2014

Valuing uses of the Bay of Plenty Regional Geothermal Resource

Report prepared for the Bay of Plenty Regional Council





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Photo Credits

Top:

- Left: Prince of Wales Geyser, Te Puia in foreground; SilverOaks Hotel Geyserland in Background. Photo by M Donald, 2013
- Centre: Kawerau Power Station. Photo courtesy of Mighty River Power, http://www.mightyriver.co.nz/Media-Centre/Media-Gallery/Geo-Gal.aspx
- Right: SCA's Paper Plant, Kawerau. Photo courtesy of GNS, http://www.gns.cri.nz/Home/News-and-Events/Media-Releases/geothermal-recognised

Bottom:

- Left: Geothermal vegetation surrounding mud pool. Photo by M Donald, 2013
- Front: Steambox at Whakarewarewa Village. Photo by M Donald, 2013

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Executive Summary

The geothermal resources within the Bay of Plenty region are multi-faceted and valued highly for their range of uses. For example, geothermal tourism is found predominantly within the Rotorua area while large-scale geothermal direct use is found in Kawerau. Other uses include electricity generation, direct use for space and water heating, ecosystem services and Maori cultural practices.

This report provides an overview of the predominant uses of geothermal resources within the region. For three sectors in particular, this report quantifies the value of the resource to the regional economy along with associated employment.

The intrinsic values associated with geothermal ecosystems and Maori cultural use are significant to the region, although these values have not been quantified. Likewise, for the value of geothermal resources for silica extraction and biotechnology potential.

Value to the Regional Economy

The total estimated value of geothermal resources to the regional economy in 2013[1] was **$482.5 million**. This equates to almost 5% of the region's GDP[2]. Geothermal resources also contributed an estimated **8,127 jobs** to the region.

Value of Geothermal Resource to Geothermal Tourism

Geothermal tourism directly contributed an estimated $87 million to the regional economy. This increased to $136 million when taking into account the impact from the geothermal tourism sector on supporting businesses and associated flow-on effects from wages and salary available in the economy. Geothermal tourism directly contributed an estimated 2,000 jobs to the Bay of Plenty, increasing to 4,500 when indirect and flow-on effects were included.

Value of Geothermal Resource to Geothermal Electricity Generation

Geothermal electricity generation directly contributed an estimated $22 million to the regional economy. This increased to $64 million when taking into the impact from geothermal electricity generation on supporting businesses and associated flow-on effects from wages and salary available in the economy. It also contributed an estimated 42 jobs to the Bay of Plenty, increasing to 354 jobs where indirect and flow-on effects were included.

The multiplier analysis for geothermal electricity generation excludes the contribution of this sector to the rest of the economy (e.g. the impact of electricity supplied to the end user such as dairy farms, retail etc.).

[1] Including indirect and induced effects
[2] The GDP for the Bay of Plenty for the year ending 2010 was $9,859 million (Toi E.D.A.)

Value of Geothermal Resource to Large-Scale Direct Use

Direct use is the use of geothermal resources for purposes such as pool heating, space heating for greenhouses as well as large-scale direct use for industrial processes (e.g. paper and wood production). This assessment focused on the value of large-scale direct use of geothermal resources to the economy.

This sector directly contributed at least $94 million to the regional economy, which increased to $282 million when taking into account the impact from large-scale direct use on supporting businesses and associated flow-on effects from wages and salary available in the economy. It also contributed an estimated 563 jobs to the Bay of Plenty, increasing to 3,271 when indirect and flow-on effects are included.

Anticipated changes to Geothermal Resource Demand

There are likely to be increased demands on the region's geothermal resources across all sectors. Therefore, competing uses and values will need to be carefully managed. Future clustering or co-locating of activities will need to be encouraged to ensure that development costs are reduced. Likewise for further development of cascade use or direct use of low temperature geothermal resources which will need to be encouraged to ensure efficient and optimal use. Collaboration between Council's and agencies will be essential to finding a balance between enabling economic development and promoting the sustainable use of the geothermal resource.

1. Introduction

Geothermal resources are used extensively within the Bay of Plenty and are valued highly for their range of uses. Geothermal resources are used for home heating, public pool heating, industrial use and horticultural purposes. They also have significant Maori cultural and ecosystem values.

The uses associated with geothermal resources vary across the region (Table 1). Generally speaking, geothermal tourism is found mainly in Rotorua where geothermal attractions are a key component of the city's identity. Geothermally heated motels, holiday parks and private pool facilities are also found in Kawerau, Awakeri, Tauranga and parts of the Western Bay of Plenty.

	Rotorua	Kawerau	Tauranga / Western BOP
Tourism	●	●	●
Electricity Generation	-	●	
Direct Use (Industrial) (Wood / Paper)	-	●	
Direct Use (Municipal Pools)	●	●	●
Direct Use (Residential / Commercial)	●	-	●
Direct Use (Horticultural)	-	-	●

Table 1. Geothermal Uses by Locality

Kawerau is the hub for geothermal electricity generation and large-scale direct use for industrial process heat (e.g. wood and paper processing). All three localities have geothermally heated municipal pools, while direct use for residential and commercial heating is mainly found in Rotorua and Tauranga. Direct use for horticultural purposes (irrigation, frost-protection greenhouse heating) is found in the Western Bay of Plenty district.

1.1 Report Purpose

This report provides an overview of the predominate uses of geothermal resources within the region. The five uses discussed in this report are:

- Tourism
- Electricity generation
- Direct use
- Ecosystem services
- Cultural

For three sectors in particular, this report quantifies the value of the resource using standard economic methodology (multiplier analysis). This includes its value added to the regional economy and employment.

Anticipated future changes to these sectors are also discussed along with implications for the long term management of the geothermal resource.

This report will help to inform geothermal management decisions, including for allocation, managing competing uses and monitoring.

1.2 Data Collection Method

Information for this report was collected using a variety of survey methods including Survey Monkey web survey, postal survey, phone, email and site visits with proprietors/owners. The surveys were conducted during October 2013, and investigated:

- The number of visitors from domestic and international sources visiting geothermal attractions including public pools
- The number of staff employed in tourism and direct heat facilities

Data was also collected from resource consent data, web searches, New Zealand statistics, academic journals and technical reports. This included the amount of geothermal energy used in commercial, industrial and domestic direct heat applications. From here, a multiplier analysis was undertaken to quantify the value of geothermal resources to the Bay of Plenty region.

Data from commercial sites are not identified individually to preserve confidentiality.

2. Overview of Geothermal Resources in the Bay of Plenty

The geothermal resources of the Bay of Plenty Region result from the tectonic activity of the Taupō Volcanic Zone (TVZ). The majority of geothermal resources are found in a broad band from Waimangu to the south of Rotorua to Whakaari (White Island) off the coast in the north-east of the region (Figure 1) (Bay of Plenty Regional Council, 2013). The geothermal fields in the TVZ region contain the higher temperature fields which have been used for electricity generation (~300°C). Outside of the TVZ are the Tauranga and Maketu systems. They are low-temperature systems; 60°C at approximately 800m (Pearson, 2000).

The region's geothermal resources are classified into six Geothermal Management Groups in the Bay of Plenty Regional Policy Statement[3]. The geothermal management groups classify the geothermal systems by temperature, features, management purpose, current use and potential for use (see Appendix 2 for details).

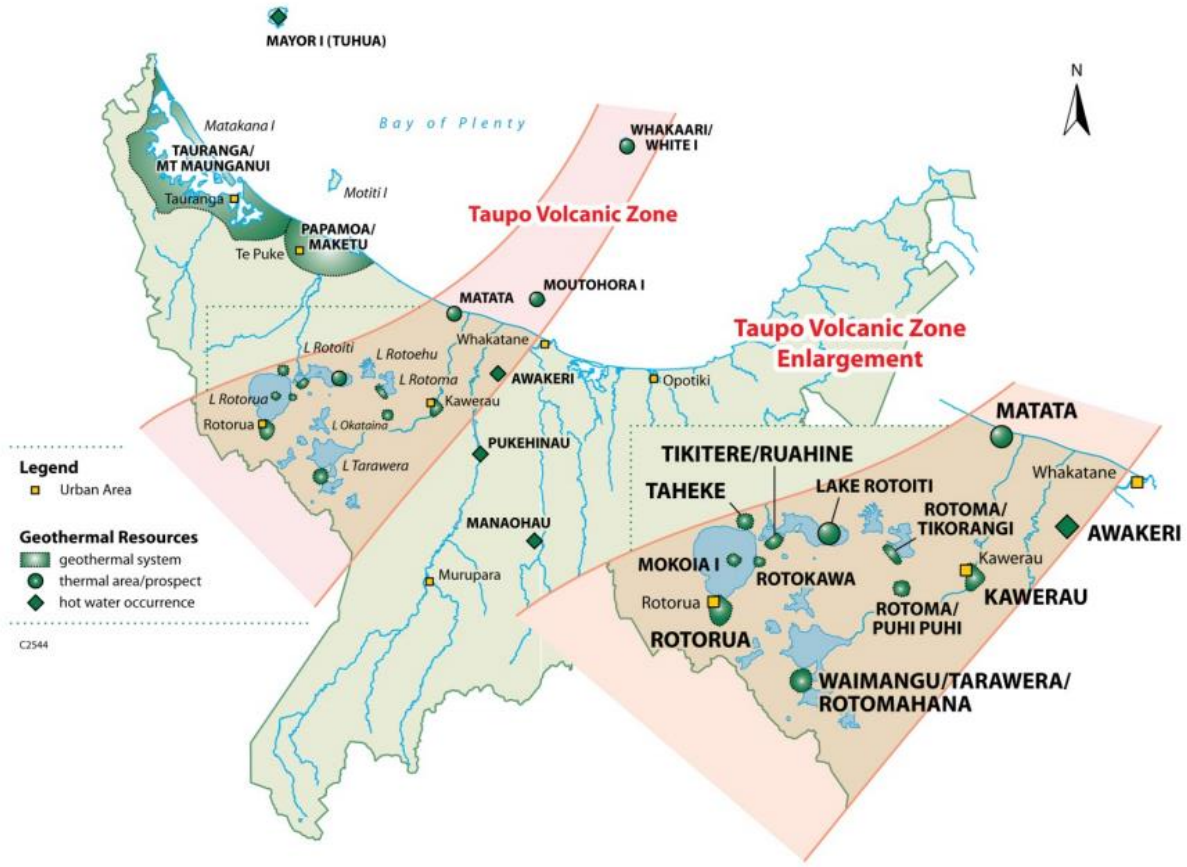

Figure 1. Map of Geothermal Systems in Bay of Plenty

[3] Geothermal provisions of the Proposed RPS became operative 1 October 2013

3. Use I: Tourism

Snapshot of Geothermal Tourism in the Bay of Plenty:

667,320	$155 million	$136 million	4,502 Jobs
Geothermal visitors to the Bay of Plenty	Geothemal tourist expenditure in BOP	Value added to BOP economy*	Employment in BOP*

** Per annum based on figures for the year 2012*

** Value added and employment impact includes direct, indirect and induced effects*

Tourism plays a significant role in the New Zealand economy. For the year ending March 2013, international and domestic visitors spent $23.9 billion, directly contributing $7.3 billion (or 3.7%) to New Zealand's Gross Domestic Product (GDP). The indirect value added of industries supporting tourism was an additional $9.8 billion (or 5%) to the GDP (Statistics New Zealand, 2013a).

As illustrated in Figure 2, tourism is New Zealand's second largest export sector. In the year ending March 2013, 2.6 million international visitors arrived in New Zealand (MBIE[4], 2013a). Over that period, international visitors contributed $9.8 billion to the economy, accounting for 16.1% of export earnings. Tourism is also an important source of employment. For the year ending March 2013, 110,800 full-time equivalents[5] (or 5.7% of total employment in New Zealand) were directly employed in the tourism industry (Statistics New Zealand, 2013a).

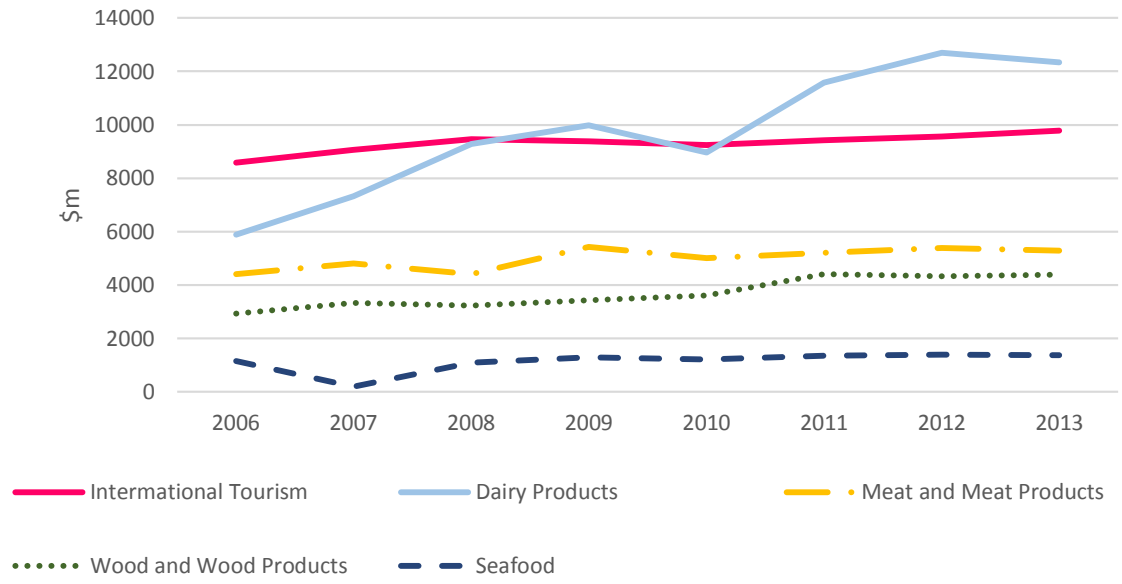

Figure 2. Comparison of International Tourism Expenditure with Selected Primary Exports (Statistics New Zealand, 2013a)

[4] Ministry of Business, Innovation & Employment

[5] Tourism Satellite Account refers to full-time equivalents as opposed to Employment Count

3.1 Geothermal Tourism in the Bay of Plenty Region

For the tourism sector as a whole within the Bay of Plenty region, spending by international visitors was $360 million for the year ending March 2013. For the same period, domestic visitors spent $770 million. Tourism expenditure across the four Regional Tourism Organisations[6] are summarised below:

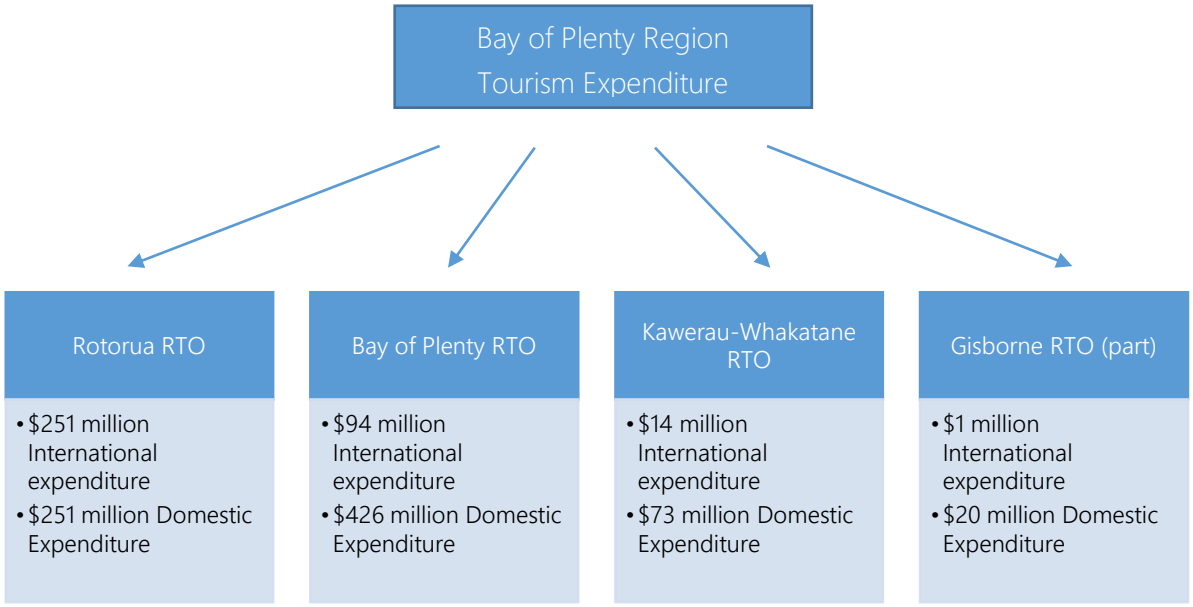

Figure 3. Bay of Plenty Region Tourism Expenditure (Source: MBIE, 2013f)

Geothermal tourist attractions in the Bay of Plenty include bathing pools, hot pools, mud pools, geysers, fumaroles (steam vents), terraces, lakes, Maori cultural tours and volcanic tours (e.g. White island). Rotorua is an international draw card and the hub for geothermal tourism within the Bay of Plenty region. Geothermal attractions are seen as the competitive advantage that Rotorua has over other destinations (Rotorua District Council, 2012). Mineral pools (pools filled with geothermal water) are a feature of many tourist accommodation facilities in Rotorua, and is advertised when promoting their business.

