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Valuing uses of the Waikato regional geothermal resource

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Abstract

In 2002 Waikato Regional Council surveyed the numbers of visitors to geothermal attractions in the Waikato region. A repeat survey was recently undertaken, involving all 50 geothermal tourism sites, divided into six categories of attraction, in the Waikato Region. The overall number of visits by domestic and overseas tourists to has increased from 2 million in 2002 to 2.6 million in 2010.

In addition the survey assessed the direct use of geothermal energy in the region, and employment numbers. Multiplier analysis was used on figures from this survey and other sources such as Tourism NZ and Statistics NZ to estimate the value of electricity production, geothermal tourism and direct uses to the regional economy. In 2009, more than 1200 people were estimated to be employed in geothermal tourism in the Waikato region, while 80 were employed in geothermal electricity production. Indirect effects[1] increased these numbers, with tourism showing a modest increase in employment effects, and geothermal generation a substantial effect. Preliminary results suggest that geothermal tourism was worth somewhere between $63 million and $121 million to the regional economy in direct value-added, while geothermal electricity production is worth $57 million. The indirect and induced effects of both activities increase the economic value to the region, particularly for geothermal generation.

[1] Refer to glossary.

Executive summary

Geothermal resources are a valuable asset to the Waikato region. They contribute to the regional economy through tourism, electricity generation and ecosystem services such as the provision of genetic resources and cultural values, particularly those of tangata whenua. The purpose of this report is to estimate the annual value of geothermal resources to the Waikato region. This has been described quantitatively where information exists to do so and qualitatively where such information is not currently available.

A survey was conducted between April 2011 and June 2011, and multiplier analysis was used to estimate the value of geothermal resources to the Waikato region. The survey and analysis investigated:

- the numbers of visitors from domestic and international sources visiting geothermal attractions in the Waikato region;
- the numbers of staff employed in tourism and direct heat facilities in the Waikato region;
- the value of geothermal tourism to the Waikato region;
- the value of geothermal generation to the Waikato region;
- the amount of geothermal energy used in commercial and domestic direct heat applications (i.e. non-electricity) in the Waikato region.

More than 2.5 million visits are made to geothermal attractions in the Waikato region each year. This figure has increased 25 per cent since 2002. In 2009, geothermal tourism directly contributed $63 to $121 million to the Waikato regional economy, providing 1298 to 2501 jobs in the tourism sector. The indirect and induced effects of geothermal tourism make a modest increase to Waikato's gross regional product (GRP). Based on Tourism New Zealand forecasts, the contribution of geothermal generation to GRP in 2016 is expected to increase by around 34 per cent, to an estimated $85 to $162 million. Jobs within the tourism sector will increase with output.

In 2009-10, geothermal electricity generation directly contributed an estimated $56.9 million to the regional economy and 80 jobs. The addition of indirect and induced effects increases this contribution substantially. As consented geothermal generation plants come on line the value to the regional economy will increase, as will employment effects.

Alongside the value of geothermal tourism and generation to the regional economy, the geothermal resource contributes to a range of ecosystem services enjoyed by the region. These have been qualitatively described, but no attempt has been made to assess the monetary value of these services.

Other values of geothermal resources include option and quasi-option values, and the non-use values (existence, altruism and bequest). These values contribute to the total economic value of the resource.

Twenty million tonnes of geothermal water and ten thousand terajoules (TJ) of geothermal energy are used in geothermal tourism, primary production, industry, and space heating.

The quantitative analysis of the contribution of geothermal resources to the regional economy through tourism and generation, and the qualitative description of direct uses and other ecosystem services will provide policy makers with a framework for considering the impact of decisions on the many benefits provided by the geothermal resources of the Waikato region.

1 Introduction

Geothermal resources are a valuable asset to the Waikato region. They contribute to the regional economy through tourism, electricity generation and ecosystem services including the provision of genetic resources and cultural values, particularly those of tangata whenua. The purpose of this report is to estimate the annual value of geothermal resources to the Waikato region. This has been described quantitatively where information exists to do so and qualitatively where such information is not currently available.

This report provides the results of a survey conducted between April 2011 and June 2011, and the results of multiplier analysis to estimate the direct, indirect and induced market economic value of geothermal resources to the Waikato region. The survey investigated:

- the numbers of visitors from domestic and international sources visiting geothermal attractions in the Waikato region;
- the numbers of staff employed in tourism and direct heat facilities in the Waikato region;
- the amount of geothermal energy used in commercial and domestic direct heat applications (i.e. non-electricity) in the Waikato region.

The multiplier analysis estimated:

- the value of geothermal tourism to the Waikato region;
- the value of geothermal generation to the Waikato region;

The survey updates and expands on the results of a survey conducted in the period from December 2001 to February 2002 (Luketina, 2002) which investigated the numbers of visitors from domestic and international sources visiting geothermal attractions in the Waikato region.

The 2002 survey identified that more than two million tourists visited geothermal attractions in the Waikato region each year. Bathing was the greatest attraction, but nature tourism and technology-related sites were also important.

Survey data was collected from commercial site proprietors by telephone, by letter, and by email. In some cases the results of site surveys by third parties were used, but in most cases the numbers were made up from observations by site proprietors or statistics kept by them. Consent data and advertising information was also used.

For those sites which do not have proprietors and for which no surveys had been conducted, numbers were estimated based on observations made during visits undertaken by Waikato Regional Council staff and contractors, both in the course of their work or for recreational purposes.

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

The visitor numbers collected in the survey support assumptions used in multiplier analysis to estimate the value and employment effects of geothermal tourism to the regional economy in 2009. Multiplier analysis is also used to estimate the value of geothermal generation for the regional economy. Projections of future contributions for each sector to the regional economy are made. Market economic value is only a component of the whole value – e.g. option and bequest values are not captured by multiplier analysis and are beyond the scope of this report.

Waikato Regional Council has identified the numbers of visitors to geothermal attractions as environmental indicators. Employment numbers and energy use are valuable indicators for environmental and economic cost and benefit analysis of using geothermal resources in various ways. Visitor and employment numbers provide an indicator of the cultural and economic significance of such attractions.

The reason for assembling such information is the Waikato Regional Council's statutory requirements to describe the state of the environment, as set out in Resource Management Act 1991 Section 35. Such indicators are used by Waikato Regional Council for setting policy and planning monitoring programmes.

Direct use of geothermal energy can be more energy-efficient than conversion to electricity, and tends to provide more local employment opportunities. However, because of the small and distributed nature of direct use, employment and energy use figures are harder to obtain than those for the electricity industry.

Geothermal ecosystems provide a range of ecosystem services to the Waikato region. These services have been qualitatively described, and the ecosystem service of tourism has been quantified in terms of its contribution to the regional economy in 2009.

It is intended that the information provided will assist in informing regional policy development for environmental and economic management; will provide a basis for submissions to central government; and may also be used as a basis for research funding. The Ministry of Science and Innovation (MSI) is now the primary funder for public good geothermal research. To date the Waikato and Bay of Plenty Regional Councils have had little input in the allocation of central government funding although approximately 70 per cent of New Zealand's geothermal resources are in the Waikato region and a further 25 per cent in the Bay of Plenty region.

