, and elsewhere in the region geothermal resources are used for heat and electricity generation, bathing, space heating, horticulture and aquaculture. The potential for electricity generation from conventional geothermal resources is large; also for direct use applications if heat loads can be found. In the wider region there is considerable further potential, if ground sourced heat pumps or enhanced geothermal techniques are considered, as these can be used throughout virtually the entire region, not just in thermal areas.

Heat pump applications

From a national perspective geothermal heat pump applications, producing heat from low temperature ground and water sources, are largely unrestricted in location (though are more attractive when associated with water-sources) and are likely to be economically attractive for large domestic and commercial-scale heating loads, especially in cooler areas subject to frosts and snow, where air-sourced heat pumps can be much less effective. The heating of Dunedin Airport is an example.

Geothermal heat pumps are unlikely to be economic for small domestic loads unless aggregated with other domestic loads and with water heating to give an economy of scale and higher load factor. One potential application is for schools. These larger scale developments are needed for geothermal heat pumps to be able to compete with air source heat pumps and other heating options.

Enhanced geothermal

In terms of enhanced geothermal heating options, the Bay of Plenty is seen as being in a favourable position relative to much of the country. Normal temperature gradients from the hot mantle of the Earth to the surface are around 30°C/km of depth. However wells drilled at Whakatane, outside the hot geothermal areas, and in other areas north of Taupo, have showed gradients closer to 60°C/km with the implication that this type of gradient may be found extensively across the Bay of Plenty region; outside those areas normally associated with geothermal activity.

Studies by East Harbour Management Services have shown that this type of gradient may be sufficient to drive currently economic investment in large scale industrial heat applications (i.e. developing a heat source for a large factory) or for high turnover spa facilities (i.e. find an ideal looking location and develop the resource beneath it).

The warm aquifer beneath the Tauranga basin is a significant resource that with appropriate development and management could potentially provide considerable heat for a range of applications including in the medium term adsorption chillers for providing cooling for cool-stores.

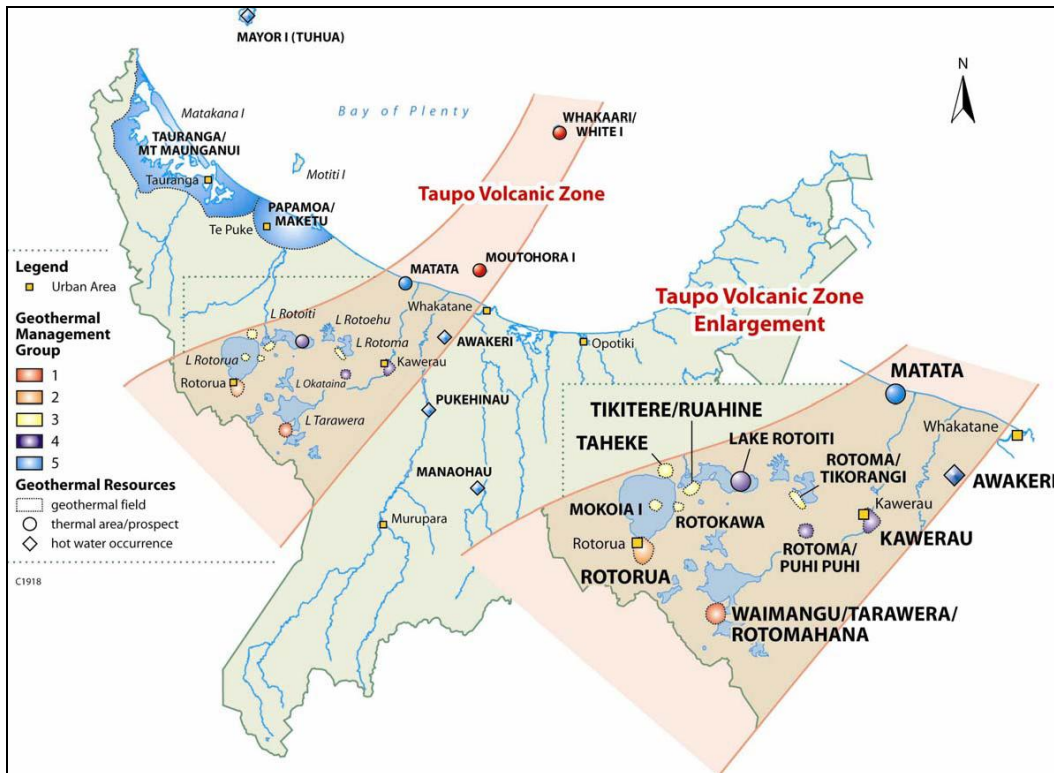


Figure 11: Major geothermal resources of the Bay of Plenty
Source EBOP

Another aspect that for regional consideration is the opportunity to take advantage of the co-location of geothermal energy and the forestry resources. The region has particular concentrations, on a national basis, of both of these resources. This could lead to particular advantages especially in terms of processing wood products. Geothermal energy is used at the Kawerau site for timber kiln drying and in pre-heaters and other applications in the pulp and paper plant, and new applications have been announced for the adjacent tissue plant.

Use of geothermal energy could help to free up other wood products for higher value fuel or for other applications such as in Taupo where it dries wood wastes for pellet manufacturing.

5.3 Regional geothermal resources

The regional high temperature geothermal resource areas are listed in Table 4 though some, as stated, have research or protected status, so cannot be developed, or the requirement for preservation of surface features limits development potential.

Table 4 Regional high temperature resources (based on Lawless and Lovelock 2004)

Field	Resource Area km ²	Depth to Reservoir m	Mean Temperature ¹ °C	Mean Potential Generating Capacity MWe ³
Fields Available for Further Development (High/Medium Confidence Resources)				
Kawerau	35	400	270	450
Rotorua	5	500	240	35
Rotoma				35
Subtotals				520
Fields Available for Limited Development (High/Medium Confidence Resources)				
Tikitere-Taheke	35	500	240	240
Subtotals				240
Fields with a Research or Protected Status (Unavailable Resources)				
Rotorua	4	500	240	35
Waimangu	12	400	260	280
Subtotals				315
Totals:				1075

Existing Bay of Plenty region geothermal generation is around 185MW (after converting heat use into equivalent electricity generation), at Kawerau. The potential for new electricity generation, based on resources that are open for development is of the order of 500MW. At an indicative development cost of \$4m/MW this would require investment of more than \$2 billion, and generation costings show that this should be generally economic.

Potential geothermal generation in the region is equivalent to more than 12% of current national electricity consumption

In addition to the high temperature resources there are many low temperature resources that have been developed to date. The following table shows assessed current direct heat usage at a number of fields in the Bay of Plenty region, though for most of these the ultimate resource potential is unknown. Appendix 2 gives a more extensive list of low to high temperature geothermal resources in the region, all suitable for direct use applications.

Table 5 Regional direct heat applications through various fields (TJ/year) (derived from White, 2009)

Geothermal and Council Regions	Space Heating	Space Cooling	Water Heating	Greenhouse Heating	Fish and Animal Farming	Agricultural Drying	Industrial Process Heat	Bathing and Swimming	Other Uses	Total
Hauraki										
Bay of Plenty										0
Maketu				1				8		9
Omokoroa								10		10
Oropi								4		4
Papamoa					2			38		40
Katikati				16				18.5	3.4	38
Tauranga	11							143		154
Te Puna	3							19	2	24
Welcome Bay	0.1							32		32
Woodlands (Athenree)								1.9	0.1	2
Rotorua-Taupo										
Bay of Plenty										0
Awakeri								4		4
Kawerau							5224	23		5247
Lake Rotoiti								3		3
Lake Rotokawa				2.3				1.2		4
Rotoma								0.5		1
Rotorua	24		79					482		585
Tikitere				4				7		11
Total	38	0	79	23	2	0	5224	795	6	6167

5.4 Applications for geothermal heat

Geothermal heat is available in a range of temperatures; from low to over 250°C and can be used in a variety of applications. Figure 12 shows some potential applications in relation to fluid temperature which can broadly be fitted into the following categories: electricity generation, commercial heating applications, residential and business heating, and people-focused applications.

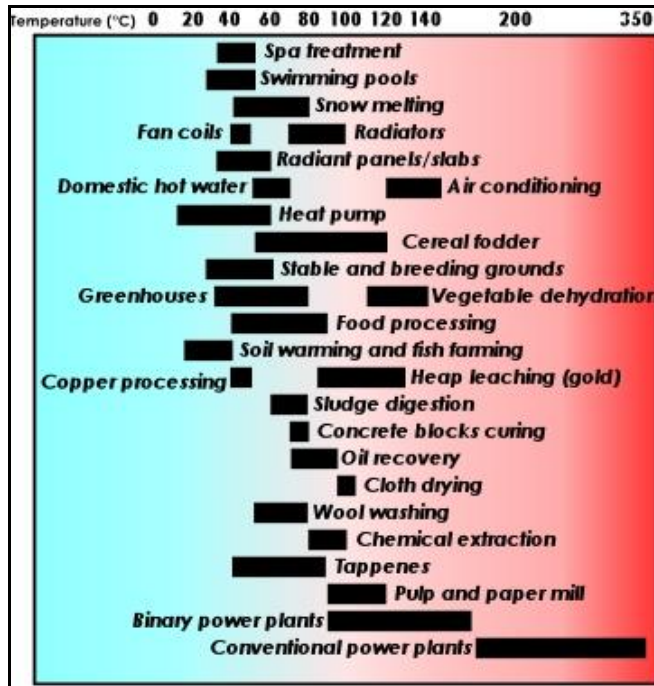


Figure 12: Showing the utilization of geothermal fluids (derived from Lindal, 1973)

5.2.1 Electricity generation

Two systems are available; conventional electricity generation from higher temperature resources using a condensing steam turbine, or binary cycle generation plant utilizing fluids in the lower temperature range above 70°C. The geothermal heat can be extracted from near surface sources or deep sources.