For the year 2012, there were an estimated 667,320[7] tourist visits to geothermal attractions in the Bay of Plenty, with around 82% of those visits to Rotorua.

[6] As shown in Appendix 3, the Bay of Plenty Region is segmented into four Regional Tourism Organisations (RTO): Bay of Plenty (which covers the Western Bay of Plenty only), Kawerau-Whakatāne, Rotorua, and part of the Gisborne RTO which covers the eastern coast of the Bay of Plenty. This is an important distinction to make, as Statistics New Zealand provide RTO statistics for each of these RTOs and all four combined make up the regional statistics for the Bay of Plenty – in other words, the Bay of Plenty RTO alone does not cover the whole region.

[7] Refer to Appendix 5 for Tourism Statistics and Calculations

3.2 Tourism Numbers: Survey results

This report divides geothermal attractions into four[8] categories:

- Bathing as part of tourist accommodation facilities (61 sites)
- Pay Bathing (13 sites)
- Nature Tourism (11 sites)
- Free Informal Bathing (6 sites)

Tourism operators were surveyed in October 2013 to find out the number of visitors to geothermal attractions, the number of staff employed and the usefulness of geothermal resources to their business. The survey methods were a mix of a postal, online surveys, phone calls and site visits with proprietors/owners. The survey period covered 1 April 2012 to 31 March 2013.

The survey specifically excluded those operators offering paid tours to geothermal sites, including Paid and Free Nature Tourism Sites to avoid double counting. Many of these operators also arrange tours to Waiotapu Thermal Wonderland, which is in the Waikato Region.

This section presents the aggregated results of the survey. The results are summarised below (Table 2) and discussed in individual sub-sections.

	Category	Tourist Accommodation Bathing	Pay Bathing	Nature Tourism	Total
Visitors	Domestic visitors ('000)	673	367	114	1,149
	International visitors ('000)	546	416	486	1,443
	Total visitors ('000)	1,219	783	600	2,592
Staff	Number of Staff (FTE)	804	156	238	1,194
	Total Number of Staff	1330	236	281	1,843
Usefulness	Usefulness of geothermal resources to organisation	Essential (80%) Useful (20%)	Essential (100%)	Essential (100%)	-

Table 2. Geothermal Tourism Survey Results

[8] The Waikato region has technology-related tourism which includes paying visitors to the Prawn Park and artificial Wairakei Terraces. There are no known technology-related tourism ventures in the Bay of Plenty.

3.2.1 Bathing as part of tourist accommodation facilities (61 sites)

This category covers those accommodation facilities where geothermal bathing pools are provided. These include large pools for all guest use as well as private pools. The pools are either geothermal water or freshwater heated by geothermal energy. For the purpose of this report, accommodation facilities which have bathing pools that are open to the public (e.g. Awakeri Hot Pools) are considered to be Pay Bathing.

The majority of the tourist accommodation facilities with bathing facilities are in Rotorua (Figure 4). A full list of the tourist accommodation with geothermal bathing facilities in the Bay of Plenty region can be found in Appendix 4.

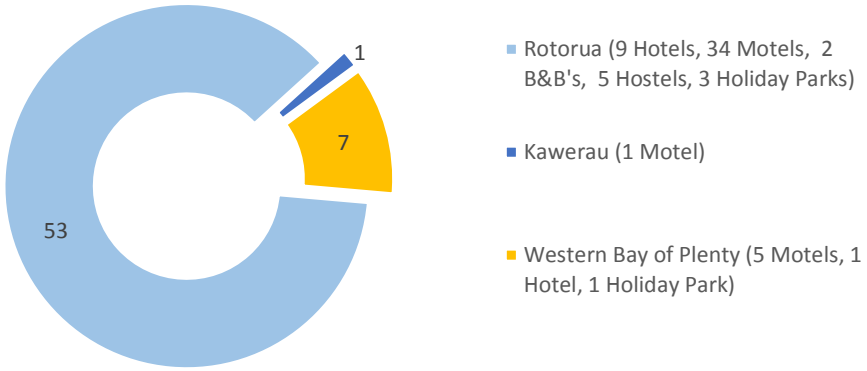

Figure 4. Number of Tourist Accommodation Bathing Facilities (1 April 2012 to 31 March 2013)

All 61 sites were surveyed in October. The survey response rate was 40%, and covered the range of accommodation types. The remainder of the data for the accommodation sites has been extrapolated from the collected data by comparing the occupancy rates, size of the facility, and type of accommodation. The results of the survey are summarised below (Table 3).

Accommodation Category	Estimated number of Domestic Visitors	Estimated number of International Visitors:	Total estimated number of visitors	% Guest pool use	Number of Staff (FTE / Total)	Importance of geothermal resource
Hotel / Resort	380,900	334,100	715,000	55%	663 / 1077	Useful
B&B	90	1,710	1,800	100%	4 /8	Essential
Hostel/ Backpackers	10680	60495	71175	60%	10 / 20	Essential
Holiday Park	45,000	65,000	110,000	89	24/44	Essential
Motel	236,782	84,318	321,100	75%	103 /181	Essential
TOTAL	673,452	545,623	1,219,075	-	804/1330	-

Table 3. Survey Results - Tourist Accommodation Bathing (1 April 2012 to 31 March 2013)

Hotel survey respondents suggested that the geothermal resource was useful but not essential to their business operation. All other survey respondents listed the importance of geothermal resources to their business operation as essential. This is evident in tourist accommodation advertising on signs, pamphlets and the internet, where the presence of thermally heated or mineral pools is seen as a major point of difference to attract business.

3.2.2 Pay bathing (13 sites)

This category covers developed geothermal bathing facilities and includes tourist accommodation facilities where the pool is open to the public. In all instances, the water is either geothermal water or fresh water that has been heated by geothermal heat. Excluded from this category are school and domestic pools as well as municipal ("Council") pools, other than the Mount Hot Pools. These are discussed in Section 5.2.3 of this report (*Direct Use for Public Pools*).

There are 13 Pay Bathing sites within the Bay of Plenty:

- Athenree Hot Springs and Holiday Park, Athenree
- Awakeri Hot Springs, Awakeri
- Blue Baths, Rotorua
- Fernland Spa Thermal Mineral Springs, Tauranga
- Manupirua Springs, Lake Rotoiti
- Mount Hot Pools, Mount Maunganui
- Omokoroa Tourist Park & Thermal Hot Pools, Tauranga
- Oropi Spa Pools and Country Café, Tauranga
- Polynesian Spa, Rotorua
- QE Health, Rotorua
- Sapphire Springs Holiday Park, Katikati
- Waitangi Soda Springs, Lake Rotoma
- Welcome Bay Hot Pools and Camp, Tauranga

These sites vary significantly in terms of size, sophistication of offerings, level of use and surrounding environment. There are large pool facilities such as Polynesian Spa and Mount Hot Pools as well as small rurally-based pools such as Waitangi Soda Springs and Sapphire Springs Holiday Park.

All Pay Bathing sites were surveyed in October 2013. The survey response rate was 62%. The remainder of the data was sourced from the internet, news articles, regional tourism reports and estimates based on other sites of similar sizes and operations. The results of the survey are summarised below (Table 4).

Estimated number of Domestic Visitors	Estimated number of International Visitors:	Total estimated number of visitors	Number of Staff (FTE / Total)	Importance of geothermal resource
367,310	415,558	782,868	156 / 236	Essential

Table 4. Survey Results - Pay Bathing (1 April 2012 to 31 March 2013)

3.2.3 Nature Tourism (11 sites)

This category covers developed facilities that charge visitors to look at geothermal attractions, such as geysers, mud pools and hot springs. It also includes areas that provide free walks through geothermal areas. This report identified eleven nature tourism sites (7 pay tourism, 4 free):

- Helipro Helicopter Adventures, Rotorua – scenic flight operator (Te Puia, Mt Tarawera)
- Hells Gate Geothermal Park & Mud Spa, Tikitere
- Ohinemutu Village, Rotorua – free
- Te Arikiroa (Sulphur Flat), Rotorua – free
- Kuirau Park, Rotorua - free
- Government Gardens, Rotorua - free
- Te Puia, Rotorua
- Volcanic Air Safaris, Rotorua – scenic flight operator (White Island, Hells Gate)
- Waimangu Volcanic Valley, Waimangu
- Whakarewarewa Village, Rotorua
- White Island Tours, Whakatane – scenic flight operator (White Island)

As mentioned earlier, there are a number of companies that offer paid tours to these geothermal attractions. These operators have been excluded to avoid double counting.

All seven 'pay tourism' operators were surveyed. The survey response rate was 71%. The remainder of data was estimated based on other sites of similar sizes and operations. The results of the survey are summarised below (Table 5).

Estimated number of Domestic Visitors	Estimated number of International Visitors:	Total estimated number of visitors	Number of Staff (FTE / Total)	Importance of geothermal resource
114,371	485,559	599,930	238 / 281	Essential

Table 5. Survey Results - Nature Tourism (1 April 2012 to 31 March 2013)

These figures do not include visitors taking guided tours to free sites or to other sites not mentioned above. Also excluded are visits to geothermal attractions that are ancillary to an existing tour e.g. trout fishing on Lake Tarawera near Te Rata Bay (Hot Water Beach). For these reasons it is likely that the visitor numbers in Table 5 are lower than actual numbers.

3.2.4 Free informal bathing (6 sites)

This category covers those largely undeveloped sites that are accessible to the public for bathing without a charge and includes sites on publicly owned land as well as accessible private land.

Free informal bathing sites in the Bay of Plenty region are shown in Table 6. These sites were not surveyed. No estimated visitor numbers are provided for this section.

Kuirau Park, Rotorua	Two covered foot pools and one uncovered pool.
Rotorua Visitor Centre	Small foot pool at the entrance to the Visitor's Centre.
Te Rata Bay, Lake Tarawera	Hot water beach located in a secluded bay. Accessible only by boat.
Te Wairua Stream, Lake Tarawera	Hot water pool surrounded in native bush and a short walk from the lake's edge. Located near a Department Of Conservation public camping ground.
Tumoana Point Hot Springs, Lake Rotoiti	Hot water beach located west of Manupirua Bay. Access via Tumoana Road.
Wai-Kimihia (Hinemoa's Pool), Mokoia Island	Located on private property. Landowner permission is required before visiting. Alternatively, tours to Mokoia Island and Wai-Kimihia are available through WaiOra Experiences.

Table 6. Known free informal bathing sites

3.3 Value of Geothermal Tourism to the Regional Economy

Quantifying the value of geothermal tourism on the regional economy involves estimating tourism expenditure and applying specific value added multipliers.

3.3.1 Parameters used

Parameter	International Tourists visits	Domestic Tourists visits
Total number of tourist visits to the region[9]	806,000	4,800,000
Total number of geothermal tourist visits the region[10]	494,520	172,800
Amount of money spent per tourist per day[11]	$111	$118 (day) $124 (overnight)
Number of nights spent in the region[12]	2.1 nights	2.3 nights
Total Output[13]	$126.25 million	$29 million
Direct Value Added[14]	$70.7 million	$16.24 million

Table 7. Parameters for Multiplier Analysis - Geothermal Tourism (2012)

[9] Refer to Appendix 5 for Tourism Statistics & Calculations.

[10] As above.

[11] Domestic Travel Survey, MBIE, 2012

[12] Rotorua District Council (2012), MBIE (2013b)

[13] Output is estimated as the number of tourists multiplied by daily spend and number of days in the Bay of Plenty region

[14] Calculated by multiplying the total expenditure by the value-added multiplier.

3.3.2 Multipliers Explained

The **direct value added** is the direct contribution of geothermal tourism to the regional economy. This amount is smaller than total output as it excludes the goods and services required to produce the output. From here, multipliers are applied to the direct value added figure to estimate the indirect and induced impacts of geothermal tourism.

The **indirect effects** are the impact from the geothermal tourism sector's output on other businesses. For example, goods and services purchased by tourism companies from their suppliers. The **induced effects** are the flow-on effects from tourism-related wages and salaries that are now available in the economy.

Multipliers were supplied by Market Economics Limited.

3.3.3 Multiplier analysis – Value of Geothermal Tourism

In 2012, geothermal tourism directly contributed an estimated $86 million to the regional economy (Figure 5). This increased to $133 million with the indirect effects and $136 million when including induced effects.

3.3.4 Multiplier Analysis - Employment

As mentioned in Section 3.2, tourism operators and proprietors were surveyed in October 2013 in relation to the number of staff employed. Based on this survey, geothermal tourism employed 1,194 full time equivalent staff and 1,843 staff in total.

In 2012, geothermal tourism directly contributed an estimated 1,977 jobs (MECs)[15] to the Bay of Plenty. This increased to 2,532 when including indirect effects and to 4,502 when including induced effects. These figures are for the number of jobs, which may be full- or part-time. The figures also include working proprietors.

These figures are higher than the survey results. This is in part because of the broader range of tourism-based businesses included in the multiplier analysis, such as accommodation and restaurants, and the difference in definitions. The survey sought information on full-time equivalent employees, where the MEC measures number of jobs. In addition, the low response rate for the Tourism Accommodation Bathing survey (40%) meant that data was extrapolated for the remaining 36 sites, which may have contributed to the error. For this reason, the multiplier analysis may be a more accurate estimation of geothermal tourism-related employment in the region.

[15] MEC is a modified employment count, which is the number of jobs, and includes working proprietors.