2 Definitions

2.1 Geothermal attraction

The operative Waikato Regional Policy Statement Section 3.7.1 (Waikato Regional Council 2000, updated 2007) states:

> Characteristics of the regional geothermal resource include:
>
> i) Thermal energy contained in rocks deep in the earth and carried by water
> ii) Mineralised fluids (containing e.g. silica, lithium, and boron)
> iii) The characteristics of all geothermal systems and features within it including the geophysical and biological features and processes associated with the surface expression of geothermal energy and fluids.
>
> Characteristics of a geothermal system may include:
>
> 1) A body of thermal energy contained in rocks deep in the earth and carried by water
> 2) A convective inflow of cool, fresh water and a consequent outflow of heated mineralised fluids (containing e.g. silica, lithium, and boron)
> 3) Surface discharges of geothermal heat and mineralised fluids, such as springs and steam features
> 4) Land formations created by geothermal processes, such as hydrothermal eruption craters and sinter terraces
> 5) Biodiversity (a variety and uniqueness in genes, species and populations of plants, animals and micro-organisms).
>
> Characteristics of a geothermal surface feature may include:
>
> a) A surface discharge of steam, water, gases, and minerals
> b) A flowing or standing body of water whose origin is either entirely or partly geothermal
> c) Time-dependant behaviours such as intermittency of geysers
> d) Infrequent or single eruptions such as hydrothermal eruptions and mud eruptions
> e) Mineral depositions such as sinters and sulphur crystals
> f) Mud volcanoes, mud flows, concentric mud ring patterns
> g) Remnant geomorphological features such as hydrothermal eruption craters, geothermal collapse pits and associated caves
> h) Heated or chemically altered ground
> i) Terrestrial and aquatic geothermal ecosystems influenced by heat, humidity, water chemistry, flow and gases

This report defines a geothermal attraction as a publicly accessible site where geothermal characteristics are a primary recreational or tourist attraction. Enjoyment of most of these sites involves either experiencing geothermal activity such as geysers and fumaroles, or bathing in geothermal water.

A smaller group of sites is the technology-related group, where people experience highly modified characteristic of geothermal technology. Currently this group contains three sites: Wairakei Terraces, a tourist attraction mainly comprising artificial geothermal features, the Wairakei Power Station borefield and the Prawn Park, where prawns are grown in geothermally-heated ponds for consumption in an on-site café.

Public sites where geothermal heat is used to heat fresh water for recreational bathing are included where it is likely that the facility would not exist without the geothermal heat source. The exception is bathing facilities that are not primarily tourism and leisure-oriented. Sites where geothermal heat is used for space heating and domestic water heating only are not included as geothermal attractions. Also excluded are sites where geothermal water is used in a domestic environment, such as homes, rest-homes, and marae, and natural hot springs that are used almost exclusively by local residents.

2.2 Direct heat applications

A geothermal direct heat application is one where geothermal heat is used for primary production, space and water heating, or an industrial application such as timber drying. Currently, direct heat applications in the Waikato region consist of:

- growing tomatoes, capsicums, native plants, orchids and gerberas in geothermally-heated glasshouses
- space and water heating for commercial facilities
- aquaculture (prawns)
- timber drying and production of wood products
- provision of water or heat for bathing pools.

2.3 Geothermal electricity generation

Geothermal electricity generation involves converting the energy contained within geothermal resources into electrical energy. This is normally done either by passing high-temperature steam through a turbine attached to an electrical generator, or by transferring heat from geothermal fluid to a more volatile fluid, which is then passed through a turbine. The latter process is termed a binary process because two fluids are used. The generation of electricity from geothermal resources enables some of the geothermal energy to be converted to a much more easily transportable form. Because of inherent engineering difficulties in converting geothermal energy to electricity, the conversion rate is generally only between 10 and 25 per cent. Geothermal electricity production is generally done as a base-load source of electricity because of a very high capacity factor (approximately 95 per cent) compared with many other electricity sources, and in particular compares very well with the capacity factors of solar and wind power.

3 Dangers of geothermal attractions

Access to geothermal features carries danger for people who stray too close to hot water and unstable ground. In August 2000, two teenagers died and a companion received critical burns after they fell into a boiling pool at Yellowstone National Park, USA. From time to time in the Waikato and Bay of Plenty regions fatalities or burns occur to members of the public who come in skin contact with hot geothermal water or mud.

Geothermal gases, primarily hydrogen sulphide and carbon dioxide, are also responsible for deaths when people are exposed to high concentrations in confined areas.

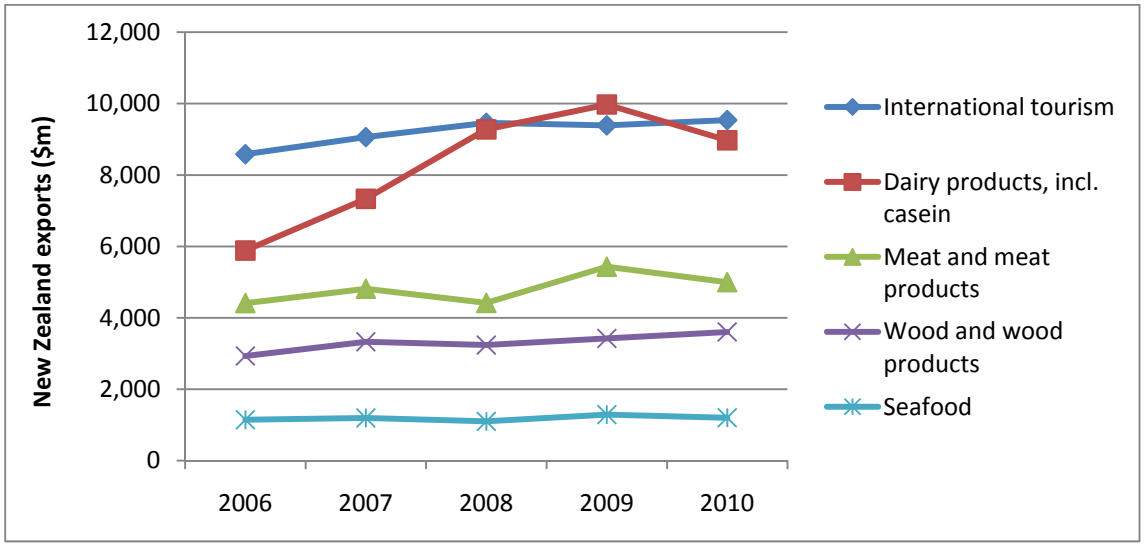
Amoebic meningitis is caused by *Naegleria fowleri*, an amoeba that inhabits earth that comes into contact with geothermal water. It can pass into the brain when water containing the organism is forced up the nose, for example while diving in a geothermal pool. It is fatal in most cases. There was a spate of deaths in the 1970s in New Zealand, another death in 2000 (Cursons et al., 2003), and a suspected case that did not result in death, also in 2000.

People who swim in natural and domestic pools do so at their own risk. A simple and effective precaution is to never put your head underwater. For public swimming facilities the best way to minimise the risk of amoebic meningitis getting into the swimming pool, in addition to the usual sanitation measures required, is to ensure that bore water is used instead of drawing water from a natural geothermal spring.

4 Tourism

Tourism is a vital component of New Zealand's economy, with international and domestic tourists spending $22.4 billion in the year to March 2010 and contributing directly $6.5 billion (3.8 per cent) to New Zealand's GDP in 2010. The indirect value-added contribution to GDP through industries supporting tourism contributed a further $8.8 billion, totalling of 8.7 per cent of GDP (Statistics New Zealand, 2010a).

Exports are a key component of New Zealand's economic wellbeing, as a small and open economy. International tourism and dairy products compete for top position as export earners, with tourism often making the biggest contribution to New Zealand's foreign exchange earnings (Figure 1).