Figure 13: Mokai geothermal power station, stage 2 opening ceremony

Conventional condensing turbine technology

A geothermal reservoir that produces mostly hot water is called a "hot water reservoir". Reservoir water ranging in temperature from 140 to 360°C is brought up to the surface through the production well where, upon losing pressure, some of the water flashes into steam, the water and steam are then separated in a "separator". The steam then powers the turbines while the hot water is reinjected, or available in some cases for alternative use; potentially binary cycle generation.

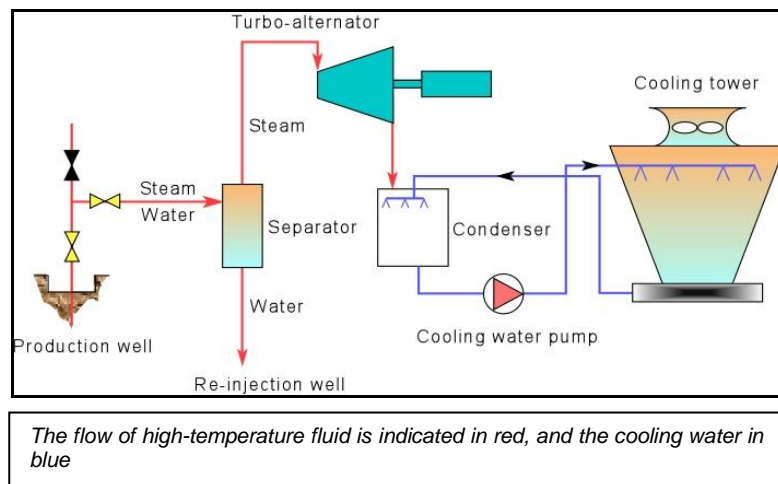


Figure 14: Geothermal condensing turbine technology

Binary cycle technology:

Reservoirs with temperatures between 90 and 180°C are not hot enough to flash enough steam but can still be used to produce electricity in a "binary cycle" power plant. In a binary system the geothermal water is passed through a heat exchanger, where its heat is transferred into a second (binary) liquid, such as isopentane or a water ammonia mixture that boils at a lower temperature than water. When heated by the geothermal fluids the binary liquid flashes to vapour, which, like steam, expands across and spins the turbine blades. The vapour is then recondensed to a liquid and is reused repeatedly. In this closed loop cycle, there are no emissions to the air of the binary fluid, but some non-condensable gases may have to be vented from the geothermal side of the heat exchanger.

Binary plants are usually constructed in small modular units of several hundred kilowatts to 10MW or larger.

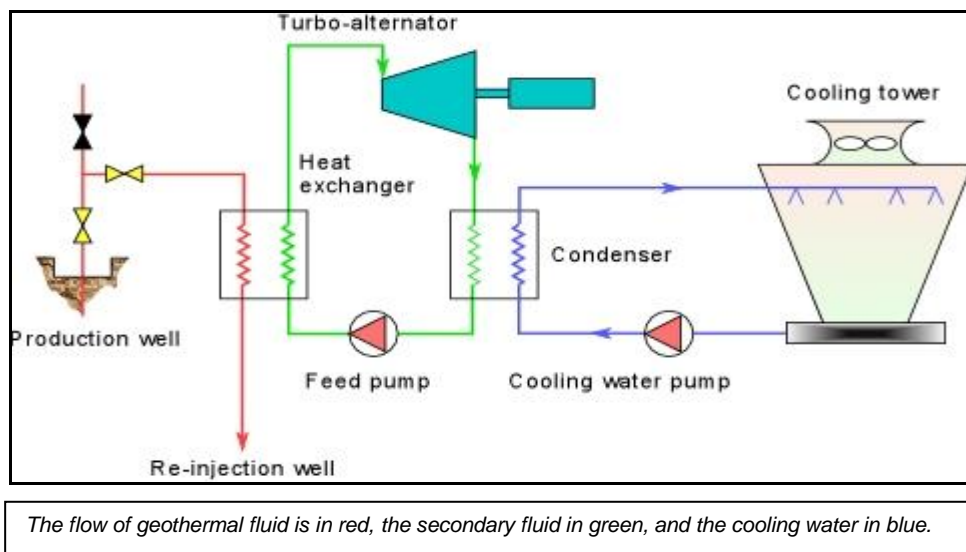


Figure 15: Geothermal binary technology

Low enthalpy technology

Reservoirs with temperatures lower than 90°C do not have sufficient heat in the hot water to generate electricity commercially but there is still sufficient heat for low temperature process heat applications.

Enhanced geothermal technology

Enhanced geothermal technology is a method of extracting useful heat from hot dry rocks, or from wet fields in rock structures that may lack permeability (the ability to transmit fluid). It is an emerging technology on which large sums of money are being spent in Europe, North America and Australia, and a number of demonstration electricity generation plants are now operating.

The principle is that high-pressure water is pumped through a specially drilled well into a deep body of hot rock, causing it to fracture and the 'reservoir' created is then penetrated by a second well, which is used to extract the heated water.

Sub-surface temperature gradients in many areas north of the Taupo are estimated to be of the order of 60°C per kilometer of depth, meaning that useful temperatures of 180°C or greater can be found at depths of 3km or less. At

this depth drilling and extraction costs are seen as unlikely to yield economic electricity generation in the short term, but may well be economic for process heat supply, or cogeneration where the heat demand is large.

The potential of this technology is not covered in this report, but it is seen as a medium term solution with some immediate niche applications, with particular application for the supply of process heat, or for cogeneration, as it is not considered economic at present for electricity generation.

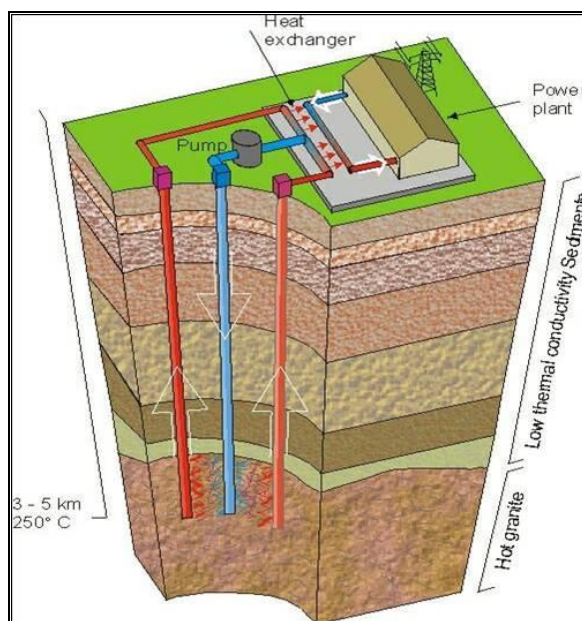


Figure 16: Schematic of an enhanced geothermal system

5.2.2 Commercial heat applications

Geothermal fluids can be used to supply high temperature heat for processing uses, such as pulp and paper manufacture at Kawerau. Intermediate to high temperature heat can be used for drying applications such as fruits and vegetables and potentially fuel crops, or for providing heat to industrial manufacturing or drying processes such as for timber drying and dairy sheds.

Lower temperature fluids can be used for such applications as pasteurizing milk, drying onions, washing wool or for providing heat for growing horticultural crops in greenhouses. An example of this is the extensive greenhouse complex at Mokai where tomato and capsicum are grown. Amongst other potential crops are lettuce, cucumber, mushrooms and cut flowers.



Figure 17: Greenhouses suitable for geothermal heating

Another use of lower temperature geothermal heat, which is relatively common overseas, is aquaculture, with New Zealand examples at Taupo where prawns are grown, or near Tauranga where tropical fish are grown. This is a labour intensive activity and thus a potential creator of employment within the region.



Figure 18: Taupo geothermally heated prawn farm

Low temperature geothermal energy can also be used via adsorption chillers to provide cooling for coolstores, displacing the major proportion of electricity used, and this is a potential application in many parts of the region, where low temperature heat is available.



Figure 19: Geothermal crop drying (US)



Figure 20: A geothermally heated timber drying kiln

5.2.3 Residential and business heating

Geothermal heat can be used for space heating of individual buildings including hotels, houses and public complexes, and for heating entire districts. An associated use is the provision of hot water, via heat exchangers.

A more efficient use of resources is to replace individual bores which extract the geothermal fluids with the use of a single bore to supply heat to a group of houses via a heat exchanger in “district heating” schemes, reinjecting the fluids back into the reservoir. Alternatively downhole heat exchangers can be used, removing the need for fluid extraction and associated potential adverse impacts on the resource, though the heat transfer ability of these systems is limited.