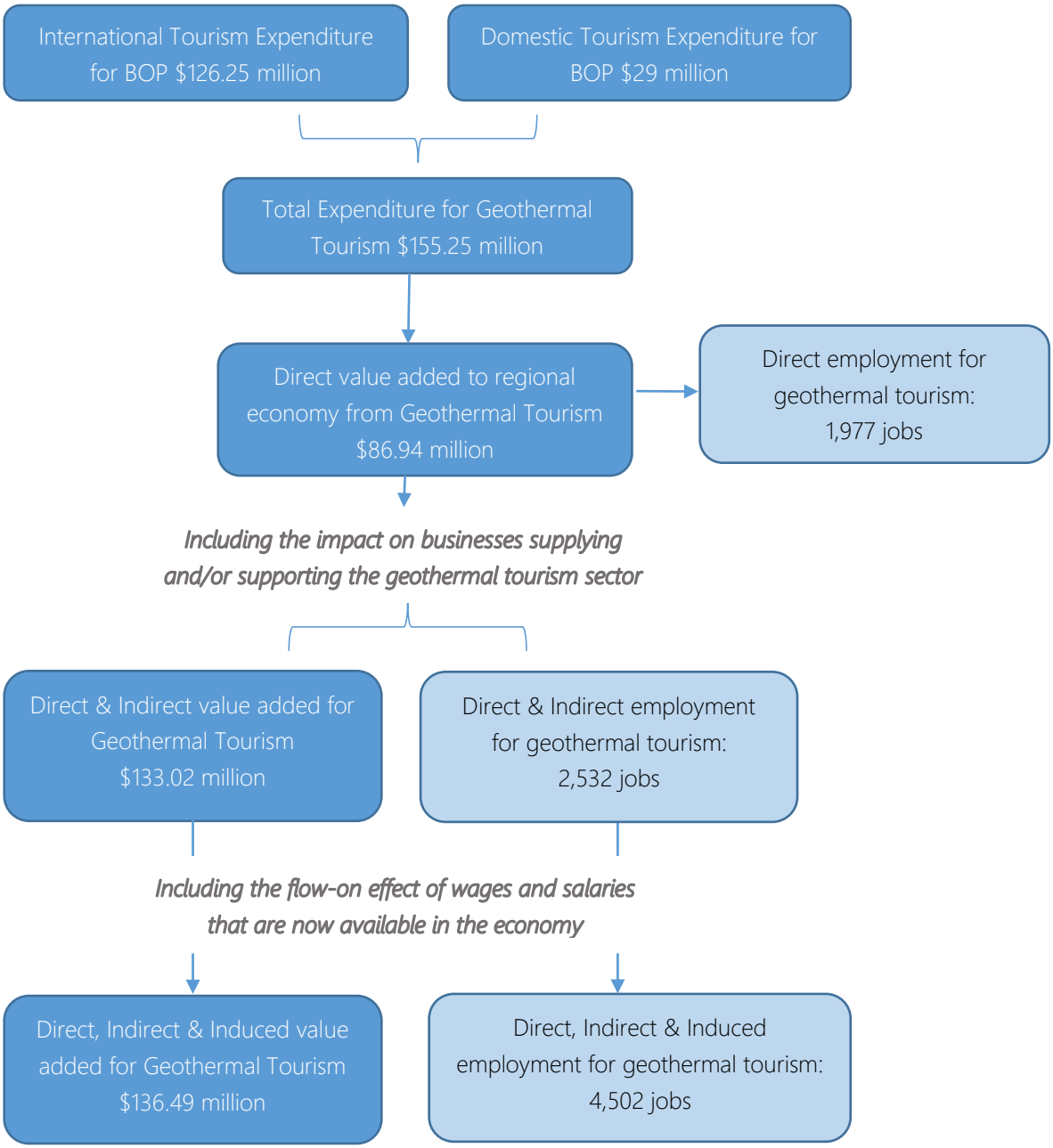

Figure 5. Result of Multiplier Analysis - Geothermal Tourism (2012)

3.4 The Future of Geothermal Tourism

Tourism forecasts estimate that 3.1 million international tourists will visit New Zealand in 2016, and for the same year, there will be 56.1 million domestic tourist visits. These represent increases of 20% and 17% respectively (MBIE, 2013c). Assuming the same patterns as in 2012[16], there will be 791,580 tourist visits to geothermal attractions in the Bay of Plenty. Of these, 589,620 (or 74%) will be international visitors. Of the domestic trips, 131,274 visits will be day trips and the remaining, overnight trips.

Applying the multiplier analysis to these tourism forecasts, in 2016 geothermal tourism is forecasted to directly contribute an estimated $133 million to the regional economy. This increases to $203 million when including the indirect effects and $209 million when taking into account the induced effects. The forecast suggests that in 2016, geothermal tourism will directly contribute 3,022 jobs, increasing to 3,869 jobs when including indirect employment and 3,929 jobs when taking into account induced employment.

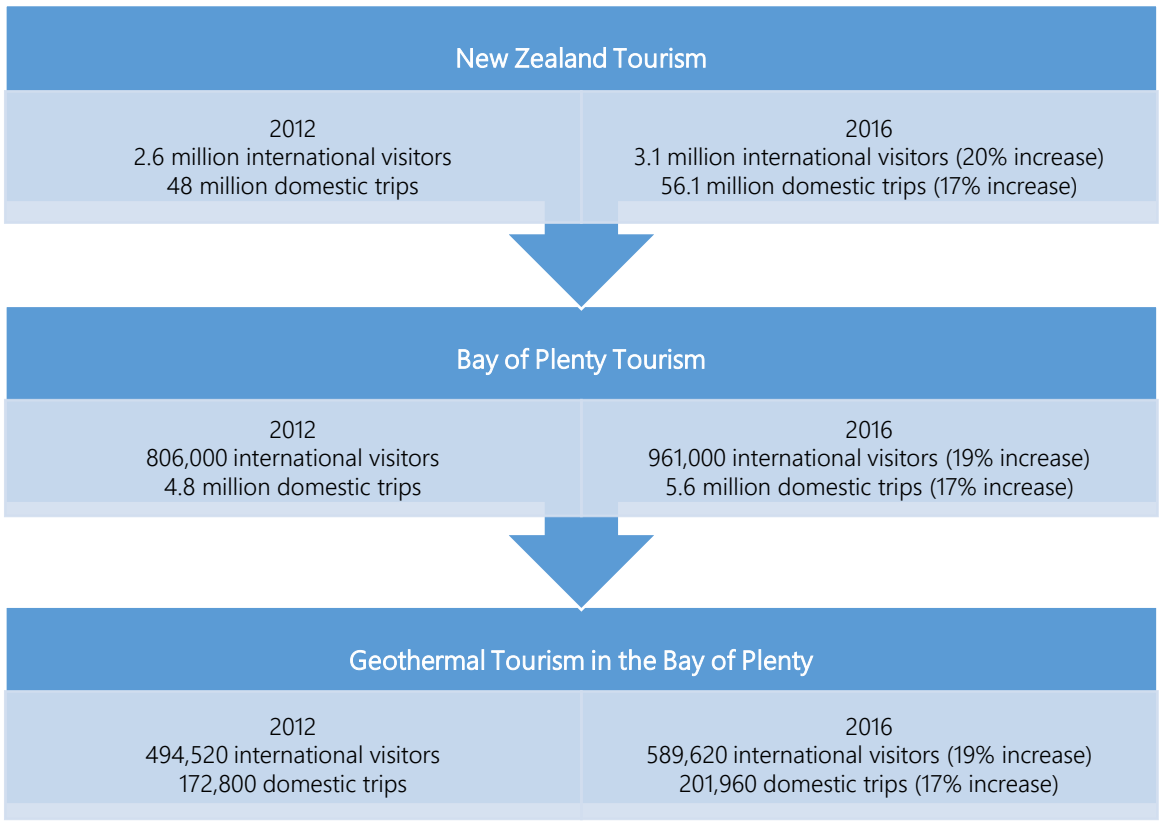

Figure 6. Comparison of Tourism Statistics for 2012 and 2016

[16] For example, percentage of tourists visiting the Bay of Plenty, percentage of tourists visiting geothermal attractions, as outlined in Appendix 5.

According to the Bay of Plenty Energy Strategy (Bay of Connections, 2011), the region could attract more than $4 billion in sustainable energy-related developments over the next 15-50 years. This includes significant growth in tourism activities associated with direct use of geothermal energy.

The Rotorua Economic Growth Strategy (Rotorua District Council, 2011) states that Rotorua is New Zealand's leader in tourism innovation and success. The Strategy supports further development of geothermal resources as a source of sustainable energy. However, it also seeks to "*minimise possible risks to tourism and competition for use of resource*" as a result of meeting the energy supply goal. The Strategy thus acknowledges the challenge of managing competing uses and values associated with geothermal resources.

4. Use II: Geothermal Electricity Generation

Snapshot of Geothermal Electricity Generation in the Bay of Plenty:

2,967 GWh	1,019 GWh	$63.67m	354 Jobs
Electricity demand in the BOP	Geothermal electricity generated in the BOP	Value to BOP economy*	Employment in BOP*

** Per annum based on figures for the year 2012*

** Value added and employment impact includes direct, indirect and induced effects*

Depending on the temperature and pressure of the geothermal resource, electricity is generated using a steam and/or a binary cycle system (Thain, Keyes and Hunt, 2006). The two most common geothermal electricity generation methods in New Zealand are flash steam[17] and binary systems[18]. Electricity is generated by using geothermal steam, or secondary fluids to drive turbines, which drive generators. In most instances, geothermal fluids are injected back into the subsurface reservoir to maintain the geothermal system[19].

4.1 National Electricity Generation and Use

In 2012, over 42,900 GWh of electricity was generated in New Zealand (MBIE, 2013d). From the 1970s until 2008 electricity demand increased at approximately 2.5% per annum (Electricity Authority, 2011). Drivers for electricity demand include economic activity, demographics, electricity prices, new technologies, industry growth, and population growth. Geothermal energy in New Zealand is reported as being the most cost-effective 'baseload' generation technology (MBIE, 2013e). Baseload electricity helps to ensure that there is a24-hour electricity supply (as opposed to just meeting peak demand).

Over 38,564 GWh of electricity was consumed in New Zealand in 2012 (MBIE, 2013f).

[17] Flash steam plants are suited to the higher temperature geothermal fields found in TVZ which have subsurface temperatures exceeding 200°C. A flash steam plant uses hot pressurised water/steam which is separated into steam and liquid once it reaches the surface. The steam is used to drive a turbine, and the hot fluid can be used to boil a secondary working fluid for a second turbine (GNS Factsheet 2: Converting geothermal heat into electricity).

[18] In binary systems the heat from the geothermal water is used in a heat exchanger to vaporise another liquid which has a lower boiling point than water (e.g. isobutene). This vaporised liquid in turn drives a turbine (GNS Factsheet 2: Converting geothermal heat into electricity). Binary cycle plants are suitable for lower temperature resources (New Zealand Geothermal Association, 2013a).

[19] As described in GNS Factsheet 2 Converting geothermal heat into electricity

As illustrated in Figure 7, the residential sector accounted for 33% of the total electricity use.

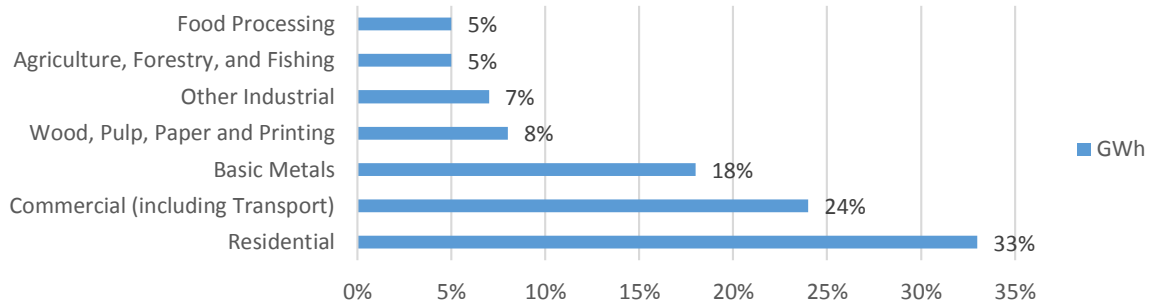

Figure 7. Total electricity use by Sector in 2012 (Ministry of Business, Innovation and Employment, 2012)

4.2 Renewable energy

The New Zealand Energy Strategy 2011 has set a target of 90% electricity to be generated from renewable sources by 2025. In December 2013, 75% of electricity generation in New Zealand came from renewable sources. The installed capacity of geothermal generation in New Zealand in December 2013 was 854 MW[20].

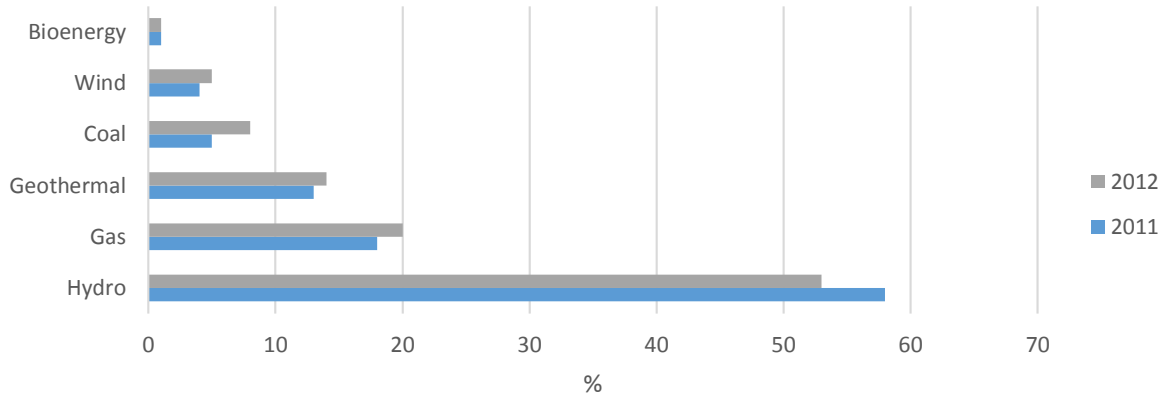

Figure 8 Electricity Generation by Fuel Type for 2011 and 2012

Electricity generation in the Bay of Plenty is predominantly from hydro or geothermal sources, and is priced in the lowest third of industrial electricity prices in the OECD (Bay of Connections, 2011c).

Geothermal electricity generation plants produce lower CO_2 emissions than gas or coal plants. This provides a competitive advantage, particularly for new geothermal developments, in terms of a lower carbon footprint; lower EFTS taxes and higher economic performance when compared to gas, oil or coal generation facilities.

[20] http://www.nzgeothermal.org.nz/elec_geo.html

4.3 Geothermal generation in the Bay of Plenty region

In 2011, the approximate electricity demand for the Bay of Plenty Region was 6.9% or 2,967 GWH of electricity generated in New Zealand that year (MBIE, 2012). The geothermal generation electricity plants in Kawerau primarily supply electricity to the wood and paper manufacturing processing at the Kawerau industrial complex i.e. there are negligible line losses.

The Kawerau Geothermal Field, located directly east of Kawerau, was first developed for steam production in 1957 (Bloomer, 1998). It is the only geothermal field within the Bay of Plenty region that is currently used to produce electricity. However, generation development is being investigated in other geothermal systems e.g. Taheke, Tikitere and Rotoma.

The Kawerau Geothermal Field has a total installed capacity of 155.2MW with 1,019 GWh of energy produced per year. The field is categorised as a Development System[21] which means that it can be developed, subject to resource consents being obtained to allocate geothermal heat and fluid.

Resource consents allocating geothermal fluid from the Kawerau Geothermal System allow for the extraction of 175,000 tonnes per day (annual average). Of this take, 71,000 tonnes per day is directly for electricity use. Some of this allocation has not been committed to use yet, and the remainder is for use as industrial heat, which in some instances is used directly for electricity production and in others, electricity production is a cascade use.