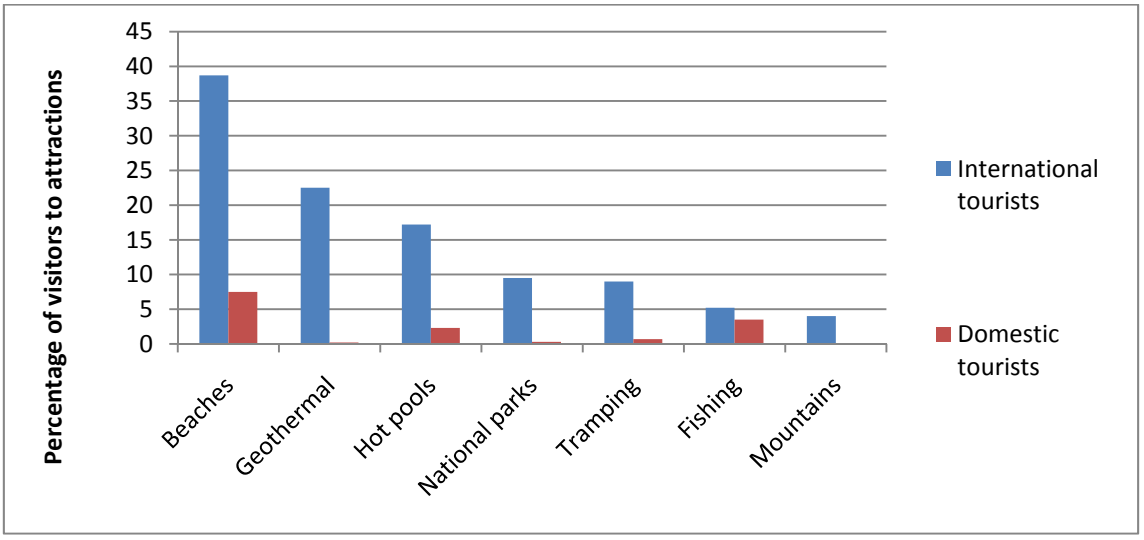
Source: (Statistics New Zealand, 2010a).

Figure 1: International tourism spending compared with selected primary exports

4.1 Geothermal tourism

Key areas of interest for international and domestic tourists[2] include wineries, museums, Maori culture, cycling and nature-based tourism (Ministry of Economic Development, 2009). In 2008, 1.6 million international tourists and 11.1 million domestic tourists participated in nature-based activities. Geothermal attractions were particularly popular with international tourists, with 500,000 (22.5 per cent) visiting geothermal sites (Figure 2). Similarly, visiting thermally heated pools was a popular activity, particularly for international tourists.

[2] Statistics New Zealand defines a tourist as 'any person travelling to a place other than their usual environment for less than 12 months and whose main purpose is other than the exercise of an activity remunerated from within the place visited' (p.38) (Statistics New Zealand, 2010b)



Source: (Ministry of Economic Development, 2009).

Figure 2: Percentage of international and domestic tourists to NZ taking part in selected activities (2008)

4.2 Geothermal tourism in the Waikato region

About 70 per cent of New Zealand's geothermal resources are in the Waikato region, making the region an attractive place for both domestic and international tourists. Attractions within the region include nature tourism (geysers, mud pools, sinter terraces), which can be freely available, such as walks through geothermal areas, or commercially developed facilities. Free bathing sites are available through the region, with as many as 800,000 visitors annually to sites surveyed. Much of the tourist accommodation in the region has bathing facilities available. In more recent years, technology-related tourism has become an important tourist attraction with sites such as the Wairakei Power Station borefield; the Prawn Park and the artificial Wairakei Terraces drawing large numbers of international and domestic visitors.

4.3 Tourism numbers: Survey results

The report defines geothermal attractions in six categories:

- Bathing as part of travel accommodation facilities: (23 sites)
- Pay bathing: (9 sites)
- Free informal bathing: (10 sites)
- Pay nature tourism: (4 sites)
- Free nature tourism: (1 site)
- Technology-related sites: (3 sites)

These categories are described and the annual visitor number estimates provided below. The results are in most cases made up from surveys of proprietors and users. Most of the estimates have a significant margin of error. Nevertheless, it is hoped that they are able to provide a useful benchmark for interested parties and for further surveys.

4.3.1 Bathing as part of tourist accommodation facilities (23 sites)

This category covers those tourist accommodation facilities (hotels, motels, camping grounds, etc.) where geothermal bathing facilities are provided. The bathing water is either geothermal water or fresh water that has been heated by geothermal water. Bathing facilities found within private establishments such as dwellings, rest homes, Christian camps, and marae are not included. To avoid double counting, those accommodation facilities that are directly attached to public bathing facilities are excluded, as all bathers are counted in the pay bathing category.

Sites were identified through resource consent records, staff knowledge, and the advertising of thermal bathing attractions on the internet and hospitality media. There are 23 sites in this category, compared to 22 in the 2002 survey. Four sites have been removed and five have been added. Since the 2002 survey Hot Water Beach motor camp and Tokaanu Hotel have closed, and Totara Springs Christian Camp has been taken out of this category because it does not directly provide tourist accommodation. Bay View Motel at Taupo has been converted to apartments. The five new sites included are marked with an asterisk. Mostly they are sites that have been newly identified as providing geothermal bathing, rather than sites that have opened up since 2002.

The numbers of bathers per facility, in most cases, are based on either observation of pool use or an estimate taken from the average number of people staying per room per night times the occupancy rate times the percentage of people staying who use the pool. The numbers from each site are not identified individually to preserve confidentiality.

Eleven of the 23 sites surveyed returned the survey form. Analysis of results from this sample showed that visitor numbers in the 2010-2011 year were similar to those in the 2001-2002 year for motels. Because of this, for the three motels that provided figures in the 2002 survey but not the latest survey, the 2002 figures were used. For the remaining sites, numbers were estimated based on facility size compared to sites for which data was available. There was a significant increase in business for motor-camps.

Annual numbers of bathers at tourist accommodation are: Total: 212,000; Domestic: 154,000; International: 58,000 (Table 1). The error range is estimated to be approximately 25 per cent.

The total is 36,700 more than the 2002 total of 175,300, an increase of 21 per cent. This is largely due to the increased number of sites in the category, the larger size of new sites compared to those removed from the category, and the increase in visitors to motor-camps. International visitor numbers have fallen by 9 percent.

Table 1: Comparison between 2002 and 2011 results for accommodation-related bathing

Year	Domestic visitors	International visitors	Total visitors
2002	111,500	63,800	175,300
2011	154,000	58,000	212,000
Change	+42,500	-5,800	+36,700
% change	+38	-9	+21

Sites in this category (with sites newly counted in the category marked with an asterisk) are:

Hauraki

Miranda Holiday Park

Okoroire Hotel

Te Aroha Holiday Park and Hot Pools*

Waingaro Hot Springs Motel*

Tokaanu-Waihi-Hipaua

Braxmere Lodge

Oasis Motel & Caravan Park

Rainbow Motels

Tokaanu Lodge Motel

Waiotapu

Waiotapu Tavern*

Wairakei-Tauhara (Taupo)

All Seasons Holiday Park

Baycrest Lodge

Boulevard Waters Motel

Chelmswood Park

Clearwater Motor Lodge

The Cove*

Karaka Tree Motel

Lakefront Motor Lodge

Lake Taupo Holiday Park

Manuels

The Reef Motel

Phoenix Timeshare Resort

Sacred Waters*

Wairakei Resort Hotel

4.3.2 Pay bathing (9 sites)

This category covers developed geothermal bathing facilities. The water is either geothermal water or fresh water that has been heated by geothermal heat. Hot pools attached to clubs such as golf and squash clubs are not included because they are only a secondary benefit of membership. Also excluded are sites used primarily in an educational context such as Swimwell in Taupo and school pools.