An emerging technology is the geothermal heat pump (refer schematic) in which fluid circuits are buried underground and the low-grade heat they extract is passed through a heat pump to provide space or water heating, providing high thermal efficiency. Note that this sort of application can be applied at any location and is not restricted to traditional geothermal areas. It takes advantage of the fact that ground temperatures are relatively constant compared to air temperatures so is a better source of heating or cooling energy than air when it comes to space or water heating or space cooling.

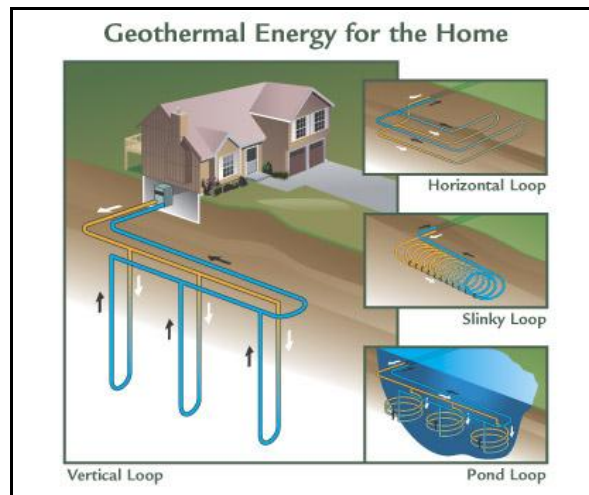


Figure 21: Geothermal heat pump schematic

5.2.4 People-focused geothermal applications

These include recreation and health use in hot springs, scenic areas, tourist parks, and health spas (balneology); providing recreation and soothing aching muscles, as at Tikitere. There may also be potential opportunities for chemical extraction depending on the minerals carried with the fluids and for the growing of thermophiles.



Figure 22: Geothermal health spas

5.2.5 Rotorua geothermal potential

The Rotorua geothermal field underlies much of Rotorua City and the southern area of Lake Rotorua. The natural features associated with the field, particularly the geysers and hot springs of Whakarewarewa, are some of New Zealand's foremost tourist attractions.

More than 900 shallow wells were drilled up to the 1970s at Rotorua to provide hot water for private homes, hospitals, schools, motels, hotels, and other commercial and industrial uses. This development was carried out in an unplanned way with considerable wastage of geothermal heat. By the late 1970s there were significant changes to the surface features at Whakarewarewa and a decline in the geothermal aquifer pressure resulting from the level of draw-off from the Rotorua wells. The Government responded by embarking on a programme of compulsory well closure within 1.5 km of Pohutu Geyser and a field management regime was also put in place. By 1990 less than 150 wells were still operating at Rotorua and since the completion of the programme, the water level in the main production aquifer and the natural features have largely recovered.

Currently field management is based on preservation rather than use. A paradigm shift in thinking is required; to mining geothermal heat and not extraction of fluid, to maximise the use of the geothermal resource. This may include seeking alternative development routes for the geothermal energy at Rotorua, such as the use of downhole heat exchangers and district heating schemes but the potentially large resource is unlikely to be used for large scale electricity generation because of the possible effects on the natural features.

Opportunities in Rotorua:

- District heating, and expansion of commercial and residential heat supply
- Higher profile for geothermal health spa adding to tourism opportunities and building on Rotorua's reputation as an international health spa centre
 - Building on QE Health and Waiora Spa
- Potentially small scale electricity generation
- These opportunities:
 - Providing increased employment and skills development in tourist related activities
 - Building on Rotorua's recognised status as a centre of excellence as an international geothermal centre

5.2.6 Promotion of regional geothermal potential

A query of the Environment Bay of Plenty website on "geothermal" will often direct the researcher to Rotorua information. While there is clear potential to enhance value in Rotorua through this energy source, there are possibilities throughout the Bay of Plenty region with opportunities existing at every field and in many other locations when considering enhanced geothermal or geothermal heat pumps.

This broad regional potential requires promotion, and enhanced information.

5.2.7 Geothermal trades training

A recent report (Brotheridge 2009) looks at skills and associated training in the geothermal industry. The report was sparked by perceived shortfalls in skills and succession issues with an aging workforce. In fact the geothermal industry skills issues are often similar to those across other trades. There is an older group approaching retirement, and some younger people who have recently entered the trades but big gaps in between and perceived lack of interest in schools and tertiary institutions.

This may be partly addressed through training centres in the region, though it is likely that skilled people may disperse initially through the region then nationally. One particular area where skills may have to develop is in geothermal heat pump training. Geothermal heat pumps are new applications in New Zealand and require the merging of skills between electricians, plumbers, drain layers and possibly well drillers. A national heat pump company has just run a 1 day seminar in Rotorua, partly because of geothermal associations, but further encouragement for this sort of training is required.

5.5 Biomass to energy opportunities

Forestry in the region is extensive, but returns low and around 20% of the wood-fibre is left in the forest at harvest or discarded during processing, and therefore wasted, though collection and utilisation of this resource is gradually developing. The opportunity is to increase returns to forest owners and expand forested areas on marginal land (or grow fuel crops), creating a wood fuel and liquid fuel industry. The development of one liquid fuel technology is underway in the region, by a consortium which includes Scion and some major industrial companies.

Use of forest resources for fuel manufacture is also seen as a contingency use for the pulp logs and associated processing infrastructure given that pulp mills are ageing, and may be marginal economically.

5.2.1 The region's forests

The Bay of Plenty region has large pine plantation forests, as shown in Figure 23, and a number of wood processing operations, most notably at Kawerau. In 2008 these forests comprised 185,000 hectares of planted production forestry and 66,000 hectares classified as "unpruned and without production thinning". The latter category would be valued at the lower end of the scale, suitable potentially for pulping, fibre-based manufacture (MDF etc.) or for energy production.

Bioenergy has a number of key advantages compared to other energy forms in that it is a sustainable or renewable resource, can produce heat, power and liquid biofuels and can be stored and deployed easily where and when required. Biomass growth provides a range of additional benefits such as carbon sinks and nutrient removal.

Current constraints for the rapid uptake of bioenergy include the lower cost of electricity generation from other energy sources and consumer and industry perceptions that bioenergy is non-traditional and has higher risks compared to other energy forms. At least some of this disadvantage will be removed with a carbon tax, which will apply in only a minor way to forest derived fuels.

5.2.2 The regional forest resource

The region's forest harvest grows as shown in Figure 24 from a current total of 10 million cubic metres to around 15 million cubic metres in 2030. Of these totals close to 20% (hauler, ground based and landing residues) are currently

wasted and an additional 45% is exported as unprocessed logs; making over 60% of the wood grown potentially available for fuel use without impact on existing added value processing activities.