Plant Name	Asset Owner(s)	Commissioning Date	Total Installed Capacity (MW)	Annual Energy Produced (GWh/year)	Cumulative Capacity (MWe)
Kawerau Binary (TG1)	Nova Energy	1989	2.4	8	169
Kawerau Binary (TG2)	Bay of Plenty Electricity	1993	3.5	26	287
Kawerau BP2	Norske Skog Tasman[22]	2004	10	43	397
KA24	Eastland Group	2008	8.3	65	569
Kawerau	Mighty River Power & partners	2008	106	877	561
TOPP1	Norske Skog	2013	25	*not available*	772
Total generation and capacity			180.2 MW	1,019 GWh/yr	2,755 MWe

Table 8 Geothermal Power Stations in the Bay of Plenty region 2013 (NZ Geothermal Association, 2013b & Teat, 2012b)

[21] Refer to Appendix 2

[22] Geothermal brine supplied by Ngāti Tuwharetoa Geothermal Assets

4.4 Value of Geothermal Electricity Generation to the Regional Economy

Quantifying the value of geothermal electricity generation to the regional economy involves looking at the amount of energy supplied as well as the associated wholesale energy price and applying specific value added multipliers.

4.4.1 Parameters Used

The following parameters were used (Table 9):

Parameter	Value
Energy supplied MWh ('000)	1,019
Price per MWh in 2012 ($)[23]	$75.65
Total Output ($m)[24]	$77.09
Direct Value Added ($m)	$21.58 million[25]

Table 9. Parameters for Multiplier Analysis - Geothermal Electricity Generation

4.4.2 Multipliers Explained

The **direct value added** is the direct contribution of geothermal electricity generation to the regional economy. This amount is smaller than total output as it excludes the goods and services required to produce the output.

As was the case for geothermal tourism, multipliers were then applied to the direct value added to determine the indirect and induced effects. The **indirect effects** are the impact on those businesses that provide support to the sector through the supply of goods and services. The **induced effects** are the flow-on effects from wages and salaries now available in the economy.

Multipliers estimate the contribution to the economy based on analysis of backwards linkages – the suppliers to a sector. The electricity sector is important too in its forward linkages – the role it plays in the output of other sectors. This analysis excludes the contribution of geothermal electricity generation to the rest of the economy (e.g. the impact of electricity supplied to the end user such as dairy farms, retail etc).

4.4.3 Multiplier Analysis – Value of Geothermal Electricity Generation

In 2012, geothermal electricity generation directly contributed an estimated $21.58 million to the regional economy (Figure 9). This increases to $62.81 million when including the indirect effects and $63.67 million when also taking into account the induced effects.

[23] Based on the average wholesale market price for WKM2201 for the year ending December 2012 (Source: Wholesale market reports – www.ea.govt.nz).

[24] Refer to Appendix 6 for the multiplier analysis calculations.

[25] Calculated by multiplying the total output by the value-added ratio

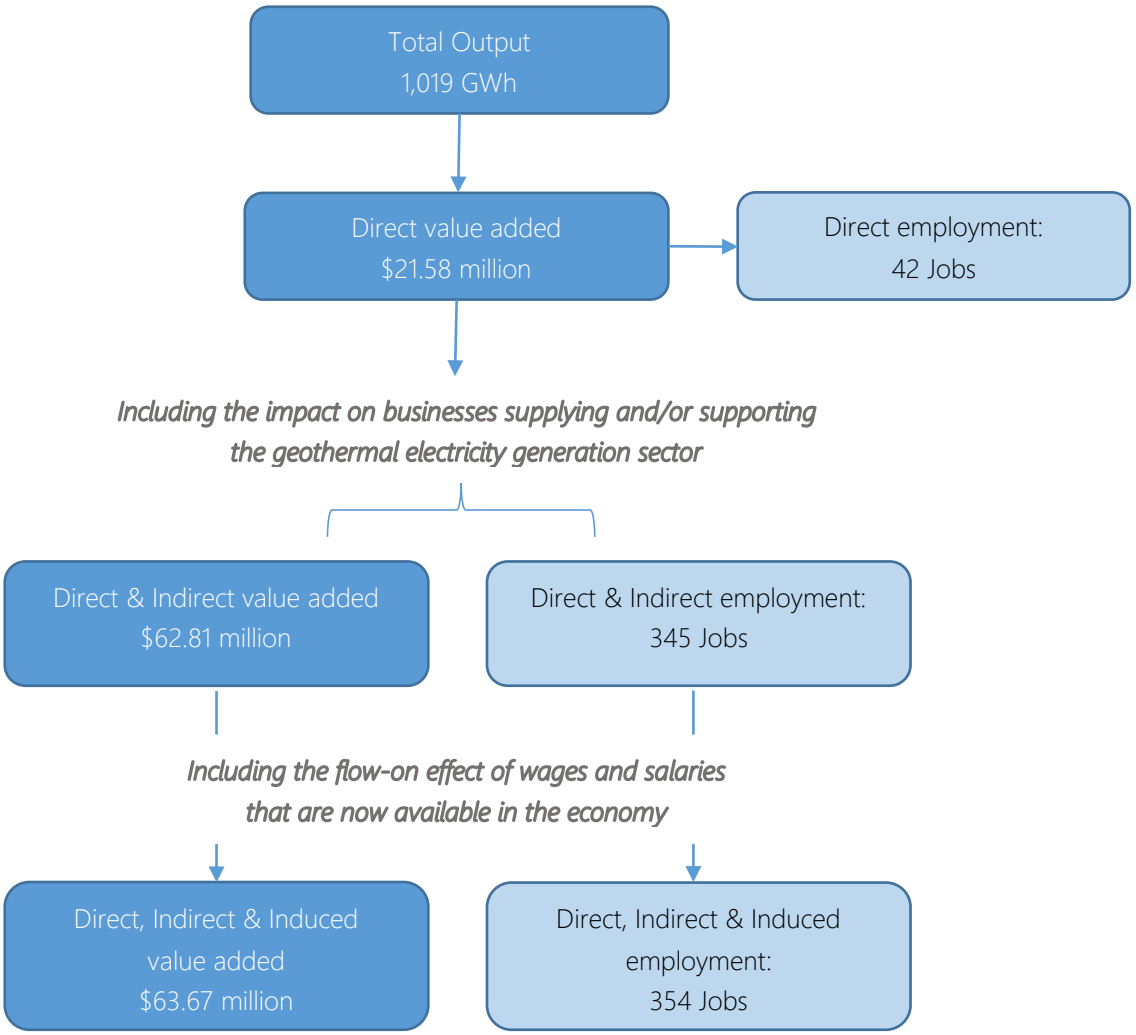

Figure 9. Result of Multiplier Analysis - Geothermal Electricity Generation

4.4.4 Multiplier Analysis - Employment

Based on a direct contact[26] and desktop analysis, it is estimated that 40 full time equivalent staff are employed in the geothermal electricity sector in the Bay of Plenty.

[26] In this case, direct contact involved an informal survey and contact via email and telephone.

Multiplier analysis has been used to estimate the employment associated with geothermal electricity generation in the Bay of Plenty. Direct employment is calculated using the total output[27] and the employment to output ratio. From here, multipliers were applied to determine the flow on employment effects for electricity generation. It is possible that this underestimates the employment contribution of running a geothermal plant. The multipliers used were based on the electricity industry sector in the Bay of Plenty, rather than specifically for geothermal. While the cost of operating and maintaining the plant is likely to be adequately reflected using this method, the cost of obtaining fuel includes all the reservoir management. This is likely to be higher than most other fuel sources.

Based on the multiplier analysis, geothermal electricity generation directly contributes 42 jobs to the region. This increases to 345 when including indirect employment and 354 when taking into account induced employment. The direct employment figures are consistent with those estimated from direct contact and desktop analysis.

4.5 The future of geothermal generation

Further investment in geothermal energy generation development is expected in order to support the proposed increase in renewables, of which geothermal will be a significant part. Improved access to geothermal resources in New Zealand would result in a limited increase to the wholesale electricity prices (MBIE, 2013e). National electricity demand is anticipated to grow by just over 1% per annum (MBIE, 2013f), while demand in the Bay of Plenty is expected to increase by 1.6% (Bay of Connections, 2011b).

There is uncertainty about national electricity consumption up until 2020, with some suggestions that consumption may remain flat up to 2016. In this scenario, large scale new investment may not take place until 2020. (MBIE, 2012b). However geothermal energy generation has continued to grow over the 2012/2013 year with a national 1% increase. Geothermal energy generation will be a significant factor in reaching the target of 90% renewable electricity generation by 2025 (MED, 2011). There is also a large commitment and push for wood processing industry growth in Kawerau which is reliant on the benefits associated with further geothermal generation.

[27] Refer to Appendix 6 for employment calculations

Several projects are planned to add further electricity generating capacity in the Bay of Plenty. These include:

- NTGA has resource consent to extract an additional 45,000 of geothermal brine per day. This increased steam supply could be used for electricity generation and/or direct heat purposes, offering significant development opportunity for either form of energy and associated downstream industrial users (Teat, 2012b).
- Taheke Power Station (35MW binary plant) is a joint venture between Taheke 8C and Contact Energy. Three exploration wells were drilled however recent flattening of power prices mean the joint venture is considering options before proceeding further.
- Te Ahi o Maui, a joint venture between Eastland Group, A8D Ahuwhenua Trust and Hawaiian owned Innovations Development Group (Teat, 2012b) obtained consents for 15,000 tonnes per day in March 2014. Plant development has not commenced.
- Tikitere (<45MW) is a joint venture between Tikitere Geothermal Power Limited[28] and Ormat Technologies. Consents have not yet been applied for.
- Rotomā may be developed.
- Te Ia o Tutea Development is a joint venture between Mighty River Power, Okere Incorporation and Ruahine Kuharua Incorporation. An initial exploration and feasibility study is underway.

As shown above, there are a number of joint ventures with Maori Trusts for new developments.

[28] Paehinahina Mourea Trust, the Manupirua Ahu Whenua Baths Trust and Tikitere Trust

5. Use III: Direct Use of Geothermal Energy

Snapshot of Large-Scale Direct Use in the Bay of Plenty (Industrial Process Heat):

86% of NZ's Direct Use for Industrial Process Heat occurs in Kawerau	$282.3 million Value added from Wood, Paper and Pulp Production*	3,271 Jobs Employment in BOP*

** Direct, indirect and induced value & employment*

5.1 Direct Use in New Zealand

Direct use is the use of geothermal resources - mainly heat - other than for electricity generation purposes. Examples of direct use include domestic heating, steam for industrial processes (e.g. Kawerau wood processing), water heating for aquaculture and space heating for horticulture.

In 2011, direct use of geothermal energy in New Zealand was around 9.3 PJ (MBIE, 2012a). As shown in Figure 10, direct use of geothermal energy has risen by 32% over the last 20 years. The 5% decrease in direct use between 2009 and 2011 reflects the closure of some wood processing plants.

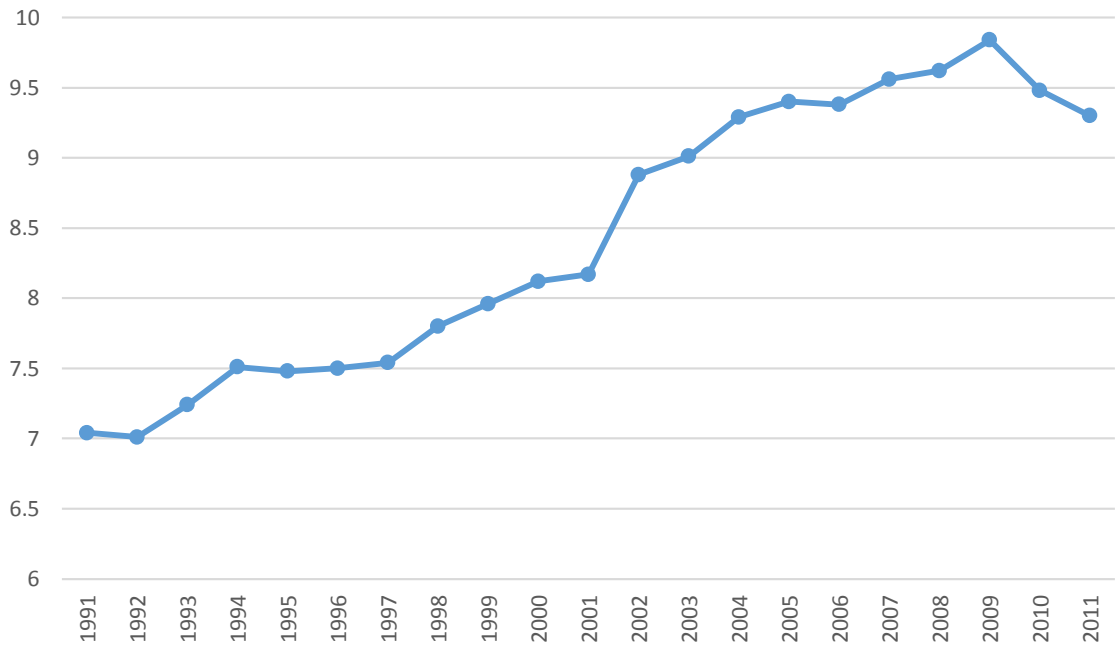

Figure 10. Direct use of geothermal energy (PJ) in New Zealand from 1991 to 2011 (MBIE, 2012a)

Industrial direct use within New Zealand presently accounts for about 65% of all New Zealand's direct geothermal heat use (Figure 11) (MBIE, 2012). Low grade geothermal heat sources, in particular, can be used for domestic and commercial purposes with the improvements in availability and efficiency of downhole heat exchanger and geothermal heat pump technology (Thain, *et. al* 2006).

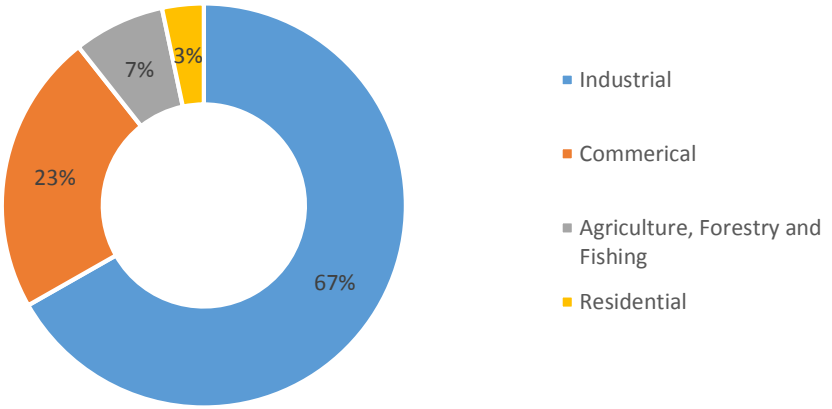

Figure 11. Geothermal Direct Use (PJ) by Section in 2011 (MBIE, 2012)

There is a significant range in efficiency of heat conversion, depending on the type of use (White, 2009). As shown in Figure 12, this ranges for direct use applications. For example, greenhouse heating utilises over 49% of supply, while fish and animal farming only utilises 18% of supply.