Matamata Sports Centre has been removed from the category this time because the geothermal source of the heating system is not advertised as an attraction and the baths are not used primarily for tourism purposes. The newly established Lost Spring in Whitianga has been added.

Eight of the 9 sites returned the questionnaire. For the last site, an estimate was made based on sites of similar size and nature.

The numbers estimated per facility are the numbers of people who use the pools per day for a year. In most cases, these numbers have been reconstructed from an analysis of the annual takings and the estimated numbers in each payment system such as concession cards, group bookings, and age groups. The numbers from each site are not identified individually to preserve confidentiality.

Annual visitor numbers are: Total: 740,000; Domestic: 450,000; International: 290,000 (Table 2). The error range is estimated to be approximately 30 per cent.

The total is 343,000 less than the 2002 total of 1.1 million, a decrease of 32 per cent. Most sites reported a drop in numbers. The removal of Matamata Sports Centre from the category also led to a decrease in overall numbers. All of the decrease came from domestic visitors, probably due to the economic recession. International visitor numbers remained stable.

Sites surveyed are:

- AC Baths, Taupo
- Taupo Hot Springs
- Tokaanu Thermal Pools
- Waikite Valley Thermal Pools
- The Lost Spring, Whitianga
- Miranda Hot Springs
- Opal Hot Springs, Matamata
- Te Aroha Hot Springs
- Waingaro Hot Springs

Table 2: Comparison between 2002 and 2011 results for pay bathing

Year	Domestic visitors	International visitors	Total visitors
2002	795,000	287,200	1,083,000
2011	**450,000**	**290,000**	**740,000**
Change	-345,000	-2800	-343,000
% change	-43	-1	-32

4.3.3 Free informal bathing (10 sites)

At various sites around the region, there are geothermal springs that are largely undeveloped, have no entry price, and are used by the public for bathing. Some are on public land, while others are on private land, but are accessible to the public. In both cases, there may be facilities such as car parking, rudimentary concrete pools, and barbecue facilities. Some sites are little-known beyond local inhabitants. Such sites are excluded, and only those that are well-known enough to constitute a tourist attraction are included. Hot Water Beach is by far the most visited site, and most of its visitors are busloads of overseas tourists.

There are 10 sites in this category, compared to seven in the 2002 survey. Three Taupo urban sites have been added: Spa Park, Rocky Point, and Taharepa.

There are no official figures available for the sites studied in the survey, and no known formal surveys undertaken. Numbers were extrapolated from a survey gauging use of each site by Waikato Regional Council staff. These were checked against the 2002 survey, and in the case of Butchers Pool, with Rotorua District Council staff, who survey use of the toilets at the site, but not use of the pool.

The total is more than five times bigger than the 2002 total of 159,700, an increase of 421 per cent (Table 3, Table 4). Much of this increase is probably due to a more accurate sampling method. The 2002 result was based on about 100 observations, whereas the current estimate was based on 180. In addition there may have been a real increase in use since the last survey due to an increase in overseas free independent travellers and bus tourists using the facilities, and in New Zealanders preferring to holiday within New Zealand and undertake low-cost leisure activities. The error range is estimated to be approximately 30 per cent.

Table 3: Annual numbers of visitors to free informal bathing sites

Site	No of visitors	No. domestic	No. international
Golden Springs	1000	1000	0
Butchers pool	15,500	12,500	3000
Waiotapu Loop Rd	21,300	11,500	9800
Kerosene Creek	42,800	33,500	9300
Kawhia	11,800	9200	2600
Hot Water Beach	700,000	490,000	210,000
Waihunuhunu	1700	1700	0
Spa park	29,500	25,600	3900
Taharepa	6700	6700	0
Rocky Point	1000	1000	0
Totals	**831,300**	**592,700**	**238,600**

Table 4: Comparison between 2002 and 2011 results for free bathing

Year	Domestic visitors	International visitors	Total visitors
2002	79,200	80,485	159,700
2011	**592,700**	**238,600**	**831,300**
Change	+513,485	+158,115	+671,600
% change	+648	+196	+421

4.3.4 Nature tourism (5 sites)

This category now includes both the previous categories pay nature tourism and free nature tourism. Because of the small numbers in the two categories, they have been merged so that a useful comparison can be made with the 2002 results.

Pay nature tourism (four sites now, previously three) covers developed facilities that charge visitors to look at geothermal attractions such as geysers, boiling mud pools, sinter terraces, fumaroles, and hot springs. Craters of the Moon has shifted to this category from the free nature tourism category following a decision by the Ministry of Economic Development to charge a rental to the trust running the site. The charge is passed on to visitors.

Free nature tourism (one site now, previously three) covers facilities that provide free walks for visitors through natural geothermal areas. The only site remaining in this category is the Tokaanu thermal walk. Craters of the Moon has become commercialised (see above), and the Te Kopia Reserve has been removed from the category because the Department of Conservation, which manages the land, does not encourage visits, for a variety of reasons including public safety as there are no formed paths.

Four of the five sites returned the questionnaire. For the fourth site, their 2002 figures were used. Annual visitor numbers are: Total: 491,000; Domestic: 186,400; International: 304,600 (Table 5). The total is 49 per cent more than the 2002 total of 330,200. The error range is estimated to be approximately 30 per cent. The numbers from each site are not identified individually to preserve confidentiality.

Some of the increase is due to a new estimate for Tokaanu that is substantially higher than the 2002 estimate. Actual counts are not made for Tokaanu, and the numbers are based on a proportion of the people who use the adjacent Tokaanu Thermal Baths. There was also a substantial increase in the numbers of visitors to Craters to the Moon, perhaps because the trust has moved from a voluntary to a professional mode of operation with increased advertising, services and facilities.

Table 5: Comparison between 2002 and 2011 results for nature tourism

Year	Domestic visitors	International visitors	Total visitors
2002	99,690	230,510	330,200
2011	**186,400**	**304,600**	**491,000**
Change	+86,710	+74,090	+160,800
% change	+87	+32	+49

Sites surveyed are:

- Craters of the Moon
- Orakei Korako Geyserland
- Waiotapu Thermal Wonderland
- Wairakei Natural Thermal Valley
- Tokaanu Thermal Walk

4.3.5 Technology-related tourism (3 sites)

This category covers free unguided views of the Wairakei Power Station borefield, and paying visitors to the Prawn Park and the artificial Wairakei Terraces. Wairakei Terraces has started up since the 2002 survey, so the category has gone from including two sites to three. Data came from a range of sources including the current and 2002 surveys, and news media. We have no data for a fourth site, guided tours of the Wairakei borefield by NETCOR, so that is excluded from the survey.

The numbers from each site are not identified individually to preserve confidentiality.

Annual visitor numbers are: Total: 292,000; Domestic: 183,000; International: 109,000 (Table 6). Despite the increase in number of sites in the category, the overall numbers have decreased slightly. Domestic visitors have increased but a drop in international visitors has led to an overall drop.

The error range is estimated to be approximately 30 per cent for the overall number.