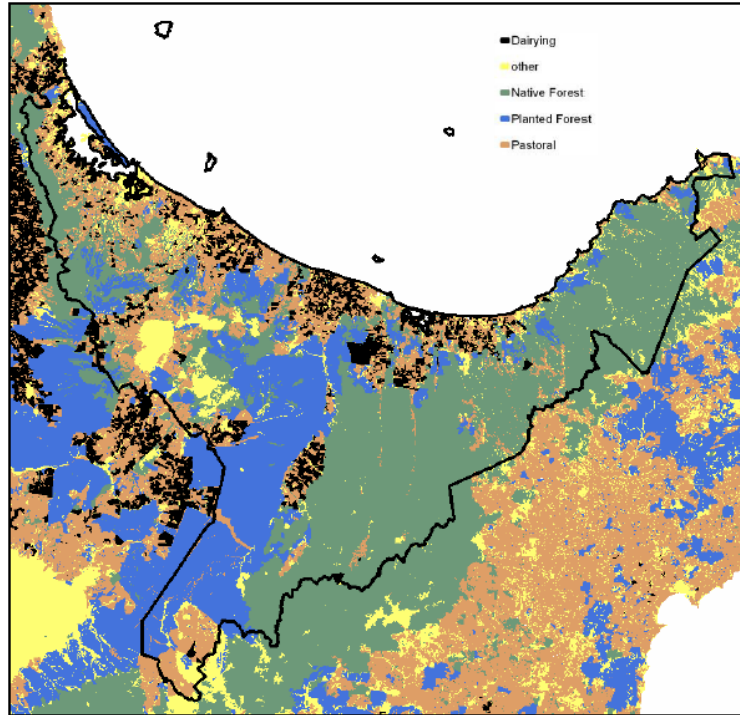


Figure 23: Regional land use
Source EBOP

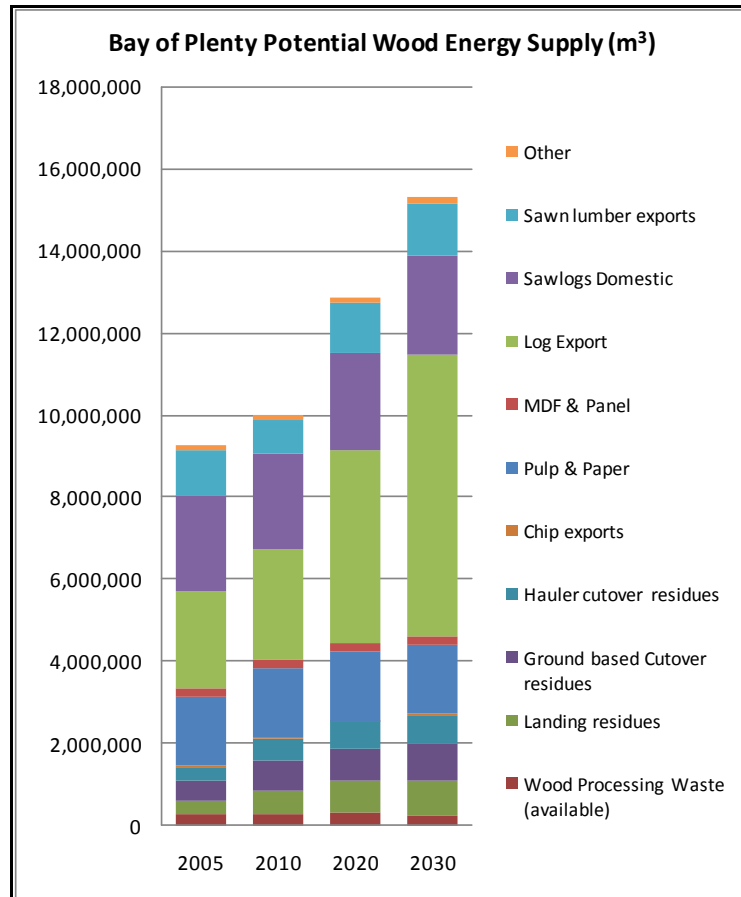


Figure 24: Projected wood harvest volumes, by product Source SCION

5.2.3 Wood energy

Internationally wood provides a large proportion of renewable energy used, and in New Zealand it currently supplies 4% of our total primary energy and approximately 30% of our industrial heat. Use of wood as an energy source is driven by several key factors. Primarily wood energy is used on the basis of its favourable economics, but also to improve energy security, decrease CO₂ emissions, reduce air pollution, and to add value to the forestry and wood processing sectors.

In Europe in particular, bioenergy is an important revenue stream for forest owners with, in Austria, recovery of forestry harvesting byproducts around 80%. The demand for bioenergy has stimulated the development of technology for recovering forest harvesting residues including slash and stumps. As a comparison, in New Zealand we currently recover only 27% of our landing residues and just 7% of our total forestry byproducts though New Zealand's steep terrain will limit overall recovery rates. Even so, there is still 13.6 PJ per annum nationally of economically recoverable wood left to rot in the forest, in addition to an estimated 8PJ of unused wood processing residues. The Bay of Plenty has the second largest exotic forestry cover, complemented by a large wood processing industry with great potential for increasing the use of wood residues for energy.

Economic studies have universally found biomass to provide the highest number of employment man-hours per unit of energy delivered⁴. Wood energy creates ongoing employment in the recovery, chipping and transporting of wood fuels in addition to jobs created in the building, installation and servicing of heat or energy conversion plant.

The job creation associated with biofuels can be achieved while at the same reducing the reliance on internationally and regionally-imported fossil fuels and decreasing carbon emissions, though the economics remain marginal (depending in large part on fuel transport distances) though these will be assisted by climate change measures.

Meeting the local airshed standards is an additional key driver for the uptake of new low emission technologies such as wood pellet with Rotorua currently in breach of the National Environmental standards (NES). If the Rotorua airshed is still in breach by 2013 no new discharge consents will be allowed to be issued. This will have significant effects on economical development as it will constrain new industrial and commercial projects. The installation of low emission wood pellet boilers at the Rotorua Girls High School has shown the benefits of converting to use of wood fuel, while contributing to reducing air emissions within Rotorua.

Throughout the Bay of Plenty there are a number of examples of wood energy use. Large scale examples include the Norske Skog pulp mill with its 40 MW wood-fired boiler. Some of the smaller installations include the 10 schools that were part of EECA's Renewable Heating for Schools project and the Titoki Healing Centre in Whakatane who are now heating with wood pellets.

5.2.4 Purpose grown fuel crops

The Bay of Plenty region is not a major source of purpose grown biomass for energy, but the growing of crops for fuel production is developing elsewhere in New Zealand. Energy crop production would not compete on good land with a vigorous and still expanding horticultural industry or with dairy farming, reference Figure 23, but pastoral and marginal land is available, particularly in the eastern part of the region. Potential crops under trial and research in New Zealand include miscanthus, salix or eucalypts, and these may also potentially replace forestry on land of moderate contour (for harvester access) as they have higher yields and produce within a few years of planting.

Some agricultural residues may also be used for energy production, as part of an overall fuel mix.

5.2.5 Biomass based energy products

Biomass as an energy source, provides a potential higher-value crop that can be grown on low value land. It has low greenhouse gas emissions in comparison with fossil fuels meaning the relative cost of biomass-based fuels improves with any carbon tax. Potential energy-related products include:

Wood chip

Wood chip is used in pulp and paper manufacture or widely exported, but is also a good quality fuel for heat production or cogeneration at large scale, or smaller commercial-scale facilities such as schools where it can be burnt in new automated boilers or as a coal substitute in existing units. It has a relatively low calorific value unless dried rendering long distance transport uneconomic.

⁴ Reference EECA personal communications



Figure 25: Unsorted chipped residues



Figure 26: Wood pellets

Pellets:

Pellets, formed by the processing of good quality wood residues (sawdust or shavings), are a high quality, energy intensive and easy to handle fuel for domestic and small commercial heating applications. They are produced in Rotorua (and other locations including Taupo, where the required drying is by geothermal heat) for both the local market and export.

Pellets are a relatively expensive fuel, reflecting the level of processing and producing heat at a cost on a par with natural gas, but provides high quality heat via automated package heaters.

Bio-oil

Bio-oil is produced from biomass by a pyrolysis process and can be burnt in boilers, or converted to biodiesel to increase its value further. The process is said to be working overseas with production plants available, and the first New Zealand trial of such a unit is to commence shortly. Bio-oil is seen as a medium-term option for relatively low cost conversion of biomass to liquid fuels, potentially available in New Zealand in around 5-years time.

Ethanol

Ethanol is a high value liquid transport fuel, already sold in New Zealand in limited quantities by Gull as around a 5% blend in petrol. Cars can, without modification, operate on a blend of at least 10% ethanol while blends comprising up to 85% ethanol are used in purpose built vehicles overseas. The fuel itself has around 65% of the energy value of petrol.

While the Fischer-Tropsch process is available now, ethanol production technologies are the focus of intensive development work by a number of parties worldwide, including a consortium in which Scion is a partner. Production at small scale proven and is expected to be commercialised within the next decade.

The potential production in the Bay of Plenty from currently wasted residues is estimated at over 500 million litres per annum based on 2030 forest harvests, with the estimated investment in ethanol production plant being around \$320m (though this figure is not to be taken as accurate). Potential production rises to 1.8 billion litres per annum if log exports are included, requiring an investment of over \$600m.

This means that the region has the resources on which to base the production of up to 40% of new Zealand's current petrol usage of 3.2 billion litres (diesel being an additional 2.9 billion litres), while attracting significant investment and creating considerable employment (including skilled manufacturing jobs), directly in the processing facility and throughout the supply chain and associated servicing industries. This would make the region, which uses around 12% of New Zealand's liquid fuels, a net exporter.

The economics of ethanol production are not clear, but Scion have estimated that for ethanol to be competitive based on production from purpose-grown forests a petrol price of around \$3/litre would be required, less if cheaper biomass were used. This scenario would require a rising oil cost and a carbon tax, and in the short-term ethanol may be imported more cheaply.

Biodiesel

Biomass can be used to produce biodiesel, through technologies such as bio-oil and gasification plus a Fischer-Tropsch process though this is not yet commercially done.

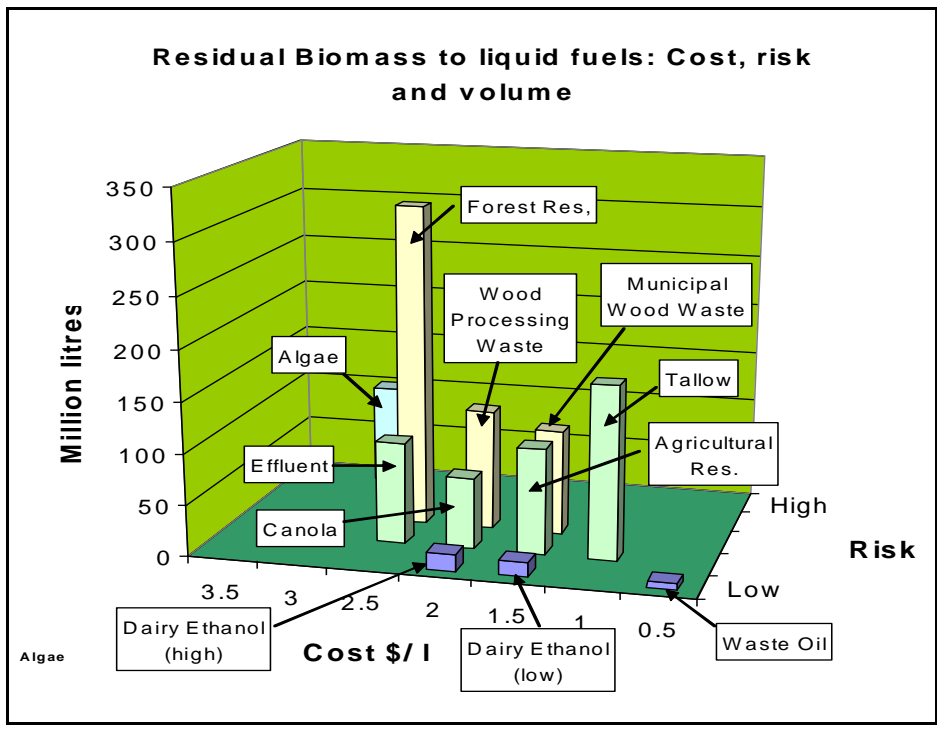


Figure 27: Indicative costs, risks and volumes for liquid fuel production
Source SCION

5.2.6 Greenhouse gas reductions from biofuels

As illustrated in Figure 28 the production of ethanol, or potentially biodiesel, has the potential to reduce the net carbon dioxide emissions from liquid fuel use by more than 90%, while the use of biofuels for heat production offers a close to 100% emission reduction, a little less for wood-pellets (around 95%) due to the degree of processing required.