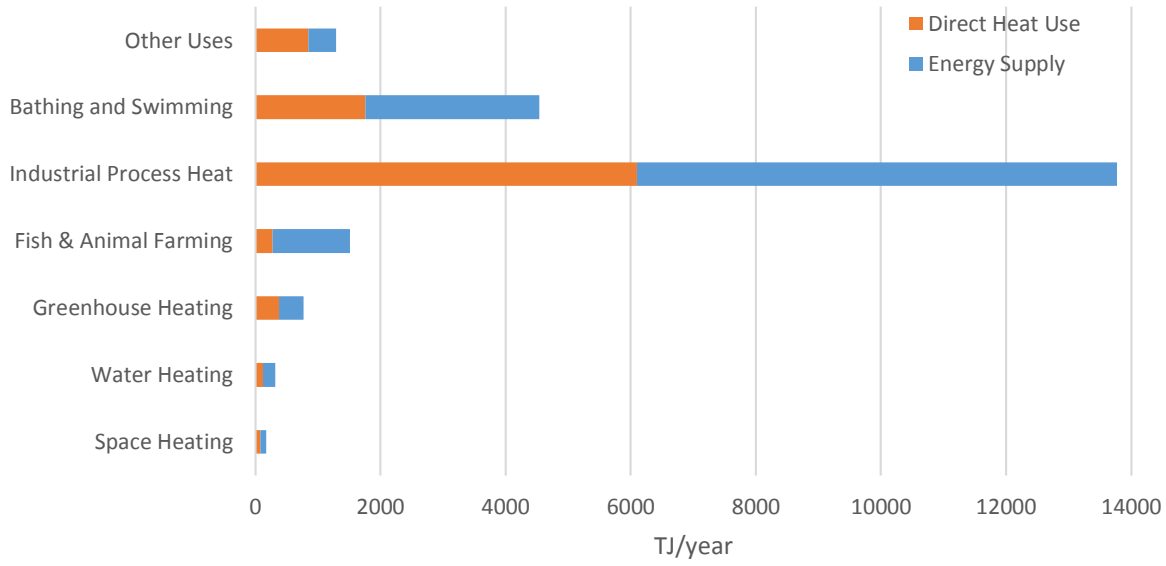

Figure 12. Comparison between Energy Supply and Direct Use in New Zealand (White, 2009)

5.2 Direct use in the Bay of Plenty region

Within the Bay of Plenty, there are a wide range of direct uses of geothermal energy. Geothermal resources are used predominantly for industrial process heat (85%) followed by water heating for bathing and swimming facilities (13%) (Figure 13).

Some direct uses may fit into more than one category below. For example, horticultural use may involve geothermal energy for space heating (greenhouse), water heating (hydroponics) and/or for irrigation (frost protection). Likewise, for public pools, where geothermal energy is used for both space heating and water heating.

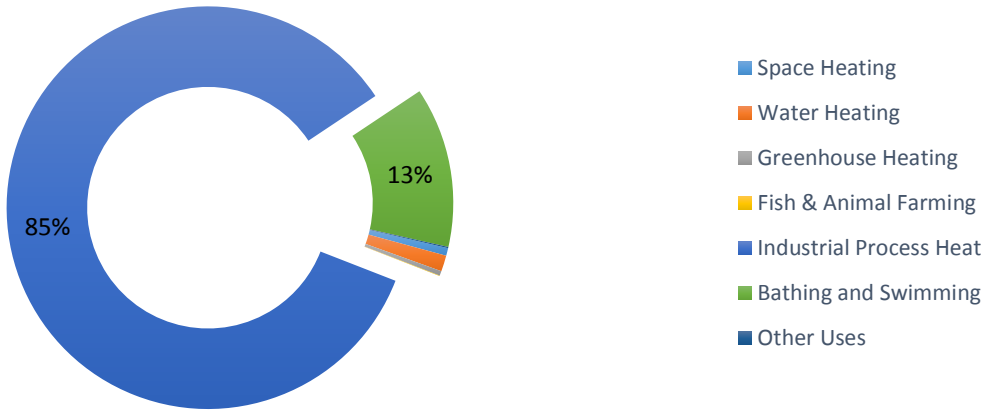

Figure 13. Direct Heat Use in the Bay of Plenty by Use (White, 2009)

The Kawerau direct heat supply is one of the largest geothermal direct heat applications in the world (White, 2009).

5.2.1 Large Scale Direct Use – Wood and Paper Processing in Kawerau

Kawerau uses process steam and heat from the Kawerau geothermal field for large scale pulp and wood fibre processing. There are four major wood processing facilities in the Kawerau area that utilise geothermal energy:

- CHH Tasman (Unbleached and bleached kraft pulp)
- Norske Skog Tasman (newsprint and magazines)
- SCA Hygiene Australasia (paper towels, hygiene products and tissue)
- CHH Woodproducts New Zealand (sawmill).

Direct use at Kawerau for industrial process heat has been assessed as 5,224TJ/year (White, 2009). The Kawerau Industrial processes have examples of cascade use where direct use applications use waste heat from the preceding plant to act as fuel for binary system power generation.

There are also benefits of clustering. In the WoodScape model report, Hall (2013) presented a case for the significant benefits in investment returns of situating wood processing in Kawerau compared to other sites around New Zealand. One of the contributing benefits is the access to geothermal energy which is lower cost than carbon based alternatives.

5.2.2 Horticulture & Aquaculture

Geothermal resources are used by 16 growers to produce kiwifruit, avocados, lettuce, herbs, tomatoes and flowers (e.g. orchids and gypsophlia). For kiwifruit and avocado orchards, low temperature geothermal water is used for summer irrigation and/or frost protection. The remaining growers utilise geothermal resources to heat glasshouses (space heating) and/or soil media and/or provide warm water for hydroponic operations.

In recent years, geothermal resources were used to cultivate tropical fish and aquatic plants, however, this fish farm at Ohauiti, is no longer in operation.

Horticultural operators were surveyed in October 2013 to find out the number of staff employed and how useful geothermal resources are to their organisation. The online and mail out survey covered the period of 1 April 2012 to 31 March 2013. The survey response rate was 41%. The remainder of data was estimated based on information from resource consents and extrapolation of data based on other similar sized sites.

Number of Staff (FTE)	Number of Staff Total)	Importance of geothermal resource
47.5	56	Essential (57% or 4 out of 7 respondents) Useful (43% or 3 out of 7 respondents)

Table 10. Survey Results - Horticultural Operators

The majority of sites were small horticultural operations that employed 2-3 staff. The larger operations (5-17 staff), were flower, lettuce and tomato growers that required a higher staff input. These figures, however, exclude the use of contractors which occurs throughout the year. For example, kiwifruit orchards utilise a large number of contractors for pruning, thinning and harvesting.

There was a mixed response in terms of importance of geothermal resources to the horticultural operations. 57% of growers found geothermal resources essential to their operations, while the remaining 43% found it useful.

5.2.3 Public Pools

This category comprises geothermally heated pools that are open to the public (e.g. municipal pools). They are all freshwater pools that are heated by geothermal energy. For example, the Rotorua Aquatic Centre uses geothermal energy to heat freshwater for two indoor and one outdoor swimming pool. Geothermal energy is also used for space heating and domestic hot water heating (Thain, *et. al*, 2006).

This category excludes those pools already mentioned in section 3.2.2 (Pay Bathing).

The seven public pools are:

- BayWave, Mount Maunganui
- Dave Hume Pools, Katikati
- Greerton Aquatic Centre, Tauranga
- Maurie Kjar Memorial Swimming Pool Complex, Kawerau
- Memorial Pools, Tauranga
- Otumoetai Swimming Pool, Tauranga
- Rotorua Aquatic Centre, Rotorua

Pool operators were surveyed in October 2013 to find out the number of pool users and staff, and how useful geothermal resources are to their organisation. The online and email survey covered the period of 1 April 2012 to 31 March 2013 (Table 11). The survey response rate was 100%.

Total estimated number of pool users	Number of Staff (FTE / Total)	Importance of geothermal resource
806, 609	69 / 131	Essential (100%)

Table 11. Survey Results - Public Pools (1 April 2012 to 31 March 2013)

5.2.4 Domestic & Commercial Use

There are over 170 resource consent holders within the region who take geothermal resources for domestic or commercial purposes. This excludes those associated with tourism, which were mentioned in Section 3.2 of this report. The geothermal resource is used for space heating, domestic water heating and swimming pool/spa water heating. The geothermal water is used either directly or via the use of heat exchangers.

One of largest and oldest commercial users is the Rotorua Hospital. The geothermal heating system, commissioned in 1977, fulfils all the heat requirements of twelve buildings (29,000m^2) as well as water heating (Steins and Zarrouk, 2012).

Bendall and Lind (2012) describe the various ways to access geothermal energy for domestic use: direct take, downhole heat exchanger, geothermal heat pump, multi-use systems or hybrid systems. Doody and Becker (2011) found that consumer awareness was a barrier to the increased use of geothermal resources for domestic purposes, particularly outside of Rotorua. Nevertheless, geothermal heat pumps are gaining popularity within New Zealand. Thain, *et. al* (2006) state that geothermal heat pumps consume less electricity, have a stable energy source, simpler design, low environmental impact and lower operating costs. However, one of the biggest barriers is the initial cost, which is twice that of a natural gas fired system. Bendall and Lind (2012) note the benefit of multi-user geothermal heating systems which spreads the cost of installation across multiple households.

5.3 Value of Direct Use for Large-Scale Direct Use to the Regional Economy

Quantifying the value of large-scale geothermal direct use on the regional economy involves looking at manufacturing output and applying specific value added multipliers. For the purpose of this report, multipliers were calculated for Paper and Wood Processing, given the significant level of direct use within the Bay of Plenty within these sectors.

5.3.1 Multipliers explained

The **direct value added** is the direct contribution of wood and paper manufacturing to the regional economy. This amount is smaller than total output as it excludes the goods and services required to produce the output in the first place.

Multipliers were then applied to the direct value added to determine the flow on effects. The **indirect effects** are the impact from wood and paper manufacturing on those businesses that provide support to the sector through the supply of goods and services. The **induced effects** are the flow-on effects from wages and salaries now available in the economy.

5.3.2 Multiplier Analysis – Value of large-scale Direct Use of Geothermal Energy

Parameter	Wood and Wood Products	Paper and Paper Products	Total
Amount of product supplied[29]	350,000 m^3	660,000 tonnes	-
Total Output ($m)	$25.93 million[30]	$328 million[31]	$353.93 million
Direct Value Added ($m)[32]	$9.1 million	$85.3 million	$94.4 million

Table 12. Parameters for Multiplier Analysis - Direct Use for Paper and Wood Processing

As shown in Table 12 and Figure 14, wood and paper manufacturing directly contributed an estimated $94 million to the regional economy in 2012. This increases to $277 million when including the indirect effects and $282.3 million when also taking into account the induced effects.

[29] Teat (2012c) and direct confirmation from one processor

[30] Total production multiplied by MPI Indicative Log Prices 2012 (averaged for the year across export (40%) and domestic (60%) grades

[31] Based on direct confirmation from one processor. Remaining output calculated based on production multiplied by the price of pulp, using MPI Indicative Log Prices 2012 (average for the year)

[32] Total output multiplied by the Output to value added ratio.

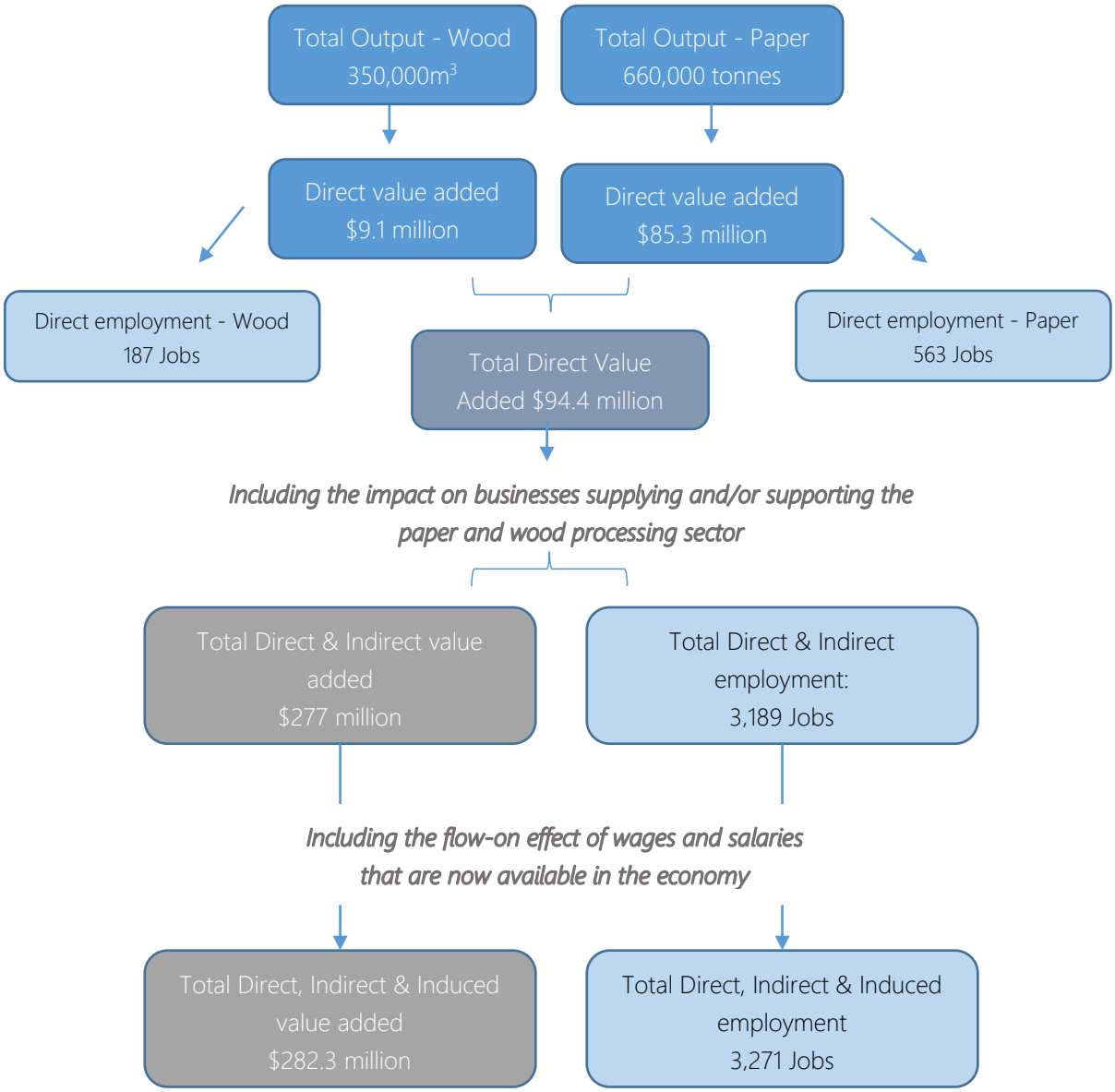

Figure 14. Result of Multiplier Analysis – Direct Use for Paper and Wood Processing

5.3.3 Multiplier Analysis - Employment

In this case, the multiplier analysis was not used to determine the number of jobs directly attributed to this sector. This is because more accurate information was obtained through the most recent census. According to Statistics New Zealand (2013b), there were 750 employees directly employed in the Wood Manufacturing Industry (which includes pulp and paper).

The multiplier analysis was used to estimate the amount of indirect and induced employment associated with wood and paper manufacturing in the Bay of Plenty. This was calculated by applying the multipliers supplied by Market Economics Limited to the known direct employment figure from Census 2013.

Based on this calculation, large-scale direct use of geothermal resources directly contributes 750 jobs to the Bay of Plenty region. It is estimated that 75% are employed in the Pulp and Paper sector, while the remaining 25% are employed in the Wood processing sector. Although not a big employer within the region, large-scale direct use of geothermal resources has a significant impact on jobs created to support or supply to the industry, such as engineering and construction.