Table 6: Comparison between 2002 and 2011 results for technology-related tourism

Year	Domestic visitors	International visitors	Total visitors
2002	160,000	137,800	297,800
2011	**183,000**	**109,000**	**292,000**
Change	23,000	-28800	-5800
% change	+14	-21	-2

4.3.6 Summary of visitor results

Overall numbers of visitors to geothermal attractions have increased by more than half a million, from two million to almost 2.6 million (Table 7), made up of a 25 percent increase in both domestic and international visitors. For both visitor types, a large part of the increase is due to more accurate counting in the free informal bathing category. There has been a decrease in the number of domestic visitors to pay bathing sites, but this is largely because a redefinition of the category now excludes Matamata Sports Centre. Overall, more New Zealanders are visiting geothermal attractions than in 2002. The decrease in international visitors to motels and motor camps is more than offset in the accommodation category by an increase in domestic holiday-makers. There has been a significant decrease in international visitors to technology-related tourism sites, which is more than offset in by an increase in numbers to nature tourism sites (Figure 3).

Table 7: Visitor numbers to geothermal attractions

Category	Domestic visitors (000)			International visitors (000)			Total visitors (000)		
	2002	2011	Δ%	2002	2011	Δ%	2002	2011	Δ%
Accommodation-related bathing	111.5	154.0	+38	63.8	58.0	-9	175.3	212.0	+21
Pay bathing	795.8	450.0	-43	287.2	290.0	+1	1,083.0	740.0	-32
Free informal bathing	79.2	592.7	+65	80.5	238.6	+196	159.7	831.3	+42
Nature tourism	99.7	186.4	+87	230.5	304.6	+32	330.2	491.0	+49
Technology-related tourism	160.0	183.0	+14	137.8	109.0	-21	297.8	292.0	-2
TOTALS	**1,246.2**	**1,566.1**	**+26**	**799.8**	**1,000.2**	**+25**	**2,046.0**	**2,566.3**	**25**

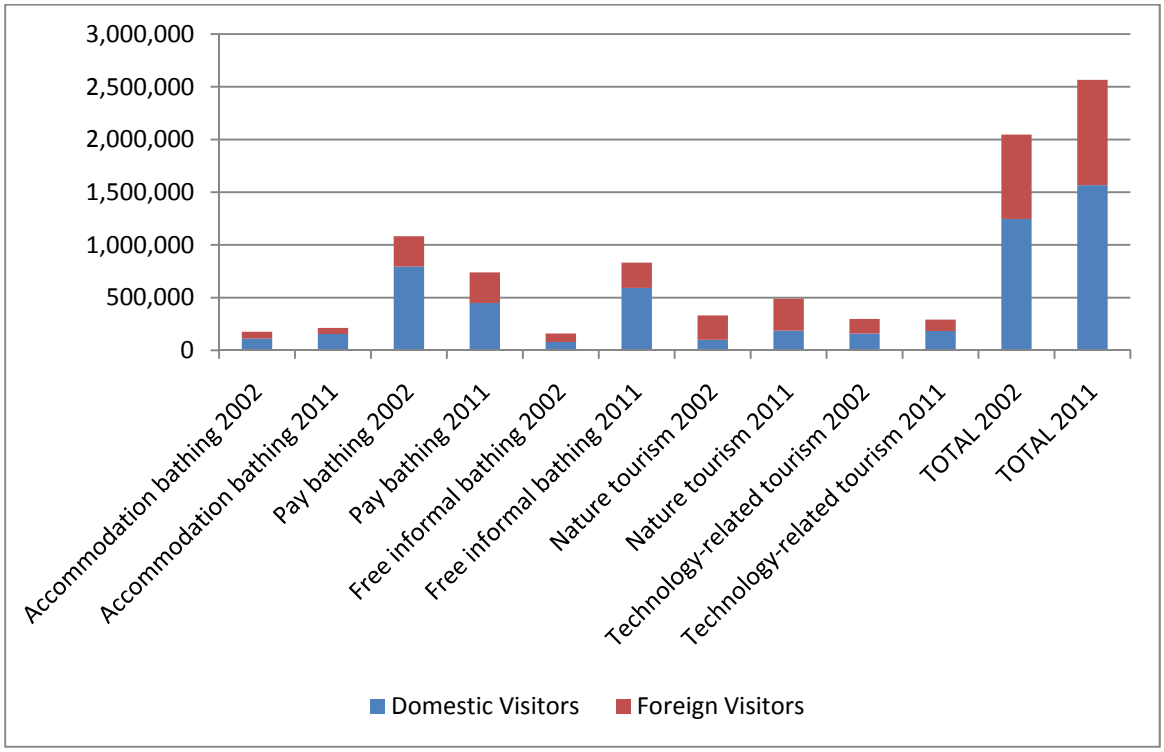


Figure 3: Visitor numbers to geothermal attractions in 2002 and 2011

4.4 Geothermal tourism – contribution to the regional economy

4.4.1 Business survey results

The geothermal resources of the Waikato region are important to local businesses. To determine how important, geothermal tourism operators were surveyed as to how useful geothermal resources were to their business. In the accommodation with bathing category, 30 per cent of tourism operators said the geothermal resource was essential to their business, and the remaining 70 per cent found it somewhat useful (Table 8). Among the 30 per cent who found it essential, one estimated that they actually had no energy saving from its use because of pumping costs. Nevertheless, the tourism value of the water made it an essential part of the business. Several others found it somewhat useful despite high pumping and maintenance costs.

In the pay bathing, nature tourism and technology-related tourism categories, all respondents considered the geothermal resource essential to their business.

Table 8: Usefulness of geothermal water and energy

Direct Users	Not useful (%)	Useful (%)	Essential (%)
Tourist accommodation bathing	0	70	30
Tourist pay bathing	0	0	100
All other geothermal tourism sites	0	0	100

4.4.2 Multiplier analysis

To estimate the value of geothermal tourism to the Waikato region it is necessary to assess how many of the tourists visiting geothermal attractions stay in the Waikato region because of the presence of geothermal attractions.[3, 4] Information from Tourism

[3] It is important to note that the following assessment of value to the region relies on the assumption that without the geothermal attractions, the time and money spent in the region for the purpose of visiting geothermal attractions would not be spent in the region. Where this assumption does not hold (i.e. visitors continue to visit the region, but

New Zealand on current and forecast levels of international and domestic tourism, patterns of spending and visits to geothermal attractions has been used. Multipliers have been calculated for the direct and flow-on impacts of tourism within the regional economy.

Of the 2.3 million international tourists visiting New Zealand in the year ending March 2010, 634,000 (28 per cent) visited volcanic/geothermal attractions (Ministry of Economic Development, 2011a). In the same year, domestic tourists totalled 46.3 million.[5] Two per cent (977,000) of domestic tourists visited geothermal attractions (Ministry of Economic Development, 2011b). Of the domestic visitors to volcanic/geothermal attractions, 21 per cent were day trips and 4 per cent were overnight visits.

In the year ended March 2010, international tourists spent an average of $2788 per visit (per person) or $133 per person/visitor night, with an average stay in New Zealand of 21 days (Ministry of Economic Development, 2011a). In the same year, spending by domestic travellers averaged $100 per person/day trip, and $115 per person/day for overnight trips, with an average stay of three days for the latter group (Ministry of Economic Development, 2011b).