This means that the relative economics of biomass as a fuel, in relation to other fuels, will improve with a carbon tax and improve the opportunities for fuel swapping in existing plant from coal or gas to wood fuel or use of geothermal heat.

Climate change impacts on the Bay of Plenty

Some of the predicted impacts of a moderate rate of climate change for the Bay of Plenty include changes in average temperature, sea level rise and rainfall patterns. In general, the Bay of Plenty, like much of the north of New Zealand, is likely to become warmer with the possibility of less rainfall in eastern areas but more in the west of the region.

Climate scientists estimate that the Bay of Plenty's temperature could be up to 3°C warmer over the next 70-100 years. This compares to a temperature increase in New Zealand during last century of about 0.7°C. To put this in perspective, the 1997/98 summer, which many New Zealanders remember as particularly long, hot and dry, was only about 0.9°C above New Zealand's average for the 1990s.

Flooding could become up to four times as frequent by 2070, together with a sea-level rise of between 30cm and 50cm by 2100.

Source MfE

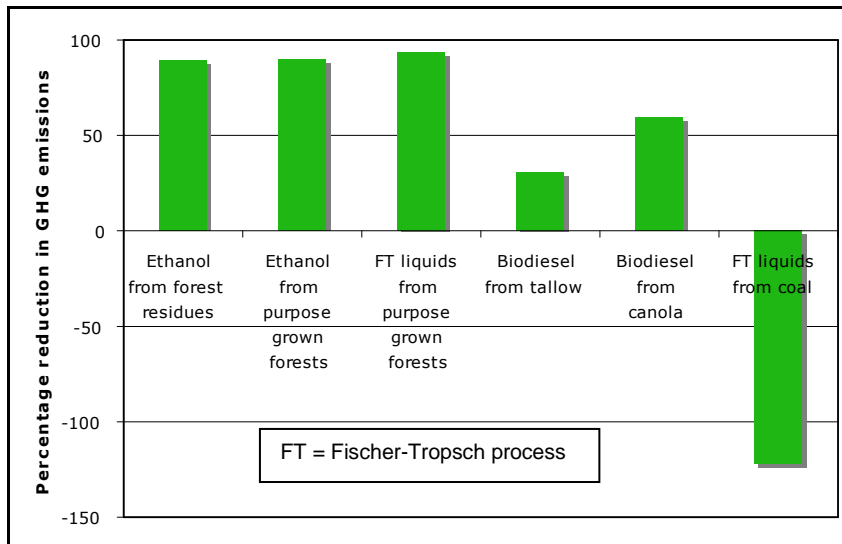


Figure 28: Greenhouse gas emission reductions relative to hydrocarbon fuels
Source SCION

5.6 Oil

The Raukumara oil blocks north of East Cape, which are currently on offer for exploration bids, may provide an opportunity for the region; from exploration support and servicing through the Port of Tauranga.

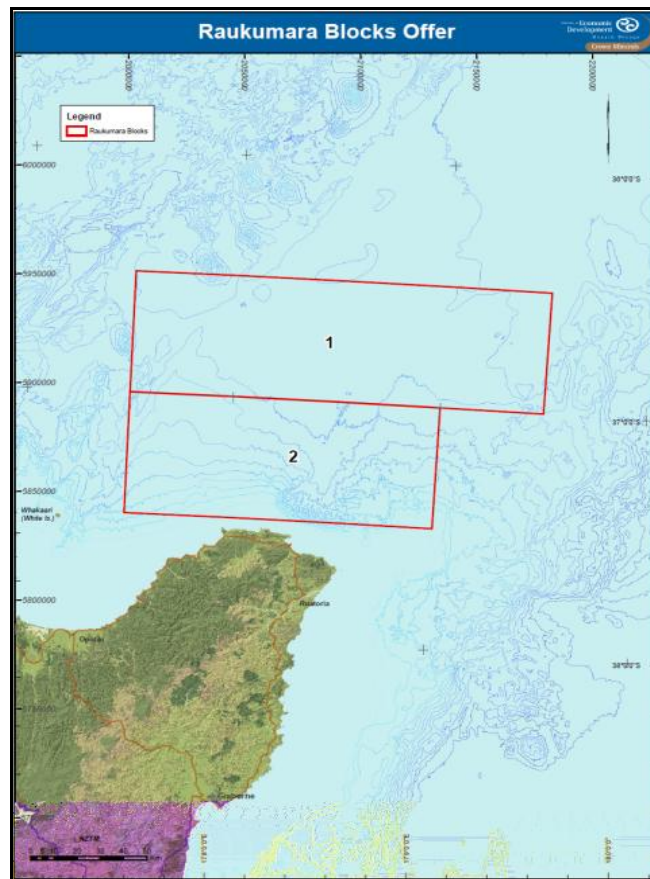


Figure 29: The Raukumara oil blocks
Source Crown Minerals

5.7 Hydro potential – Electricity Generation

Installed hydro generation within the region is currently 173MW with 13.5MW of new capacity currently under study by Bay of Plenty Electricity. The remaining regional hydro potential has been assessed at 681MW in large, medium, mini and small scale projects, but only around 20MW appears to be outside Department of Conservation lands or native forests and therefore readily developed.

The opportunity, which is seen as quite small, is the development in the medium term of small hydro as embedded generation within the local electricity networks. Current high Bay of Plenty area electricity prices are favourable for

this, but the significant geothermal developments available may moderate prices so the prospects for hydro are seen as small overall.

5.8 Other energy forms

Other energy forms considered include wind, tidal and wave power but they are seen as having limited or no potential for the region.

Emerging technologies such as biomass gasification and hydrogen generation from biomass are yet to be commercialised, while biogas generation from industrial, farming or domestic wastes is possible, but the potential scale very small.

6 Enabling capabilities

6.1 Infrastructure

The Port of Tauranga

The Port of Tauranga is New Zealand's largest and most efficient port. Its imports include coal used at the Huntly power station, and it exports logs and chip; both commodities potentially reduced in volume with the implementation of this strategy. However the development of liquid fuel manufacturing would see shipping of ethanol and biodiesel through the port. The port could also be the host for the servicing of the Raukumara oil prospects off East Cape.

Electricity distribution networks

The electricity networks require some strengthening to remove constraints and ensure reliable supply. This work is identified in the network companies' planning documents. To optimise the benefits from this requires the region to interact with the network companies and take responsibility for coordinating planning (including long term planning - a key requirement for the energy industries) and ensuring action occurs to facilitate these improvements.

Major electricity generation developments proposed will be connected directly to the Transpower grid and are outside regional responsibility. Such development however will create significant regional economic activity, and employment.

Gas distribution networks

No strategic issues seen.

6.2 Information sources

Regional sources of energy-related information and advice include:

Rotorua-based **Energy Champion**, www.energychampion.co.nz

Whakatane-based **Energy Options**, www.energyoptions.org.nz

Waiariki Polytechnic <http://www.waiariki.ac.nz> is a regional institute of technology, with campuses in Rotorua, Taupo, Tokoroa and Whakatane

Scion, www.scionresearch.com is a Crown Research Institute focussed on forestry, wood fibre and its utilisation for energy and industrial use

BOP Polytech, www.boppoly.ac.nz is a Tauranga-based polytechnic, which offers courses in its own right and in association with Waikato University [uwt.waikato.ac.nz](http://www.uwt.waikato.ac.nz)

6.3 Training providers

The region has two well established trades training providers in the Waiariki Institute of Technology in Rotorua, and Bay Of Plenty Polytechnic in Tauranga. Each has offshoot programmes throughout the region.

Energy trades people are nationally in short supply and many existing trades people have not had the additional up-skilling on specific energy technologies with the result that there is a great shortage of competent people to specify and install energy equipment for both business and homeowners. The skills shortage extends also to the needs for optimal equipment maintenance and operation.