Based on the multiplier analysis, paper and wood manufacturing indirectly contributes 3,189 jobs, which increases to 3,271 jobs when taking into account induced employment.

5.4 The future of geothermal direct use

According to the Bay of Plenty Energy Strategy (Bay of Connections, 2011), the region could attract more than $4 billion in sustainable energy-related developments over the next 15-50 years. This includes:

- Extensive geothermal direct heat supply to industry;
- Significant growth in energy-intensive processing industries
- Warm and healthy low energy homes and commercial buildings based on solar space and water heating initiatives or on geothermal heat pumps

5.4.1 Industrial Process Heat – Paper and Wood Processing in Kawerau

Anticipated changes to geothermal direct use for industrial process heat include the following:

- Potential of using full available log volume from Central North Island Forests. Hall (2013) states that this would add a further $282 million per year to the GDP and employment would increase by 344 direct jobs and 670 indirect jobs by 2015.
- Increased clustering of geothermal industry in the Bay of Plenty. The Bay of Plenty Regional Economic Growth Strategy (Bay of Connections, 2011) seeks to encourage the establishment of downstream geothermal business clusters. The Bay of Plenty Energy Strategy (Bay of Connections, 2011) also specifically seeks a "*regional focus on the development of timber drying using geothermal heat, taking advantage of the co-location of geothermal energy and forestry resources*".
- Greater opportunities for direct usage as well as cascade use. The Bay of Plenty Energy Strategy (Bay of Connections, 2011) seeks the "development of direct-heating and cascade heating applications, promoting this as a regional opportunity.

5.4.2 Horticulture / Aquaculture

It is anticipated that there will be opportunities for more direct usage and some cascade use of geothermal energy for food production e.g. horticulture, aquaculture. The Bay of Plenty Energy Strategy (Bay of Connections, 2011) specifically seeks a "*regional focus on the development of food production initiatives using geothermal heat*". The Bay of Plenty Aquaculture Strategy (Bay of Connections, 2011) identifies the use of geothermal energy sources as an opportunity for land-based aquaculture.

5.4.3 Domestic and Commercial Heating

The Bay of Plenty Energy Strategy (Bay of Connections, 2011) states that "*home owners' demand for insulation, alternative energy sources (e.g. solar and ground source geothermal) and good building designs to save energy costs is growing*". This will increase the uptake of direct use energy for heating, particularly for large commercial developments or large high heating-load homes (White, 2009). Drivers include increased efficiency of heat withdrawal or distribution as well as making better use of the resource for its community-wide benefits.

As mentioned earlier, there are significant benefits to multi-user geothermal heating systems particularly in terms of shared development costs (Bendall and Lind, 2012). This is acknowledged in the Bay of Plenty Energy Strategy (Bay of Connections, 2011) which seeks to "*encourage residential clusters for geothermal use*". The Ministry of Economic Development (2010) also suggests a strategy to increase public awareness around geothermal direct use and identifies a role for industry to address issues around the availability of trained installers.

The Rotorua Economic Growth Strategy (Rotorua District Council, 2011) supports the investigation of sustainable municipal heating and household geothermal bathing opportunities. However, this must be balanced with "*minimising possible risks to tourism industry and competition for use of resource*". This Strategy acknowledges that there is a challenge in managing competing uses and values associated with geothermal resources.

6. Use IV: Geothermal ecosystems

There is significant biodiversity associated with geothermal features, especially due to the unique habitats created by high temperatures and chemistry variations of soil and water that exist in these geothermal areas.

The intrinsic values associated with geothermal ecosystems have not been quantified in this study as monetising these values is very difficult and imprecise. Instead a narrative on the values has been used.

6.1 Biodiversity

Approximately 313ha of geothermal vegetation has been mapped in the Bay of Plenty region. Of this 97.2% of geothermal vegetation was ranked as Nationally Significant (Fitzgerald & Smale, 2010).

Habitat	Flora and Fauna
Heated ground	Threatened and rare plants include the declining native ladder fern, (the taxonomically indeterminate and declining *Christella aff.dentata* ('thermal') and the naturally uncommon *Dicranopteris linearis*, *Fimbristylis velata*, giant hypolepis (Hypolepis dicksonioides), prostrate kanuka and red-bearded orchid.
Fumaroles	Threatened plants include the nationally vulnerable *Machaerina complanata*, the declining native ladder fern (*Nephrolepis flexuosa*), the taxonomically indeterminate and declining *Christella aff. dentata* ('thermal') and the naturally uncommon Fimbristylis velata, giant hypolepis (*Hypolepis dicksonioides*), and *Dicranopteris linearis*. Fumaroles harbour two species of macroinvertebrates confined to high-temperature, low-pH waters: *Ephydrella thermarumand* an endemic mosquito (*Culex rotoruae*).
Geothermal stream sides and wetlands	Threatened plants include the nationally vulnerable Machaerina complanata, the declining Cyclosorus interruptus and native ladder fern (Nephrolepis flexuosa), and the naturally uncommon giant hypolepis (Hypolepis dicksonioides). Indeterminate species include the declining Christella aff. dentata ('thermal'). These systems contain two species of macroinvertebrates confined to high-temperature, low-pH waters: the ephydrid fly *Ephydrella thermarum* and an endemic mosquito (*Culex rotoruae*).
Cooled hydrothermally altered soils	Threatened and rare plants include the nationally critical flying duck orchid (*Sullivania minor*), the declining native ladder fern (*Nephrolepis flexuosa*) and the naturally uncommon red-bearded orchid (*Calochilus robertsonii*), *Fimbristylis velata,Dicranopteris linearis* and prostrate kanuka (Kunzea ericoides var. microflora).
Sites with atmospheric influences from geothermal resources (eg. Acid rain, toxic gas, warm microclimates)	An example is the very few Pohutukawa and small algal flora, and invertebrates in soil and litter which are able to survive on White Island.

Table 13. Flora and Fauna in Geothermal habitats (taken directly from the Landcare Research Website[33])

[33] http://www.landcareresearch.co.nz/publications/factsheets/rare-ecosystems/geothermal

Geothermal vegetation has been reduced to about 50% and 35% of its pre-European extent in Rotorua and Otanewainuku ecological districts respectively (Beadle, MacKinnon and Shaw, 1996). This is from the combination of clearing, burning, domestic and industrial use of geothermal fields. Some of the identified threats to geothermal vegetation in the Bay of Plenty region include: effects of extractive use on microclimate, tourism, invasive weeds, livestock, fire and wetland infilling and drainage.

6.2 Water Quality

Aluminium load from geothermal sources in Lake Rotorua may have in historic times protected the lake from the potential adverse effects of the naturally high phosphorous (McIntosh, 2012).

Geothermal fluids can contain high levels of heavy metals which can have an adverse impact on water quality. High concentrations of metals and metalloids, such as arsenic, boron, chromium, copper and mercury were found in the receiving waters of the Tikitere Geothermal Field (Stephens and Clearwater, 2006).

High concentrations of ammonia in geothermal waters converting to nitrate create adverse nutrient loading effects on the Rotorua lakes. For example the Waiohewa Stream contributes 30 tonnes of nitrogen annually to Lake Rotorua. A de-nitrification plant in Tikitere has been set-up to remove the nitrogen before it enters the lake[34].

6.3 Biotechnology resource

There are many novel bacteria in geothermal soils in the Taupo Volcanic Zone and it provides rich potential source for previously uncultured species (Stott, *et al.*, 2008). The value associated with this includes biotechnology discovery and understanding the metabolic and taxonomic biodiversity in nature. Enzymes can be found in high temperature geothermal water. These extremophiles provide a source for study for potential use in industrial applications (e.g. enzymes used in biofuel production)[35].

6.4 Value to the region and future management

Commercial opportunities exist in mineral extraction and the value of biotechnology potential from bacteria/enzymes in these unique ecosystems. In the Kawerau production wells, silica is the predominant mineral in the geothermal fluids. It provides an addition use and source of revenue from geothermal brine. It is estimated that up to 13,000 tonnes per year of silica could be extracted from the wells in Kawerau (Teat, 2012e).

[34] http://www.rotorualakes.co.nz/Geothermal_nutrient_removal

[35] http://newscenter.berkeley.edu/2011/07/05/hot-springs-microbe-yields-record-breaking-heat-tolerant-enzyme/, https://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&ved=0CDEQFjAB&url=http%3A%2F%2Fwww.gns.cri.nz%2Fcontent%2Fdownload%2F4323%2F23823%2Ffile%2FExtremophiles%2520biodiscovery.pdf&ei=A32eUpPeG4bkkgXk1IGYCA&usg=AFQjCNHKfVLgiiKRTRdpbjQGGH49Ipf9HA&sig2=IHMc6IVU0ZdQ0EiDyGaCcQ&bvm=bv.57155469,d.dGI

7. Use V: Geothermal and Cultural Use

Geothermal resources are regarded as a taonga among Maori communities in the Bay of Plenty. Traditional[36] use of geothermal resources has included:

- Warm pools (waiariki) for bathing, relaxation and treating ailments such as rheumatism
- Boiling springs (ngawha) for cooking and to prepare flax for weaving
- Hot ground for cooking and heating
- Mud, from some pools, for medicinal purposes
- Minerals, such as kokowai (red ochre) for paint and dye

The intrinsic values associated with Maori cultural use have not been quantified, particularly since many of the metaphysical values cannot be quantified.

Geothermal resources, particularly in areas such as Whakarewarewa, Ngapuna, Rotokawa and Ohinemutu are a way of life, a part of Maori culture and source of tribal identity.

The Maori world view acknowledges the tangible and intangible aspects of the environment. Therefore, geothermal resources are not only valued for their practical use, but also for their intrinsic and spiritual values. The story of Kuirau Park is one such example:

> *"In early Maori times the small lake in the park was much cooler and was known as Taokahu. Legend tells us that a beautiful young woman named Kuiarau was bathing in the waters when a taniwha (legendary creature) dragged her to his lair below the lake. The gods above were angered and made the lake boil so the Taniwha would be destroyed forever. From that time on, the bubbling lake and the steaming land around it have been known by the name of the lost woman, although the spelling has changed a little".*[37]

Geothermal resources are considered a legacy or gift from the tohunga Ngatoroirangi. The legend of Ngatoroirangi describes how geothermal energy was transported to New Zealand:

> *"Ngātoroirangi climbed Tongariro. Freezing, he called to his sisters*[38] *in Hawaiki for help, 'Kua riro ahau i te hau tonga' (I am seized by the cold from the south) – hence the name Tongariro.*
>
> *Assisted by the fire gods*[39]*, the sisters sent fire that burst out at Whakaari (White Island), Moutohorā (Whale Island), the Rotorua lakes, Mt Tarawera, the Paeroa Range, Ōrākei Kōrako, Tokaanu, and finally at Tongariro, saving their brother".*[40]

[36] Pre-European
[37] http://www.newzealand.com/int/feature/kuirau-park/
[38] *Kuiwai and Haungaroa (Stokes, 2000)*
[39] *Te Pupu and Te Hoata (Stokes, 2000)*
[40] http://www.teara.govt.nz/en/nga-waewae-tapu-maori-exploration/page-5

It is evident that the relationship of Maori communities in the Bay of Plenty with Ngatoroirangi's fire is cultural, social, spiritual and as of recent decades, economic.

Geothermal resources are a major tourism attraction with the Bay of Plenty and a means of employment with specific roles within Maori communities (e.g. tour guide, cultural performer). Whakarewarewa Village is an example of an existing thermal village and tourist attraction.

A number of Maori Trusts are also entering a variety of commercial arrangements for new geothermal energy generation projects e.g. the joint venture Te Ahi o Maui Power Station (Kawerau A8D Ahuwhenua Trust, Eastland Group and Innovations Development Group).

8. Management of Geothermal Resources in the Bay of Plenty

Geothermal resources are managed, under the Resource Management Act by the Bay of Plenty Regional Council. Natural hazards, associated with these resources, are jointly managed by the Region, District and City Councils. The issues of regional significance[41] associated with geothermal resources are:

- Adverse effects on the intrinsic values of geothermal systems[42]
- Allocation of geothermal heat and water[43]
- Lack of information
- Need for integrated management

Appendix 2 summarises which Geothermal Management Groups must be protected and which ones can be used at some level for extractive use.

[41] From Proposed Bay of Plenty Regional Policy Statement (Operative Geothermal Resources provisions, 1 October 2013).

[42] "*The intrinsic values of geothermal systems, their natural features, ecologies and cultural value are vulnerable to the effects of surrounding land use, groundwater use and use of water from the geothermal system*"

[43] "*Using the regional geothermal resource for energy development and protecting its other values is a difficult balance. Management of values that have been detrimentally affected is also required*"

9. Discussion

The use of geothermal resources within the Bay of Plenty for tourism, electricity generation, wood/paper manufacturing and other direct uses contribute significantly to the region's economic, social, cultural and environment wellbeing.

The following table summarises the contribution of geothermal tourism, electricity generation and large-scale direct use to the regional economy and employment.

	Value ($ million)			Employment (jobs)		
	Direct value added	Direct and indirect value added	Direct, indirect and induced value added	Direct employment	Direct and indirect employment	Direct, indirect and induced employment
Geothermal Tourism	$86.94	$133.02	$136.49	1,977	2,532	4,502
Geothermal Energy Generation	$21.58	$62.81	$63.67	42	345	354
Direct Use for Paper and Wood Processing	$94.4	$277	$282.3	750	3,189	3,271
Total	**$209.92 m**	**$492.83 m**	**$482.46 m**	**2,769 Jobs**	**6,066 Jobs**	**8,127 Jobs**

Table 14 Multiplier Analysis Summary

9.1 Sector Comparison

The total estimated value of geothermal resources to the regional economy in 2013[44] was **$482.5 million**. This equates to almost 5% of the region's GDP[45]. Geothermal resources also contributed an estimated **8,127 jobs** to the region.

Large-scale direct use of geothermal energy contributed the greatest direct value to the regional economy with $94.4 million, followed by geothermal tourism with $86.94 million. The direct contribution from geothermal electricity generation was lower, however the contribution, including indirect and induced effects, tripled the overall contribution of the sector to the regional economy. Both geothermal electricity generation and large-scale direct use have a greater impact on those businesses that support or supply to each sector, e.g. engineering or construction companies. Large-scale direct use (wood and paper processing) contributed the greatest overall value to the regional economy with $282.3 million.

[44] Including indirect and induced effects
[45] The GDP for the Bay of Plenty for the year ending 2010 was $9,859 million (Toi E.D.A.)

Geothermal tourism contributed the most direct employment to the region (by job numbers). This is because tourism is a labour intensive industry [with a high proportion of part-time employment] as well as having working proprietors. Although not a big employer within the region, large-scale direct use of geothermal resources has a significant impact on jobs created to support or supply to this sector.

Values not been quantified for this report include the intrinsic values associated with geothermal ecosystems and Maori cultural use. Likewise, for the future value of geothermal resources include for silica extraction and biotechnology.

9.2 Future Changes to Geothermal Resource Demand or Use

This report also looks into future anticipated changes to these sectors, which is summarised in Figure 15.