To estimate volcanic/geothermal tourism for the Waikato region (excluding other regions where geothermal attractions exist - such as the neighbouring Bay of Plenty) it is assumed that 45 to 55 per cent of geothermal tourists (both domestic and international) visit attractions in the Waikato region. This equates to 732,000 to 896,000 visitors. These figures are a good fit with independently collected survey data (Table 7), which focus on visits to individual attractions rather than the entire holiday, suggesting that geothermal tourists visit 2.9 to 3.4 geothermal attractions during their stay in the Waikato region. It is further assumed that the range for domestic overnight stays is one to two nights (out of three nights), while international visitors are estimated to spend two to three nights[6] in the Waikato region for the purpose of visiting these attractions.

To complete the estimation of the value of geothermal tourism to the Waikato region, value added multipliers have been calculated. Output is the quantity of goods supplied multiplied by the price of each unit. Direct value-added is the output multiplied by the output to value-added ratio, so calculated to remove double-counting. The indirect effects are the impact from the tourism sector activity on other businesses (including those supplying goods and services to the sector). The induced effects are the flow-on effects from wages and salaries now available in the economy. The multiplication of the direct value-added effects with the Type I multiplier determines the direct and indirect effects. The multiplication of the direct value-added effects with the Type II multiplier determines the direct, indirect and induced effects.

The Type I and Type II multipliers have been estimated to be 1.49 and 2.24 respectively. The output to value-added ratio is 0.51.[7]

visit other attractions instead of geothermal), the assessment will result in an overestimation of the tourism value of geothermal.

[4] Tourism NZ regions do not match regional council boundaries. For example, the WRC region includes part of the Rotorua District, where the Tourism NZ region does not.

[5] Figures for domestic travel and spending are based on a new data series starting from September 2009, using an improved method resulting in more accurate data (Ministry of Economic Development, 2011b).

[6] Out of a 19 night average stay forecast for 2016 (Ministry of Economic Development, 2010a)

[7] Estimates provided by Market Economics Limited.

Table 9: Geothermal tourism contribution to the regional economy (based on 2009/10 data)

Year	Type of geo-thermal tourist[8]	Geo-thermal tourists (000)	Avg. daily spend per person $	Days in the Waika to region (est.)	Value-added multipliers		Output to value-added ($m/$m)	Contribution to the regional economy ($m)		
					Type I	Type II		Direct value added	Direct and indirect	Direct, indirect induced
2009	Dom. (day)	286-350	$100	1	1.49	2.24	0.51	7.4 – 9.1	11.1 – 13.5	16.7 – 20.4
	Dom. (o/n)	161-197	$115	1-2				17.1 – 41.8	25.5 – 62.4	38.4 – 93.8
	Int'l	285-349	$133	2-3				38.5 – 70.5	57.3 – 105.1	86.2 – 157.9
	TOTALS							**63.0 – 121.5**	**93.9 – 181.0**	**141.2 – 272.1**
2016	Dom. (day)	247-423	$94	1	1.49	2.24	0.51	8.7 – 10.6	13.0 – 15.8	19.4 – 23.7
	Dom. (o/n)	184-225	$115	1-2				19.9 – 48.8	29.7 – 72.6	44.7 – 109.2
	Int'l	393-480	$141	2-3				56.1 – 102.8	83.6 – 153.2	125.6 – 230.4
	TOTALS							**84.7 – 162.2**	**126.2 – 241.7**	**189.7 – 363.3**

Based on the data and assumptions, geothermal tourism has a significant impact on the regional economy (Table 9), contributing directly $63.0 to $121.5 million in the year to March 2010. Direct and indirect effects were $93.9 to $181.0 million. With the addition of induced effects, this contribution increased to $141.2 to $272.1 million.

Tourism forecasts estimate that in 2016, New Zealand is forecast to host 3.1 million international tourists, and 56.1 million domestic tourist visits. Of the domestic visits, 36.7 million will be day trips, and 19.4 million will be overnight trips (Ministry of Economic Development, 2010a). Assuming the same patterns as in 2010, 873,000 (28 %) international tourists in 2016 will visit volcanic/geothermal attractions. Of domestic travellers, 1.2 million visits will be to geothermal sites: 403,000 visits will be day trips and 758,000 will involve overnight trips. Daily spending[9] for international, domestic day trips and domestic overnights is forecast to be $141, $94 and $115 respectively, with international tourists staying in New Zealand for 19 nights on average, and domestic overnight trips being three nights on average.

Using the forecast data, the 2010 assumptions regarding length of stay and the 2010 value-added multipliers (which assumes that the structure and linkages within the tourism sector remain the same over this period), in 2016 the direct contribution of geothermal tourism to the Waikato regional economy is estimated to be from $87.7 million to $162.2 million. Adding indirect and induced effects lifts this contribution to $189.7 million to $363.3 million.

[8] Note: Figures for domestic visitors refer to all ages. International spending refers to spend in New Zealand, excl. international air fares. Excludes some travel expenditure by government and business sectors.

[9] The figures provided by Tourism New Zealand are not inflation adjusted.

4.5 Geothermal tourism – employment

4.5.1 Business survey results

All tourism sites where visitor numbers are counted (Section 4.3.6), and all large-scale direct heat users were surveyed for employment numbers. Figures were obtained for the total number of staff and the equivalent full-time staff (EFTS) numbers. Excluded from this part of the survey are the many non-tourist businesses in Taupo that use relatively small amounts of geothermal heat for space and water heating. These are excluded because their business is not dependent on geothermal energy to the same extent as those that are involved in tourism. Most of the staff figures were supplied by the companies with some obtained from the internet and other sources. The numbers from each site are not identified individually to preserve confidentiality (Table 10). Accuracy is estimated to be about 20 per cent.

Employment figures were not surveyed in the 2002 survey, so no comparison can be made.

The categories are:

- **Tourist accommodation bathing:** all accommodation sites that provide geothermal bathing facilities, as listed in section 4.1 above. There are 23 sites in this category. Excluded are the several motels in Taupo that use geothermal heat for space heating but not for swimming pools, and the accommodation sites such as Christian camps that are not tourism-oriented.
- **Tourist pay bathing:** all commercially operated tourism-oriented geothermal bathing facilities as listed in section 4.3.2 above. There are nine sites in this category. Excluded are bathing facilities that are not tourism-oriented, such as Matamata Sports Centre.
- **All other geothermal tourism sites:** This includes pay nature tourism and technology-related tourism sites. Wairakei Terraces and Netcor are not included as no data was available for these sites. There are five sites in this category.

Table 10: Employment by geothermal tourism

Employment by geothermal tourism	Total Staff	EFTS
Tourist accommodation bathing	407	242
Tourist pay bathing	182	124
All other geothermal tourism sites	80	46
TOTAL	**669**	**412**

4.5.2 Multiplier analysis

Multiplier analysis has been used to estimate the employment associated with geothermal tourism in the Waikato region. The economic output[10] generated by Waikato regional geothermal tourism (Table 8), the employment to output ratio for the tourism sector as a whole (11.5), and employment multipliers for tourism (calculated to be 1.27 for Type I and 1.66 for Type II) provide an estimate of 1298 to 2501 modified employment count (MECs) for direct employment in this sector (Table 11).[11, 12]

[10] Output is estimated as the number of tourists multiplied by daily spend and number of days stayed in the Waikato region (Table 11).

[11] Source of multipliers: (Market Economics Limited, July 2011a)

[12] The Purchasing Parity Index (PPI) has been used to transform output from $2007 to $2009 to estimate employment within the tourism sector.