Waiariki Institute of Technology has announced that it will be establishing in 2010 a National Centre of Excellence for Conservation, Energy and Environmental Sustainability. This will provide a core base for the region to meet regional and national energy related trades training.

Industry trades (plumbers, builders, electricians) and renewable energy (bioenergy solar, geothermal) associations have themselves identified the need for improved skills and experience for specifying and installing renewable energy technologies. The linking of these industry groups with training providers will be essential if the skills and experience constraints are to be speedily addressed.

The training providers will also need to consider the skills and experience required for geothermal health spa and land based aquaculture developments.

At the tertiary education level the Geothermal Institute at Auckland University provides a sound base for professional geothermal skills development but there is no similar training provider for bioenergy.

6.4 Research and development

Bioenergy

Bioenergy research is primarily undertaken by Scion although what they can achieve is very much constrained by the very limited amount of funding available for wood-to-energy research. To achieve the levels of research and development required to implement the regional strategy will require significant representation to Government to increase funding. Funding comes from either the Foundation for Science and Technology for pure research, or the Energy Efficiency and Conservation Authority (EECA) for applied development projects.

The EECA Wood Energy Programme has been very successful in funding demonstration projects and case studies showing the wood energy opportunities and their benefits but the programme is constrained and more should be done.

The Taupo Clean Energy Centre has been undertaking wood energy projects within the wider region and along with the work by the few consultants with knowledge and expertise available there is a small pool of experience. There is a need to further develop this pool of experience so that the full potential of regional wealth from bioenergy can be achieved.

Geothermal

Geothermal energy research is primarily undertaken by GNS Science although because of limitations on funding their capabilities are largely constrained to geothermal reservoir modelling, and they currently undertake limited work in the technologies for geothermal heat mining and utilisation. To achieve the levels of research and development required to implement the regional strategy will require significant representation to Government to increase funding which currently comes from either the Foundation for Science and Technology (FRST) for pure research, or the Energy Efficiency and Conservation Authority (EECA) for applied development projects.

FRST has a limited geothermal budget and EECA has no geothermal application programme.

Because of the age of many geothermal engineers New Zealand has a diminishing capability in this area with the major constraint in the area of applications for use of geothermal energy. There is a need to better develop this pool of experience so that the regional wealth from direct use of geothermal energy can be maximised.

Energy use

The Electricity Commission and EECA have programmes for encouraging the wise use of energy in business, and the achievement of the warm and healthy homes objective, but the information is spread around many places and often difficult to find. EECA is working with the Energy Management Association of NZ to try and improve the skills and capabilities of energy advisers and to provide information on energy efficiency options but this is an area where local regional knowledge must be developed as it generally relates to local advisers, equipment suppliers and installers.

7 Strategies

7.1 Economic growth

The energy strategy focuses on three energy-related economic growth areas; geothermal energy, biomass-to-energy and expansion of industry.

Geothermal energy

The mining of geothermal energy can produce heat for electricity production or other heating applications. The objective is to maximise the utilisation of the region's geothermal resources, on a sustainable basis, to create regional economic growth, employment and well being. Initiatives include:

- Building on Rotorua's success, history and reputation to establish the region as a tourist destination based on geothermal health spa
- Development of direct heating applications, promoting this as a regional opportunity
- Development of a regional approach to the exploitation of the regions shallow geothermal prospects
- Fostering the rapid development of the region's geothermal electricity generation potential
- A regional focus on the development of food production initiatives using geothermal heat
- A regional focus on the development of timber drying using geothermal heat, taking advantage of the co-location of geothermal energy and forestry resources
- Promoting research into the benefits from the co-location of geothermal energy and forestry resource processing

Biomass-to-energy

Biomass can be used to make two energy fuels; wood fuel for heat production, and liquid biofuels for transport fuel. These can provide forest owners with additional revenue streams from forest residues that are currently wasted and higher value from wood produced. This value can be enhanced by the following strategies:

- Development of strategies for the maximisation of the value of the region's forestry resources
- Development of extraction processes for residues as a valuable fuel
- Maximisation of the utilisation of biomass for production of transport fuel and heat
- Fostering the development of wood and residues to transport fuel technologies; establishing Rotorua as the national centre for research on production of transport fuel from lignocellulose
- The development of a fuel cropping strategy

Expansion of industry

The provision of reliable supplies of energy at the lowest price to assist regional industry to be cost competitive in manufacturing, food processing and wood processing.

7.2 Employment

Skills

Energy-related activities can assist the region to provide its people with skilled jobs, requiring the development of trade skills that are in national shortage. This by:

- Development of skills training programmes that establish BOP as centre of excellence in energy utilisation technologies and capability
- Development of trades training programmes so that there are adequate numbers of appropriately skilled people to install and maintain energy equipment
- Development and promotion of energy based opportunities
- Providing appropriate energy training opportunities so that the region has adequate numbers of appropriately skilled energy experts who can assist investors secure commercial energy projects; e.g. project managers for glasshouse developments or timber kiln developments
- Promoting the region as a suitable place for energy training events such as repetition of recent geothermal heat pump training and the upcoming New Zealand Geothermal Workshop

Research and Development

The region can become the national centre for the utilisation of renewable energy:

- Establishing R&D clusters based on :
 - Geothermal
 - Biomass-to-energy
 - Energy use technologies and services

7.3 Security of energy supply

Mechanisms to ensure coordinated planning for security of supply

There is currently no means for the region to interact with prime energy suppliers to ensure that community interests are taken into account during infrastructure planning. The region can take more control, and ensure better outcomes, by instituting mechanisms to assist future planning:

- Establishing 20 and 50 year electricity and gas infrastructure plans
- Ensuring District Plans include provision for required transmission corridors
- Establishing processes for proactive interaction with energy market participants

Providing lowest cost reliable energy to business

- Programmes to assist business secure reliable energy supply
- Programmes to assist business to use energy wisely

7.4 Warm and healthy homes

The objective is to provide all residents of the region with warm and healthy homes while minimizing the construction or retrofitting costs minimizing energy use, and maximizing the use of sustainable energy.

- ***A well designed and constructed house in the Bay of Plenty Climate should require very little heating, and no cooling***
- ***Solar water heating will reduce water heating costs by up to 50%***
- ***Geothermal water heating (including heat pump options) will lead to further savings***

Access to existing government programmes

- Securing access to government funding programmes that assist people in the region to have warm and healthy homes including accessing government incentive programmes for home insulation and the installation of efficient heating, solar water heating
- Building on current Energy Options and other local experience in securing and delivering programmes
- Securing funding from government “WarmUp NZ” programme
- Lobbying government to extend programmes to cover geothermal heat pump applications

Ensure buildings are designed for efficient use of energy

Solar energy, based on good design, can significantly reduce the amount of energy use in buildings; with good building design not only reducing the energy use, but also moisture, condensation and noise issues, while providing a generally more comfortable and healthy living environment. Initiatives include:

- Improved information on standards for insulation and double glazing, leading to improvements in building performance
- Establishing as a primary objective the design of houses for optimal solar efficiency, reducing heating requirements to very low levels and eliminating the need for summer cooling

Solar water heating:

- Can reduce water heating costs by up to 50%
- Is proven, with a range of suppliers and products, but
 - Requires more installers with improved skills
- Is economic if designed into new houses
- But the current high cost of obtaining building consents for systems requires addressing

Building design:

- Solar energy is cost effective for house heating, but can also cause overheating of buildings in summer. It is recommended that:
 - Solar energy be included in basic design, and
 - Its effective use for heating and cooling be introduced as housing design criteria

Upgrading existing houses:

- There is a need for increased knowledge of options amongst home owners
- Enhancement of skills within building trades on best practice for heating and cooling is required
- The cost of building consents for solar heating is high because of processing procedures

- Ensuring that energy technology suppliers and installers are competent and in adequate numbers
- Improving access to information on the benefits, costs and availability of efficient residential energy options
- Building a region-wide residential energy use improvement capability based on improved provider capabilities, continuity of work, and economies of scale.

7.5 Improved environment

With energy costs increasing, and a pending cost of carbon emissions the increased use of renewable regional geothermal, solar and biomass resources offers significant environmental benefits in addition to economic growth.

Efficient use of energy

- Introducing energy strategies which will assist the region to reduce unnecessary use of energy

- Leading to reduced costs of energy increased business productivity, and enhanced wellbeing

Increased use of renewable energy

- The energy strategy is principally based around increased use of renewable energy
- Potentially positioning the Bay of Plenty as the renewable energy centre of New Zealand

Climate change

- The implementation of the energy strategy would result in the Bay of Plenty being a major contributor to assisting the Government meet New Zealand's international obligations for climate change
- Benefitting significantly from climate change policies and initiatives

8 Actions

8.1 General growth actions

1. Wealth and well being from energy recognised throughout the region

- Revise the Regional Policy Statement to take account of the Energy Strategy
- Revise the Regional Geothermal Plan to reflect the Energy Strategy
- Prepare reference case studies of energy projects in the region, and other promotional material as applicable to take the message to the community that the region is rich in energy opportunities
- Establish a timetable and mechanism for annual review and updating of the Regional Energy Strategy and Action Plan by the Regional Governance Group
- Ensure that energy is incorporated in Regional Economic Growth Strategy activity areas (Regional Governance Group)

2. Action within sub-regions

- Include Energy Strategy actions within the Long Term Council Community Plan and District Plan reviews for each territorial authority
- Include for energy efficiency/wise use in any territorial authority investment decision making
- Establish sub-regional monitoring and reporting to the Regional Governance Group based on opportunities, activities and achievements
- Introduce a regular energy section in the EDA newsletters
- Appoint sub-region energy champions to ensure there is always someone "local" taking an interest in energy

3. Energy saving and integrated renewable energy programmes

- Establish regional energy use coordination group to facilitate sub-regional initiatives
- Establish regional promotion programme.