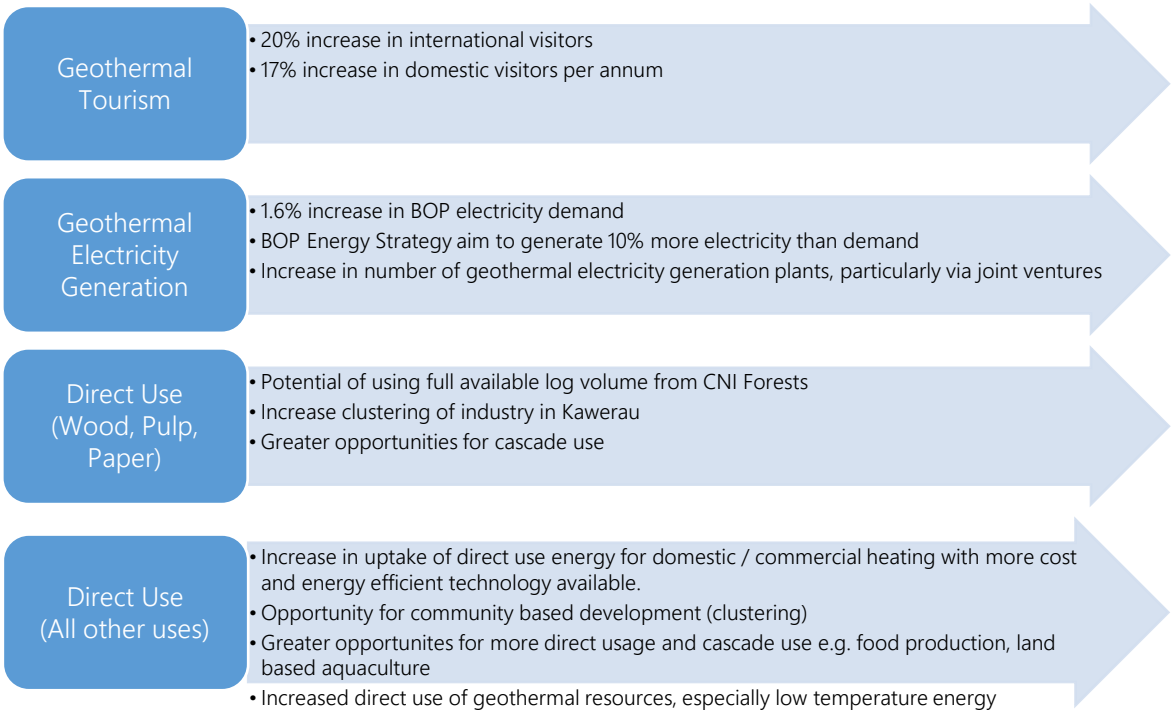

Figure 15. Anticipated changes across all Geothermal Sectors in the Bay of Plenty

Looking at the anticipated changes across all sectors, it is clear that there will be increased demands on the region's geothermal resources. This means that:

- Competing uses and values will need to be carefully managed.
- Councils will need to work together given the range of actions / objectives within the various district and regional economic development strategies. It will be essential for Councils to find a balance between:
    - enabling economic development; through the extractive and intrinsic use of the geothermal resource promoting the sustainable use of the geothermal resource
    - protecting the diverse values associated with the same resource.
- Collaboration will be essential, given the anticipated changes outlined in Figure 15. This would include local government; industrial and commercial sector (including energy companies); Iwi / Maori Trusts; research agencies and education institutions.

A recurring theme is the need to encourage clustering and some cascade use. Clustering or co-locating activities will reduce development costs. Cascade use can assist in using geothermal resources efficiently and optimally.

9.3 Recommendations

As the first study of its kind within the Bay of Plenty region, the following actions are recommended:

- That this study is repeated within the next five years to:
    - Refine the method of data collection, particularly in relation to geothermal tourism and direct use
    - Re-assess the assumptions and refine the multipliers to better reflect the geothermal sector
    - Gauge trends in the uses and associated economic value of geothermal resources
- That Council considers collaborating with other agencies in relation to this study to increase the quality of information collected and identify opportunities in the study outcomes.
- That further work is undertaken to refine the outputs and associated multiplier analysis for large-scale direct use (paper and wood processing).
- That further work is undertaken to attempt to quantify the value of geothermal ecosystem services (including mineral extraction) and Maori cultural use.

10. Conclusion

This report confirms that geothermal resources are of significant value to the regional economy. Collectively, Geothermal Tourism, Electricity Generation and Direct Use for Paper and Wood Processing **directly** contributed an estimated $202.92 million to the region's economy in 2012. Taking into account **indirect and induced** effects, this value increased to $482.46 million. The three sectors directly contributed around 2,769 jobs to the region, increasing to 8,127 jobs once the indirect and induced effects are included. Refining the sector-wide multipliers would increase the robustness of these estimates. The intrinsic values associated with geothermal ecosystem services and Maori cultural uses are significant to the region. These values have not been quantified for this report, however a qualitative assessment of cultural, biodiversity and recreational values would be a useful addition to this report.

Growth is anticipated within each sector of the geothermal economy, starting with an expected increase in geothermal visitors to the region. This will directly contribute an estimated additional $48 million to the regional economy. Electricity demand is anticipated to increase by 1.6% annually in the Bay of Plenty. There will also be the increase in generation capacity through further geothermal electricity generation developments. Direct use is likely to increase across all sub-sectors with improved technology and collective efforts by councils to encourage clustering or co-location of industries as well as some cascade use for food production. This will provide additional opportunities for land-based aquaculture and horticultural operations.

Increased demands on the geothermal resource will require a careful balance between enabling economic development; promoting the sustainable use of the geothermal resource and protecting the diverse values associated with this resource.

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Appendix 1 – Glossary and Definitions

Glossary – Economic Terms

Direct effects - The activity of the sector (e.g. electricity generation, tourism).
Employment count (EC) - Measures the number of employees in a sector. Working proprietors are not included (unless they pay themselves a wage or salary).
Employment multipliers - Determine the direct, indirect and induced effects of the output of one sector on employment in the economy
Gross regional product (GRP) or value-added - Is a measure of the flows of goods and services produced by an economy over a year. It excludes the value of intermediate goods and services as these are implicitly included in the price of final goods.
Indirect effects - The impact from one sector's output on other businesses (including those supplying goods and services to the sector).
Induced effects - The flow-on effects from wages and salaries now available in the economy.
Modified employment count (MEC) - Based on the EC and including estimates of the numbers of working proprietors for each industry type. Market Economics Limited has modified the EC to calculate the MEC.
Output - A measure of the total flow of goods and services within an economy. This includes intermediate demand, primary inputs and final demand. It is calculated by the quantity of goods supplied multiplied by the price of each unit.
Value-added - See GRP (above).
Value-added multipliers (Type I and Type II) - Used to determine the contribution of a sector to the economy (GDP; GRP). Type I are used to estimate the value of the direct and indirect effects; Type II are used to estimate the value of the direct, indirect and induced effects.

Glossary – Energy Terms

Gigawatt - One billion watts or 1000 megawatts.
Gigawatt hours (GW h) - A unit of energy (see MW h)
Kilowatt - One thousand watts
Megawatt (MW) - One million watts.
Megawatt hours (MW h) - A unit of energy. A 1MW generating plant run for one year (24hr x 365) would produce 8760 MW h, or 8.76 GW h.
Petajoules (PJ) - A unit of energy used for expressing the energy contents of fuels and other energy sources. 1 PJ = 1,000 TJ; 1 TJ = 0.278 GW h.[46]
Terajoule (TJ) - A measurement unit of energy that is often used to express the energy content of fuels. 1 TJ = 0.278 GW h.[47]

[46] http://www.stat.fi/meta/kas/petajoule_en.html
[47] http://www.stat.fi/meta/kas/tj_en.html

Definitions

Geothermal system: A system defined by scientific investigation comprising geothermal energy stored as geothermal water or steam and the rocks confining them and associated water, steam and gas emissions and the geothermal surface features resulting from these emissions and is believed to have no hydrological connection to another system. (Operative Geothermal Provisions of Proposed Bay of Plenty Regional Policy Statement)

Geothermal Ecosystem/Ecology: a dynamic life-supporting system made up of a group of living organisms (including plants and animals) that has adapted to, and is reliant on, geothermal resources. (Operative Bay of Plenty Regional Water and Land Plan)

Geothermal energy – Means energy derived or derivable from and produced within the earth by natural heat phenomena; and includes all geothermal water. (Resource Management Act)

Geothermal Surface Feature: includes structures formed by deposition from, or the release of, geothermal water (including steam and energy) from geothermal areas and any resulting earthforms, any geothermally activated geysers, fumaroles, sinter structures, tomos, mud pools, hot and cold water pools, springs, steam and gas vents, and also includes inactive structures formed by extinct or intermittent geothermal activity. (Operative Bay of Plenty Regional Water and Land Plan)

Geothermal Water: Means water heated within the earth by natural phenomena to a temperature of 30 degrees Celsius or more; and includes all steam, water, and water vapour, and every mixture of all or any of them that has been heated by natural phenomena. (Resource Management Act)

Any geothermally sourced water which is initially greater than 30º Celsius but falls below 30º Celsius as a result of an activity will continue to be considered as geothermal water under this regional plan.

Appendix 2 – Geothermal Management Groups

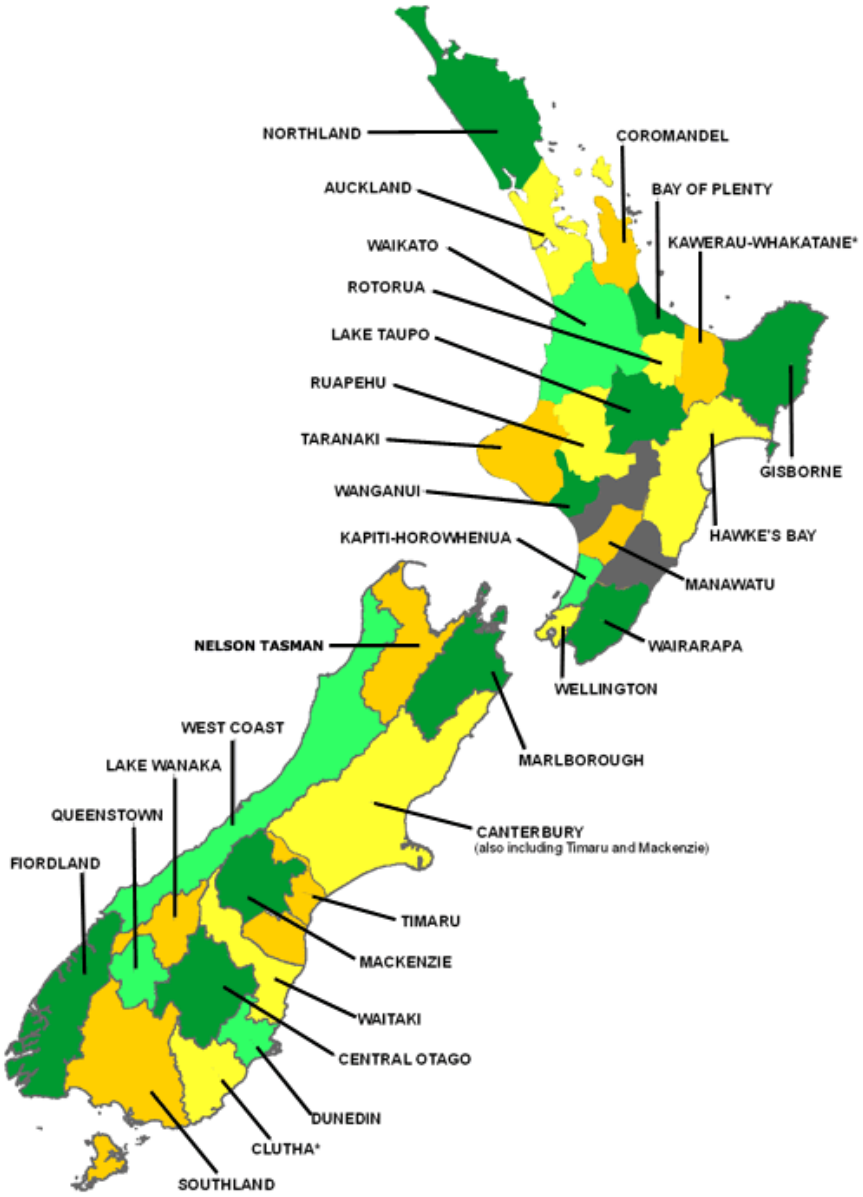
Geothermal management Group	Temp	Existing use	Presence of Significant geothermal features (SGFs)	Significant geothermal feature vulnerability to extractive use	Management purpose	Potential for extractive use	Geothermal systems
Protected systems Group 1	> 70°C	No existing extractive use	Numerous SGFs, some with outstanding characteristics	High to moderate	Surface feature values override extractive values. Protection of GFs, which have outstanding natural, intrinsic, scenic, cultural, heritage and ecological values.	No potential for extractive use.	Waimangu-Rotomahana Tarawera Whakaari (White Island) Moutohora (Whale Island)
Rotorua System Group 2	> 70°C	High levels of existing use. Extractive and non-extractive	Numerous SGFs, some with outstanding characteristics	High to moderate	Surface feature values that rely on pressure and temperature maintenance override extractive values. System management that limits extractive uses to avoid, remedy or mitigate adverse effects on the outstanding natural, intrinsic, scenic, cultural, heritage and ecological values.	Limited potential for further extractive use.	Rotorua
Conditional development systems group 3	> 70°C	Varying levels of existing extractive use	Some SGFs	Moderate	The values of SGFs have priority over extractive values. System management will provide for use and development, contingent upon the ability to avoid, remedy or mitigate significant adverse effects of development on the SGFs present in those systems.	Potential for development of extractive use (heat or fluid).	Tikitere-Ruahine Rotokawa-Mokoia Island Rotoma-Tikorangi Taheke
Development systems group 4	> 70°C	Varying levels of existing extractive use	Few or no SGFs	Moderate to low	System management that provides for extractive use, provided significant adverse effects on SGFs are remedied or mitigated.	Potential for development of extractive use (heat or fluid).	Kawerau Lake Rotoiti (outflow is in the bed of the lake) Rotoma-Puhi Puhi

Geothermal management Group	Temp	Existing use	Presence of Significant geothermal features (SGFs)	Significant geothermal feature vulnerability to extractive use	Management purpose	Potential for extractive use	Geothermal systems
Low-temperature systems group 5	>30°C <70°C	Varying levels of existing extractive use	Few or no SGFs	N/A	System management that provides for extractive use, where the adverse effects of the activity can be avoided, remedied or mitigated. Discharge of geothermal fluid must be managed to avoid significant adverse effects on surface water and stormwater.	Potential for development of extractive use (heat or fluid).	Mayor Island (Tuhua) Tauranga/Mount Maunganui (Mauao) Papamoa/Maketu Awakeri Pukehinau (Rangitaiki) Manohau (Galatea)
Research Systems Group 6	Unknown	No present use	Surface features not characterised.	Vulnerability not characterised	Enable research into the characteristics of the system necessary to support their reclassification. Allow takes and discharges for investigation purposes only (including those having temporary effect on geothermal features, if it can be demonstrated that they will not permanently threat SGFs or the natural characteristics of the system).	More information required before the system can be classified into groups 1-5.	