Table 11: **Geothermal tourism contribution to regional employment**

Year	Type of tourist	Geothermal tourism output $m	Employment multipliers		Output to value-added (MEC per $m)	Estimated contribution to regional employment (MEC)[13]		
			Type I	Type II		Direct impacts	Direct and indirect	Direct, indirect induced
2009	Dom. (day)	14.6 – 17.9	1.27	1.66	11.5	153 – 187	197 – 238	254 – 311
	Dom. (o/n)	33.7 – 82.4				353 – 862	448 – 1095	586 – 1432
	Int'l	75.7 – 138.7				792 – 1452	1006 – 1843	1314 – 2410
	TOTALS					**1298 – 2501**	**1648 – 3176**	**2154 – 4152**
2016	Dom. (day)	17.1 – 20.9	1.27	1.66	11.5	179 – 218	227 – 277	296 – 362
	Dom. (o/n)	39.2 – 95.9				411 – 1004	521 – 1275	682 – 1666
	Int'l	110.4 – 202.3				1155 – 2117	1467 – 2689	1917 – 3514
	TOTALS					**1744 – 3339**	**2215 – 4240**	**2895 – 5543**

Adding the indirect effects increases the MEC to 1648 to 3176, and adding the induced effects lifts the MEC to 2154 to 4152. These figures are considerably higher than the survey results (Table 10). This is expected because of the broader range of tourism-based businesses included in the multiplier analysis, such as accommodation and restaurants. For this reason, the multiplier analysis is a more accurate estimation of geothermal-related employment in the region.

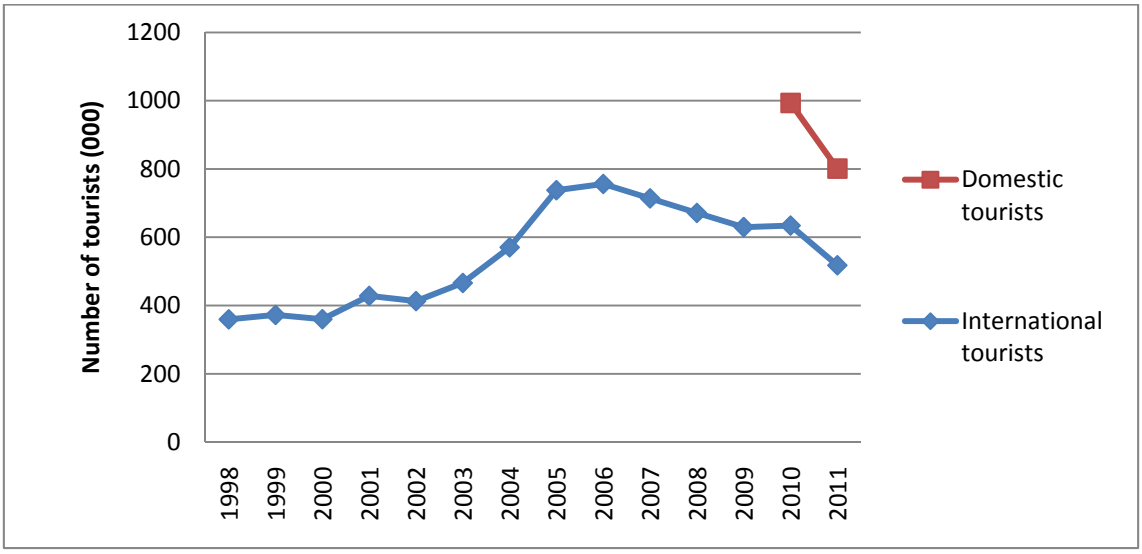
Looking forward to 2016, (assuming the employment multipliers and the employment to output ratio remain unchanged), the direct employment (MEC) in the geothermal tourism sector is estimated at 1744 to 3339. Indirect effects lift this range to 2215 to 4240. Adding the induced effects produces a range of 2895 to 5543 (Table 10).

4.6 The future of geothermal tourism

The number of international tourists visiting geothermal attractions in New Zealand increased sharply in the early to mid 2000s, and then steadily declined (Figure 4). From 2010 to 2011, the number of international tourists visiting geothermal attractions fell steeply, likely reflective of recessionary conditions in the world economy, and the high value of the New Zealand dollar. Domestic travel also fell steeply from 2010 to 2011, in line with economic conditions in New Zealand.[14]

[13] Assumes that interrelationships within the sector do not exist or are negligible, and therefore double counting is not an issue.

[14] Domestic tourism data is limited because of new data series for domestic travel (Ministry of Economic Development 2011b).



Source: (Ministry of Economic Development, 2011a; 2011b)

Figure 4: New Zealand geothermal tourism 1998 to 2010

New Zealand's Tourism Strategy 2015 has a vision that 'tourism is valued as the leading contributor to a sustainable New Zealand economy' (The Tourism Industry Association. et al., 2007). Outcomes sought by 2015 are that the tourism sector:

- delivers a world-class visitor experience;
- is prosperous and attracts ongoing investment;
- takes a leading role in protecting and enhancing the environment; and
- works together with communities for mutual benefit.

All of these outcomes are relevant for geothermal tourism, and given its attractiveness to international and domestic visitors, it has an important role in achieving the vision articulated in the Tourism Strategy.

4.7 Costs and benefits of geothermal tourism[15]

Benefits of geothermal tourism include:

- Contribution to regional and national economy
- Maintenance of culture
- Contribution of GST to central government – from both domestic and international tourists
- Excise taxes – from international tourists
- Strengthened Maori cultural values and social practices
- Improved quality and access to services for New Zealanders
- Improved environmental quality for New Zealanders
- Public awareness and support for maintaining and improving natural areas

Costs specific to geothermal tourism include:

- Pumice and gravel used on tourist tracks spreading across and changing fragile sinter surfaces
- Pathways cut across sinter terraces, stopping regeneration
- Geothermal pools drained or partially drained to stop them flowing across the tourist paths (for example, at Tokaanu)
- Erosion of grounds by foot traffic causing collapse of pool surrounds (for example Champagne Pool at Waiotapu)
- Litter
- Changes in the number of species present

[15] Cullen 2007; Waikato Regional Council 2010a.

- Damage to plant and animal species
- Weed incursion
- Maintenance costs of geothermal areas – some freely available to the public but paid for through local or regional rates, and through taxation.

5 Geothermal electricity generation

Electricity is a basic necessity for a 21st century lifestyle in New Zealand. Both current and future economic growth will be dependent on a secure, affordable and sustainable supply of electricity. National electricity consumption has increased at an annual average of 2.5 per cent since 1974[16] (Ministry of Economic Development, 2010b), and is forecast to continue growing at 1.5 per cent per year into the future (Electricity Authority, 2011a). Drivers of demand for electricity include population growth, rising incomes and new technologies reliant on electricity (NZIER & Harrison Grierson, 2011).

The Waikato region has a combination of hydro, geothermal, wind, gas and coal-fired generation, with a total installed capacity of 3.1 gigawatts (GW) in 2009, making up 33 per cent of the nation's generation capacity (Ministry of Economic Development, 2010b). The region produces approximately 40 per cent of the nation's electricity (Electricity Authority, 2011b). The electricity sector is disproportionately represented in GRP for the Waikato region, with the sector making up a greater share of GRP than it does of national gross domestic product (GDP) (Phillips, 2009).

Electricity is necessary to our everyday lives – households consume 45 per cent of electricity used within the Waikato region.[17] Sectors that contribute to our economic wellbeing, such as dairy farming, dairy product manufacturing, manufacturing and retail rely on a consistent and reliable electricity supply. As a net exporter of electricity, other regions rely on the Waikato region for their energy supply (Phillips, 2009).