8.2 Reliability of Electricity supply

1. Development of regional 20 to 50 year gas and electricity infrastructure plans

- Provide a mechanism for annual review of electricity and gas distribution networks
- Require network companies to discuss and consult on their asset management plans
- Establish opportunities for the community to engage with infrastructure providers

2. Integration of infrastructure planning with urban development planning

- Encourage land developers to present subdivision energy requirements for inclusion in the annual review of gas and electricity infrastructure plans
- Assist planning for new substations and lines/pipelines to be planned ahead of land use changes such as when planning new subdivisions
- Ensuring sympathetic design of infrastructure as part of subdivision

- Working to reduce opposition to location of infrastructure and duplication of effort
- Enabling access rights to energy corridors to be secured early on, with plans recognising this. This also applies at subdivision level with the utility sites to be defined and included in plans

3. Establishment of gas and electricity transmission corridors

- Encourage infrastructure providers to secure land corridors well ahead of need by formal agreement with landowners
- Choice of route for transmission corridors to take account capital and maintenance costs, along with minimisation of effects on landowners and others
- Work with network requiring authorities to establish and publish standard regional compensation formulae for securing land corridors

4. Demand Management to reduce peak system loadings

- Foster a regional “smart grid” initiative covering demand management, ripple control
 - Noting that cool sheds have an ability to load shed at the time of morning and evening peaks when the cost of electricity is high

5. Development of a “Business Energy Users” cluster

- As a lobby group for improvements in energy supply and delivery services from service providers
- To hold seminars and “field days” to assist business leaders understand energy supply and use options so that adoption by their own business, or lobby for reliability enhancement is most effective
- To provide a mechanism for business to raise reliability of supply concerns during the annual review of the gas and electricity infrastructure plans

8.3 Employment and Skills

1. Improve building trades energy-related skills

- Establish a cluster group with trade and energy associations, training providers and equipment suppliers to establish an energy-related skills development training programme including upskilling of existing practitioners
- Push for government for support for regional building trades training

2. Science and technology

- Recognise Scion as a Centre of Excellence for wood-to-energy research
- Lobby government (FRST, EECA) for an increase in funding for wood-to-energy research
- Lobby for priorities for lignocelluloses-to-transport fuel research
- Establish Rotorua geothermal development research programme to include aspects of direct heat applications, small scale electricity generation, EGS research and geothermal heat pump research
- Lobby government (FRST,EECA) for an increase in funding for research on the direct use of geothermal energy
- Work with GNS Science and the Clean Energy Centre to develop an extended programme of research on the direct use of geothermal energy
- Work with relevant research agencies to develop a regional research programme for land based aquiculture

3. Establish cluster to develop a programme of activities for up-skilling building professionals in energy technologies

- Develop a unified and co-operative energy management skills and practices development programme covering:
 - Energy related advice
 - Energy auditing
 - Technology, knowledge and skills development
- Establish working relationships with national energy-related trade associations to develop and deliver regional up-skilling training
- Continue to promote Rotorua as a training centre for geothermal heat pump installers and agents

4. Establish energy technology demonstration centres

- Establish energy technology demonstration centres adjacent to Waiariki and BOP Institutes

5. Improve access to energy efficiency information

- Website-based information: extend the “Rotorua Energy Champion” site
- Encourage trades and professionals focusing on energy technologies and services to list on the regional energy website
- Promotion of energy efficiency initiatives through industry associations.

8.4 Achievement of warm and healthy homes

1. Develop a regional warm and healthy homes initiative covering

- Secure funding from government WarmUp NZ programme
 - New home owners
 - Low socio-economic groups
- Extend “Energy Options” existing capabilities across the whole region
- Territorial authorities to include information with communications with homeowners and at building consent offices on energy use options
- Establish working group with regional building trade associations to ensure that good energy use practices are incorporated in building design and construction – seminars, “field days”, access to information

2. Solar energy

- To be included in basic house design – seminars and “field days” for architects and builders
- Introduced as housing design criteria its effective use for heating and cooling

3. Establish demonstration homes

- Illustrating the range of options, and energy related features and benefits, to home owners
- Linking to building trades skill development
- Securing government funding for improving existing homes

4. Streamline & reduce costs of energy-related building consents

- Institute standard procedures for minor works, and standard systems that address energy issues

8.5 Geothermal

1. Rotorua is geothermal programme

- Establish Rotorua Geothermal Cluster
- Develop geothermal utilisation strategy and action plan
- Seek assistance from Government for action plan
- Undertake a pilot district heating scheme

2. Rotorua geothermal health spa

- Establish Rotorua Geothermal Health Spa Cluster

Target international branding of Rotorua geothermal health spa

3. Geothermal direct use

- Regional geothermal direct use cluster – include hot pools at Mt Maunganui, Maketu
- Establish working group on direct use technology and applications (including kiln drying, horticulture and other applications)

4. Establish regional Geothermal Hothouse Heating Cluster

- Including landowners, horticulture growers, and Hort NZ

5. Establish R&D requirements

- Establish Geothermal Heat Extraction R&D Cluster
- Establish processes for sharing of knowledge and experience
- Establish skills and development capability requirements, and development initiatives

6. Land based aquaculture

- Establish Geothermal Aquaculture Cluster

8.6 Biomass to energy opportunities

1. Wood-to-energy programme

- Reinforce Scion's status as a Centre of Excellence for wood-to-energy research
- Lobby government for an increase in funding for:
 - Wood to energy research
 - Pilot and demonstration programmes
- Establish forest-residues quality standards and sorting standards to enhance fuel value and use
- Introduce local government and institutions procurement policies considering wood fuel
- Establish Forest Residue Wood Fuel Cluster
- Establish a Loggers, Forest Owners and Chip Hogs cluster to:
 - Establish practices that improve quality
 - Reduce cost of producing wood fuel from forest residue
 - Increase value to forest owners

2. Wood-to-transport biofuel

- Support Scion's international standing in wood-to-transport biofuel research
- Develop a regional fuel cropping strategy, based on a regional study
- Lobby for priority funding/support for lignocellulose-to-transport fuel research

3. Rotorua air emissions abatement

- Establish a programme to encourage the use of wood pellets and direct use of geothermal heating to reduce air emissions arising from hot water and space heating
- Prepare an information base and consultancy services that will make adoption of wood pellets and geothermal heating by building owners hassle free and at lowest cost

8.7 Wise use of energy for business

1. Information

- Establish processes to improve access to energy efficiency information
- Enhance website based information: extending the "Rotorua Energy Champion" site

2. Demonstration

- Establish energy technology demonstration centres in association with Waiariki and BOP Institutes
- Establish development programmes of "field days" to demonstrate new technologies and energy use practices
- Support energy professionals cluster through seminars and upskilling programmes

3. Marine /port cluster

- Establish cluster for export oriented businesses
- Marine operators to identify opportunities for collective action.
- Establish Marine Transport Biofuel Cluster
- Promote the Port of Tauranga as a "renewable fuel" port

APPENDIX 1: Information Resources

“Renewable Energy Assessment Bay of Plenty Region” SKM 2007

<http://www.eeca.govt.nz/sites/all/files/regional-renewable-energy-assessment-Bay-of-plenty-07.pdf>

“Bioenergy Options For New Zealand Analysis Of Large-Scale Bioenergy From Forestry” SCION

<http://www.scionresearch.com/Portals/0/Large-scale%20bioenergy%20from%20forestry.pdf>

“Situational Analysis Biomass Resources and Conversion Technologies Bioenergy Options for New Zealand” SCION

<http://www.scionresearch.com/Portals/0/SCIONBioenergyOptionsReport.pdf>

“Draft Waikato Regional Energy Strategy” October 2008. Environment Waikato

“An Assessment of Geothermal Direct Heat Use in New Zealand” Report by the New Zealand Geothermal Association. Brian White 2006.

http://www.nzgeothermal.org.nz/publications/Reports/NZGADirectHeatAssessmentReport_2006.pdf

“An Updated Assessment of Geothermal Direct Heat Use in New Zealand” Report by the New Zealand Geothermal Association. Brian White 2009.

<http://www.nzgeothermal.org.nz/Publications/Whats%20New/Updated%20Direct%20Heat%20Report.pdf>

“Distributed Energy Roles for Geothermal Resources in New Zealand” East Harbour Management Services 2008

<http://www.nzgeothermal.org.nz/publications/Reports/DistributedEnergyReportFinal23June08.pdf>

“Rotorua District Energy Assessment, Status and Opportunities”, East Harbour Management Services and Scion for BrightEconomy, February 2007.

“Asset Management Plan” Unison Networks Limited, August 2006.