Source: Bay of Plenty Regional Policy Statement (Operative Geothermal Resources provisions)[48]

[48] http://www.boprc.govt.nz/knowledge-centre/policies/the-next-regional-policy-statement/

Appendix 3 – Regional Tourism Organisations (RTO) Area Location Map



Appendix 4 – Tourist Accommodation with Geothermal Bathing

18th Avenue Thermal Motel	Aaryn Court Motel
Alpin Motel	Ambassador Thermal Motel
Base Rotorua	Bel Aire Motel
Bennetts Motor Inn,	Boulevard Motel
Cameron Thermal Motel	Cleveland Motel Ltd
Cosy Cottage Thermal Holiday Park	Distinction Rotorua Limited
Executive on Fenton	Fernleaf Motel
Four Canoes Hostel,	Gateway International Motel
Gibson Court Motel	Golden Glow Geothermal Society
Havana Motor Lodge,	Heritage Rotorua,
Holiday Inn Rotorua	Hotel Armitage
Inner City Homestay	Kawerau Thermal Motel
Kiwi Motel	Kowhai and Colonial Motel
Kuirau Park Motor Lodge,	Malfroy Motor Lodge
Midway Motel	Millenium Hotel
Mokoia Motel	Monterey Motel
Moose Lodge & Golf Resort	Motor Lodge Motel
New Castle Motor Lodge	Novotel Lakeside Rotorua
Palm Court Motor Inn	Pineland Motor Lodge
Princes Gate Holdings Limited	Quality Resort Heritage Motor Inn
Red Rock Thermal Motel	Regent Flashpackers
Regent Hotel	Ridge Country Retreat
Rob Roy Motel	Rotorua Manhattan Motel
Rotorua Motel	Rotorua Thermal Holiday Park
Rydges Rotorua Hotel Limited	Sequoia Motel
Silver Birch Holiday Park & Motel	Spa Lodge Backpackers
Sudima Hotel Lake Rotorua	Terume Hot Springs Resort
Tresco Rotorua Bed and Breakfast	Union Victoria Motel
Utuhina Lodge Motel,	Victoria Lodge
Wylie Court Motor Lodge	Youth Hostels Association of NZ Inc

Appendix 5 – Tourism Statistics & Calculations

NZ tourism numbers 2012

	Number of trips to/within NZ	Estimated percentage who visited geothermal attractions in NZ
International Tourists[49]	2.6 million	28% (731,185)
Domestic Tourists[50]	48 million	2% (1,139,390)

The proportion of visitors visiting the Bay of Plenty are provided below.

Bay of Plenty tourism numbers 2012

Regional Tourism Organisation (RTO)	% of International Tourists visiting RTO's[51]	Number of International Tourists	% of Domestic Tourists visiting RTO's[52]	Number of Domestic Tourists
Bay of Plenty RTO	7%	182,000	5%	2,400,000
Rotorua RTO	22%	572,000	4%	1,920,000
Kawerau-Whakatane RTO	2%	52,000	1%	48,000
Total		**806,000**		**4,800,000**

Using the above visitor numbers, the proportion of visitors visiting geothermal attractions could be calculated. This is summarised below.

Bay of Plenty Geothermal tourism numbers 2012

Regional Tourism Organisation (RTO)	% of International Tourists visiting geothermal attractions	Number of International Tourists	% of Domestic Tourists visiting geothermal attractions	Number of Domestic Tourists
Rotorua RTO	75%	429,000	6%	115,200
All other RTO's	28%	65,520	2%	57,600
Total		**494,520**		**172,800**

[49] Source: Data tables for International Visitor Survey (MBIE, 2013a)
[50] Source: Data tables for Domestic Visitor Survey (MBIE, 2013b). Number of domestic trips is 47,642,515 - 31,083,087 day trips (65% of total) and 16,559,428 overnight trips (35% of total)
[51] Source: Data tables for International Visitor Survey (MBIE, 2013a)
[52] Source: Data tables for Domestic Visitor Survey (MBIE, 2013b)

The assumed proportion of visitors to geothermal attractions in the Bay of Plenty is calculated as follows:

- Rotorua - International Visitors: Rotorua District Council (2012) estimates that at least 75% of international visitors come to Rotorua to visit geothermal attractions.
- Rotorua - Domestic Visitors: Rotorua District Council (2012) estimates that 28% of domestic visitors come to Rotorua to visit geothermal attractions.
- For areas outside of the Rotorua RTO, the national estimate has been used: 28% of international visitors and 2% of domestic tourists visit geothermal attractions (MBIE, 2013a and MBIE, 2013b).

It is estimated that 35% of domestic tourists stay overnight while the remaining 65% undertake day trips (MBIE, 2013b). Domestic tourists stay on average 2.3 nights and international tourists stay on average 2.1 nights (SOE Rotorua, 2012 & Tourism forecast report 2013 – 2019, MBIE, 2013).

In the year ended December 2012, international tourists spent an average of $111 per day, with an average stay in New Zealand of 19.1 days (MBIE, NZ tourism sector outlook, 2013). In the same year, spending by domestic travellers averaged $118 per day trip, and $124 per overnight trip (Domestic travel survey, MBIE, 2012).

Tourism forecasts for 2016 estimate that 3.1 million international tourists will visit New Zealand, and for the same year, there will be 56.1 million domestic tourist visits. This is an anticipated increase of 20% and 17% respectively. Assuming the same patterns as in 2012[53], there will be 791,580 tourist visits to geothermal attractions in the Bay of Plenty. Of these, 589,620 (or 74%) will be international visitors. Of the domestic trips, 131,274 visits will be day trips and the remaining, overnight trips. This is an anticipated increase of 19% for international visitors and 17% for domestic trips visiting geothermal attractions in the Bay of Plenty (MBIE, 2013c).

[53] For example, percentage of tourists visiting the Bay of Plenty, percentage of tourists visiting geothermal attractions, as outlined in Appendix 5.

Geothermal tourism contribution to the Bay of Plenty economy

	Type of geo-thermal tourist	Geothermal tourists (000)	Avg. daily spend per person	Days in the BOP region	Gross Output ($m)	Value added multipliers		Output to value added ($m/$m)	Contribution to the regional economy ($m)		
						Type 1	Type 2		Direct value added	Direct and indirect	Direct, indirect, induced
2012	Domestic (day)	112.32	118	1	13.25	1.53	1.57	0.56	7.42	11.36	11.65
	Domestic (o/n)	60.48	124	2.1	15.75				8.82	13.49	13.85
	International	494.50	111	2.3	126.25				70.70	108.17	111.00
	Totals	667.30			155.25				86.94	133.02	136.49
2016	Domestic (day)	131.27	94	1	12.34	1.53	1.57	0.56	6.91	10.57	10.85
	Domestic (o/n)	70.686	115	2.1	17.07				9.56	14.63	15.01
	International	589.6	141	2.5	207.83				116.39	178.07	182.73
	Totals	791.56			237.24				132.86	203.27	208.59

Geothermal tourism contribution to BOP employment

	Type of tourist	Geothermal tourism output $m	Value added multipliers		Output to value added (MEC/$2007m)	Estimated contribution to regional employment (MEC)		
			Type 1	Type 2		Direct impacts	Direct and indirect	Direct, indirect, induced
2012	Domestic (day)	13.25	1.28	1.3	12.74	168.81	216.07	2150.58
	Domestic (o/n)	15.75				200.66	256.84	260.85
	International	126.25				1608.43	2058.78	2090.95
	Totals					1977.89	2531.69	4502.38
2016	Domestic (day)	12.34	1.28	1.3	12.74	157.21	201.23	204.38
	Domestic (o/n)	17.07				217.47	278.36	282.71
	International	207.83				2647.75	3389.13	3442.08
	Totals					3022.44	3868.72	3929.17

Appendix 6 – Geothermal Electricity Generation Calculations

Geothermal Electricity Generation contribution to the Bay of Plenty economy

Energy supplied MWh (000)[54]	Price per MWh 2011 ($)[55]	Gross Output ($m)[56]	Value Added Multipliers[57]		Output to value added ratio ($m/$m)[58]	Contribution to Bay of Plenty economy ($m)		
			Type 1	Type 2		Direct value added	Direct and indirect	Direct, indirect and induced
1,019	75.65	77.09	2.91	2.95	0.28	21.58	62.81	63.67

Geothermal Electricity Generation contribution to BOP employment

Geothermal generation output $m	Employment Multipliers Bay of Plenty region[59]		Output to value added ratio (MEC/$2007m)[60]	Estimated contribution to regional employment (MEC)		
	Type 1	Type 2		Direct impacts	Direct and indirect	Direct, indirect and induced
77.09	8.14	8.36	0.55	42.40	345.12	354.45

[54] Annual Energy Produced (GWh/year) – refer to Table 7 for breakdown per plant

[55] Based on the average wholesale market price for WKM2201 for the year ending December 2012 (Source: Wholesale market reports – www.ea.govt.nz).

[56] Based on multiplying the energy supplied (MWh) by the price per MWh

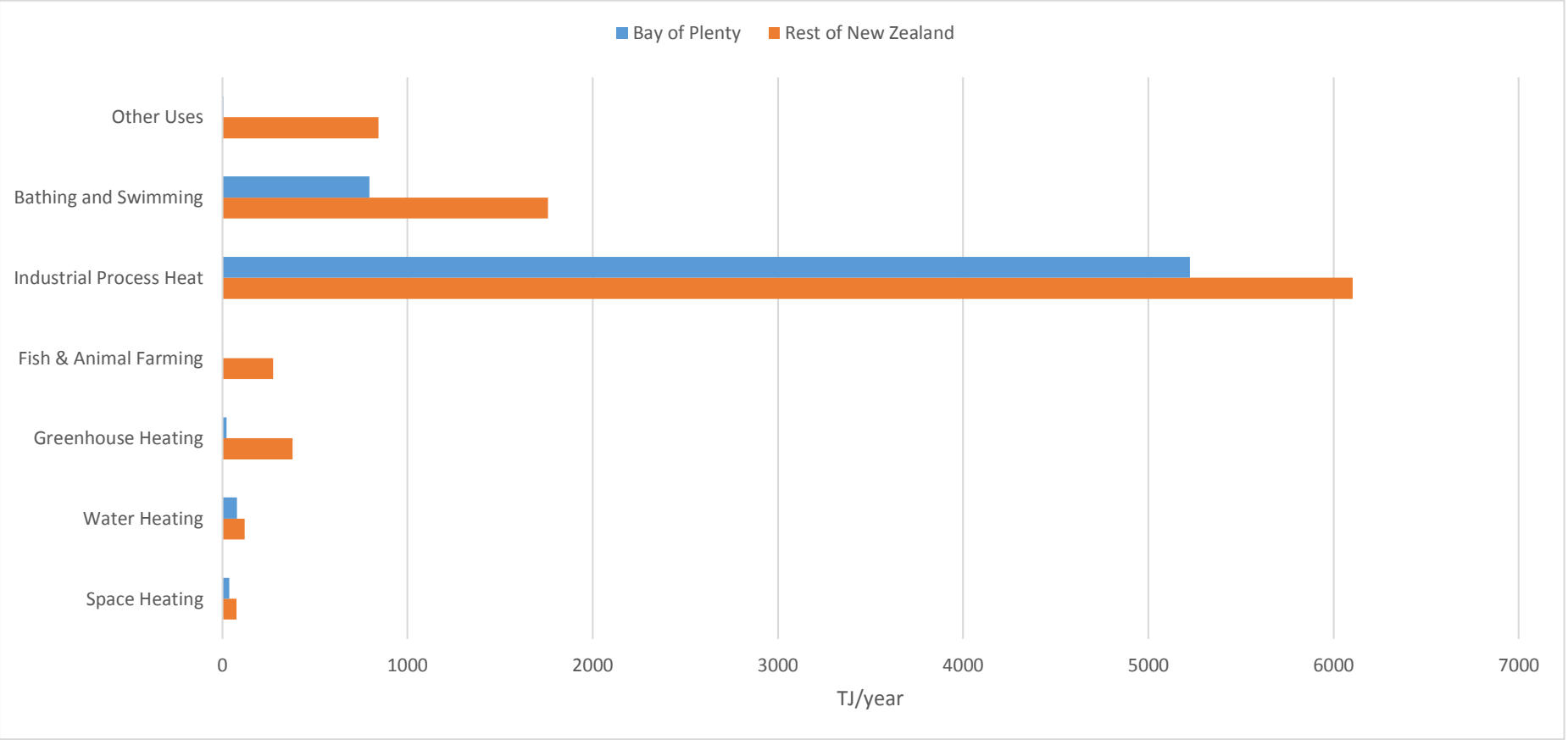
[57] Source of multipliers: Market Economics. It is assumed that this is based on the market average for electricity generation industry as a whole, as opposed to geothermal electricity generation specifically.

[58] Source of Output to value added ratio: Market Economics.

[59] Source of multipliers: Market Economics. It is assumed that this is based on the market average for electricity generation industry as a whole, as opposed to geothermal electricity generation specifically.

[60] Source of Output to value added ratio: Market Economics.

Appendix 7 – Comparison between Direct Use in the BOP and NZ



Appendix 8 – Direct Use for Industrial Process Heat Calculations

Direct Use (Paper and Wood Processing) contribution to the Bay of Plenty economy

	Product supplied[61]	Total Output ($m)[62]	Value Added Multipliers[63]		Output to value added ratio ($m/$m)	Contribution to Bay of Plenty economy ($m)		
			Type 1	Type 2		Direct value added	Direct and indirect	Direct, indirect and induced
Paper Manufacturing 2012	660000	328	2.98	3.04	0.26	85.3	254.1	259.3
Wood Manufacturing 2012	350000	25.93	2.47	2.53	0.35	9.1	22.4	23.0
Total	-	353.93				94.4	276.6	282.2

Note:

- Production: Teat (2012c) provides a breakdown of the amount of pulp, paper and sawn logs produced in Kawerau, including the proportion of product that is exported or used domestically. Specific production volumes were also obtained from two processing facilities.
- Wood Output: Based on multiplying the amount of product supplied by average log price. Teat (2012c) notes that approximately 60% of logs are used domestically while 40% are exported. The log prices were obtained from Ministry for Primary Industries (2012) and applied as an average across all export and domestic grades. Because of this crude methodology, the resulting output ($m) could possibly undervalue the sector. This method, albeit crude, is considered appropriate in the absence of specific information about the output for specific log grades. Further work is needed to determine a more accurate indication of the output from wood production.
- Pulp/Paper prices: Based on multiplying the amount of product supplied by pulp price. The pulp prices were obtained from Ministry for Primary Industries (2012) and applied as an average across the export and domestic grades. One processing facility provided both their production figures and associated output. This output was incorporated into the calculations. Further work is needed to determine a more accurate indication of the output from pulp and paper production.

[61] Source: Teat (2012c). Paper in t, Wood in cubic metres

[62] Based on multiplying amount of product supplied by average log/pulp price (MPI Indicative Log Prices 2012).

[63] Source of multipliers: Market Economics. It is assumed that this is based on the market average for the wood/paper processing industry as a whole, as opposed to that part of the sector that specifically uses geothermal direct heat.

Direct Use (Paper and Wood Processing) contribution to BOP employment

	Paper and Wood product manufacturing output $m	Employment Multipliers Bay of Plenty region[64]		Output to value added ratio (MEC/$2007m)	Estimated contribution to regional employment (MEC)		
		Type 1	Type 2		Direct impacts	Direct and indirect	Direct, indirect and induced
Paper manufacturing 2012	328	4.88	5.01	1.37	563	2747	2821
Wood manufacturing 2012	26	2.36	2.41	4.4	187	441	450
Total	353				750	3189	3271

Note:

- Direct Employment: Based on the most recent census data (750 employees within the "Wood Manufacturing Industry[65]", with an estimated split of 25% for wood and 75% for Pulp and Paper). This was considered the most appropriate and accurate data for direct employment. Using the Output to value added ratio, would have result in lower direct employment numbers (449 for paper, 110 for wood) which would indicate either the Output or Output to value added ratio is not quite right.

[64] Source of multipliers: Market Economics. It is assumed that this is based on the market average for the wood/paper processing industry as a whole, as opposed to that part of the sector that specifically uses geothermal direct heat.

[65] Name of Industry Segment used in Census 2013