“Annual Planning Report (incorporating the Grid Reliability Report)”, Transpower, 31 March 2009.

“Assessment of Local Hydro-electric Potential – Bay of Plenty Catchment Region”, Ministry of Works and Development Hamilton District Office, December 1982.

“Waters of National Importance - Identification of Potential Hydroelectric Resources”, Report prepared for the Ministry of Economic Development, East Harbour Management Services, January 2004.

“Availabilities and Costs of Renewable Sources of Energy for Generating Electricity and Heat; 2005 Edition” Report prepared for the Ministry of Economic Development, East Harbour Management Services, June 2005.

Geothermal Reports: GNS Science at the Wairakei Research Centre has over 50 reports from GNS, DSIR and CRI.

APPENDIX 2: Geothermal Resources and Their Use

(from Updated Direct Use Report, NZGA 2009)

The following geothermal resources and their use have been identified through review of the “Concise Listing” report, through direct advice by regional councils, through cross-checks by Agnes Reyes (GNS Science), and by limited interviews with users.

Area or Spring	Region	Known Usage	Temperature	Heat Assessment
Hauraki Geothermal Region				
Maketu Hot Springs/Little Waihi	Bay of Plenty	3 known wells feeding two pool complexes and a hot house	30-42 °C	Take: 194,000 t/y at 36 °C (151kJ/kg) = 29TJ Use: reject at 25 °C (105kJ/kg) = 9TJ
Mayor Island (Tuhua) Hot Springs	Bay of Plenty	None known, intertidal springs	Warm	None
Omokoroa	Bay of Plenty	Swimming pools	39 °C	Take: 172,000 t/y at 37 °C (153kJ/kg) = 27TJ Use: reject at 23 °C (97kJ/kg) = 10TJ
Oropi Spa Pools	Bay of Plenty	Swimming pools	57 °C	Take: 52,500 t/y at 54 °C (228kJ/kg) = 11TJ Use: reject at 35 °C (147kJ/kg) = 4TJ
Paengaroa Hot Springs	Bay of Plenty	Well water used for therapeutic swimming pool and in a motel. A farmer has reported drilling a 98 °C well on his property	37 °C	Unknown
Papamoa Hot Spring	Bay of Plenty	Water used to raise and quarantine tropical fish, swimming pools	46 °C	Take: 1,264,000 t/y at 39 °C (163kJ/kg) = 201TJ Use: reject at 30.5 °C (128kJ/kg) = 40TJ
Sapphire (Katikati) Hot Springs	Bay of Plenty	Swimming pools, greenhouses (16TJ usage) and irrigation (22TJ usage)	39 °C	Take: 796,800 t/y at 43 °C (180kJ/kg) = 142TJ Use: reject at 32 °C (136kJ/kg) = 38TJ
Tauranga (Mauao) Geothermal System	Bay of Plenty	More than 100 producing wells of depth range 60-450m discharging 20-54 °C fluid (either pumped or artesian) for public and private swimming baths and hotel/motel complexes. Water allocation is split roughly 27% domestic, 44% commercial and 29% municipal.	<54 °C	Take: 2,237,000 t/y at 44 °C (185kJ/kg) = 413TJ Use: reject at 27 °C (115kJ/kg) = 154TJ
Area or Spring	Region	Known Usage	Temperature	Heat Assessment
Te Puke Hot Springs	Bay of Plenty	None known	Unknown	None known
Te Puna	Bay of Plenty	Swimming pools, heating and some irrigation	51 °C	Take: 427,300 t/y at 46 °C (136kJ/kg) = 81TJ Use: reject at 35 °C (145kJ/kg) = 24TJ
Welcome Bay	Bay of Plenty	Swimming pools and heating	53 °C	Take: 938,700 t/y at 37 °C (154kJ/kg) = 189TJ Use: reject at 34.5 °C (145kJ/kg) = 32TJ

Woodlands (Athenree) Hot Springs	Bay of Plenty	Swimming pools, heating and irrigation	38 °C	Take: 204,800 t/y at 36.7 °C (154kJ/kg) = 31TJ Use: reject at 34 °C (145kJ/kg) = 2TJ
Rotorua-Taupo Geothermal Region				
Waimangu-Rotomahana Geothermal Area	Waikato/Bay of Plenty	Tourism facilities	<81 °C	None
Awakeri (Pukaahu) Hot Springs	Bay of Plenty	3 operational wells to 98m and springs feed 56-70 °C water for swimming baths	<70 °C	Take: 66,000t/y of fluid at 56 °C (234kJ/kg) = 15TJ Use: reject at 42 °C (176kJ/kg) = 4TJ
Humphreys Bay Hot Spring	Bay of Plenty	1 well is known but there is no known use - located on the shore of Lake Tarawera	Unknown	None known
Kawerau Geothermal Field (includes Onepu Thermal Springs)	Bay of Plenty	Many wells supplying Norske Skog Tasman pulp and paper mill, and Carter Holt Harvey Tasman pulp and timber drying facilities. Shallow wells supply heat to a public recreation hall and pool. Previous greenhouses have been removed. There are planned expansions of supply to the tissue mill.	<310 °C in wells	Take: assessed at 11,088TJ Use: assessed at 5,224TJ (see Appendix 3) (also includes 100/23TJ bathing)
Lake Okataina Springs	Bay of Plenty	None - seeps in lake shore beach sands	30-36 °C	None
Lake Rotoiti Geothermal Area (includes Manupirua, Maraeroa, Otutarara)	Bay of Plenty	1 well drilled at Moose Lodge to 218m tapping 55 °C water for heating a pool. Possibly other private wells in the area (reassessed downwards)	<130 °C in sediments	Take: about 46,800 t/y at 56 °C (234kJ/kg) = 11TJ Use: reject at 41 °C (173kJ/kg) = 3TJ
Area or Spring	Region	Known Usage	Temperature	Heat Assessment
Lake Rotokawa Geothermal Area (Rotorua)	Bay of Plenty	8 shallow wells (most < 45m) tap fluids >99 °C. All wells have artesian discharge. These heat a glasshouse, school and swimming pools	>99 °C	Take: 23,600t/y at 102 °C (428kJ/kg) = 10TJ Use: reject at 67 °C (279kJ/kg) = 3TJ
Mangakotukutuku Springs	Bay of Plenty	None	24 °C	None
Matata Geothermal Prospect	Bay of Plenty	None - inferred to exist from resistivity measurements, though locals are aware of springs	Unknown	None
Mokoia Island (includes Hinemoa's Pool)	Bay of Plenty	There are several baths on SE of island	54 °C	None
Rotoma Geothermal Area (includes Tikurangi, Puhi Puhi and Otei)	Bay of Plenty	Rotoma Holiday Park has 3 small hot pools fed from a 38 °C pumped well. Waitangi (soda spring) has been modified for bathing using weir, Otei spring has disappeared. One deep well drilled (data unavailable)	springs < 50 °C, fumeroles < 90°C	Take: about 22,200t/y at 38 °C (159kJ/kg) = 4TJ Use: reject at 35 °C (147kJ/kg) = 0.5 TJ
Rotorua Geothermal Field	Bay of Plenty	Numerous wells (140 production bore sites, 86 reinjection bore sites, 42 downhole heat exchangers) drilled for direct use (mostly 90-120 m deep) tapping water at around 150 °C. Various tourist attractions, Domestic and commercial heating and hot water supplies, swimming pools and mineral baths, hospital and large hotel air conditioning. Increasing use of reinjection and downhole heat exchangers but a general	<194 °C in wells, springs to 100 °C	Take: Approximately 3,658,000t/y at about 458kJ/kg = 1,675TJ plus a further 20TJ from downhole heat exchange Reinject: 3,180,000t/y at around 73 °C (304kJ/kg) = 967TJ Other surface water: 478,000t = 145TJ

		reduction in use overall. About 69% of the water take is for commercial uses, 26% for domestic uses and 5% for municipal use		Use = 1,675 + 20 - 967 - 145 = 585TJ
Taheke Geothermal Area	Bay of Plenty	Springs are used for bathing	<97 °C	None
Tarawera Geothermal Area (includes Te Rata and Humphrey's Bay Springs)	Bay of Plenty	Springs are used for bathing	<90 °C	None
Tikitere (Ruahine Springs) Geothermal Area	Bay of Plenty	Tourism at Hells Gate. About 11 wells supply heating for mushroom growing (?), holiday camp, private baths. About 35% of heat goes to private uses and 65% to commercial uses	<190 °C assume 130 °C for wells	Allocated take: 83,200t/y at 130 °C (546kJ/kg) = 46TJ Use: reject at 100 °C (419kJ/kg) = 11TJ
Area or Spring	Region	Known Usage	Temperature	Heat Assessment
Waiaute Springs	Bay of Plenty	None	23 °C	None
Whale Island (Moutohora) Geothermal Area	Bay of Plenty	None	100 °C	None
White Island (Whakaari)	Bay of Plenty	Private scenic reserve, formerly used for sulphur mining	<350 °C	None
Misc North Island Thermal Springs				
Manaohau Hot Spring	Bay of Plenty	None known (located in Urewera National Park)	Unknown	None
Pukehinau (Waikokopu) Hot Springs	Bay of Plenty	None known	45 °C	None