Nationally, our reliance on electricity is increasing. In the 10 years to 2010, total observed electricity consumption increased by 15 per cent (Figure 5). This was made up of a 43 per cent increase in the agriculture/forestry/fishing industries (from a relatively low base), a 32 per cent increase in commercial, and a 19 per cent increase in residential consumption. Industrial consumption is much the same in 2010 as it was in 2000, although it has been higher in the intervening years. This may be a reflection of wider economic conditions. Growth in demand will require increased generation activity. The source/s of the increased generation will be important in determining New Zealand's economic future, with long run marginal costs differing between options, along with reliability and consistency of supply (Electricity Commission 2010a).

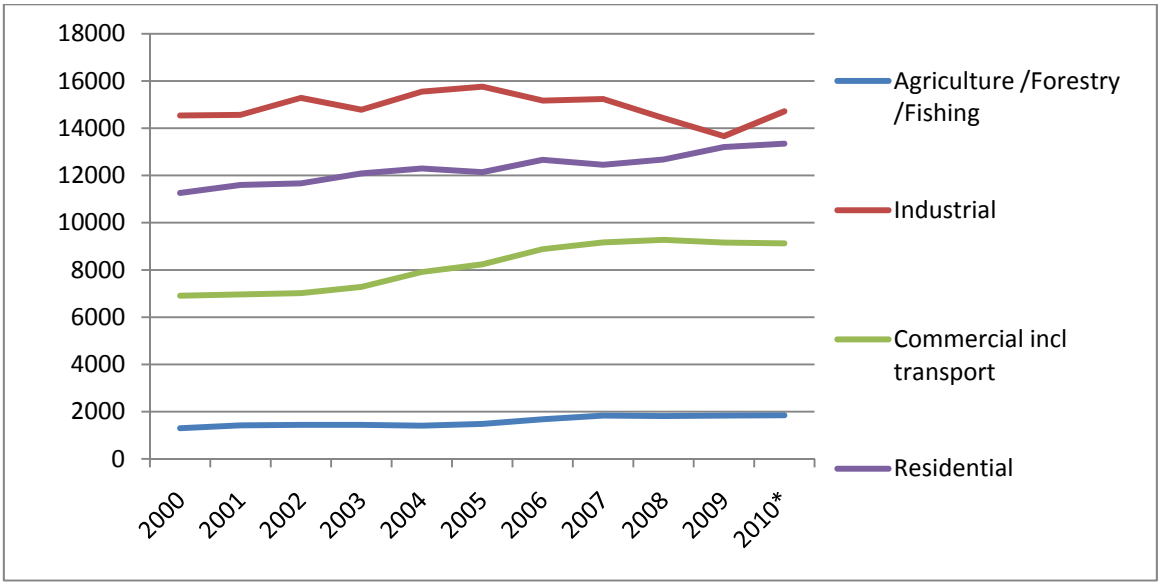


Figure 5: NZ: Observed electricity consumption by sector (GWh)

[16] Electricity use by residential, industrial, commercial and agriculture/forestry/fishing users has grown by an annual average of 1.6, 2.5, 3.9 and 4.8 per cent respectively.

[17] Exclusive of the electricity used for generation and supply.

5.1 Renewable energy

Sourcing renewable energy is increasingly important for New Zealand as concern grows about the international and local impact of fossil fuel emissions and security of supply. In New Zealand in 2009, 72 per cent of electricity was generated with renewable sources, with 78 per cent of that from hydro (Ministry of Economic Development, 2010b). Geothermal accounted for a further 15 per cent of renewable generation. According to the Ministry of Economic Development (MED), the existing capacity of geothermal generation in New Zealand is about 635 megawatts (MW), all of this in the North Island, and more than 75 per cent in the Waikato region (Ministry of Economic Development, 2010b; Phillips, 2009).

The Draft New Zealand Energy Strategy specifies the development of renewable energy resources, reliable electricity supply and reducing energy-related greenhouse gas emissions as areas of national focus contributing to the central government priorities of resource development, secure and affordable energy and environmental responsibility. In line with this, increased investment in renewable generation, particularly in geothermal and wind, is encouraged through removal of 'unnecessary regulatory barriers' (Ministry of Economic Development, 2010c). The Waikato region will be an important player in meeting the aims of the New Zealand Energy Strategy including achieving 90 per cent renewable generation by 2025 and security of supply, given the availability of hydro and geothermal resources in this region, and the region's current production of one-third of New Zealand's renewable energy (Ministry of Economic Development, 2010c; Waikato Energy Forum, 2009).

Geothermal generation can provide a consistent and reliable supply of electricity; it is not dependent on, or affected by, weather conditions in the short term – typically achieving load factors of 95 per cent, compared with factors of 30 to 50 per cent for hydro and wind.[18] Geothermal generation, when properly developed and managed, is clean, abundant and reliable, with relatively low greenhouse gas emissions compared with fossil fuel alternatives.[19] The long run marginal costs of geothermal generation are relatively low, especially when carbon costs for competing generation are taken into account (Electricity Commission 2010a). Although geothermal plants have relatively high development costs, incremental installation is possible. Running costs are modest, and the resource can be managed sustainably (Electricity Commission, 2010b; Energy Efficiency and Conservation Authority, 2011; New Zealand Geothermal Association, 2009). These attributes make geothermal generation an attractive option for our future needs, meeting the main concerns for future electricity needs, of tackling carbon emissions and delivering a secure supply at affordable prices.

In 2002, the life cycle emissions of key pollutant gases (CO_2, SO_2 and NO_X) for electricity generation from renewable and non-renewable sources was explored based on data reported by International Energy Agency (IEA) in 1998. Life cycle analysis takes into account both the emissions associated with energy generation and also with construction of plant and manufacture and transport of machinery and components. This analysis revealed that pollutant gas emissions can be greater for renewable than for non-renewable electricity generation because the renewables generally harness energy sources that are more 'dispersed' or 'dilute', as opposed to the more 'concentrated' energy represented by coal or oil (Heath, 2002). While the information showed that geothermal energy provided benefits in terms of lower greenhouse gases relative to fossil fuel energy, when geothermal was compared with other renewable sources it did not fare so well, particularly with carbon dioxide and nitrous oxide emissions (Tables 12 and 13).

[18] In the Statement of Opportunities, geothermal generation was attributed with 0.9, indicating a high availability at peak times (a score of 1.0 would guarantee to be fully available at peak times). Contrast this to thermal and hydro with storage achieving 0.95, 0.30 for marine and 0.20 for wind (Electricity Commission, 2010a).

[19] Although 'all New Zealand sources produce some greenhouse gases…' (Electricity Commission, 2010b).

Table 12: **Life cycle emissions (g/KWh) of key pollutant gases for selected fossil fuels and geothermal energy[20]**

	Coal (best practice)	Coal (FGD and low NOX)	Oil (best practice)	Gas (CCGT)	Geothermal
CO2	995	987	818	430	79
SO2	11.8	1.5	14.2	-	0.02
NOX	4.3	2.9	4.0	0.5	0.28

Source: (Heath 2002; adapted from IEA, 1998)**.**

Table 13: **Life cycle emissions (g/KWh) of key pollutant gases for renewable energy sources**

	Energy crops	Hydro (small)	Hydro (large)	Solar (photo-voltaic)	Solar (thermal)	Wind	Geothermal
CO2	17-27	9	3.6-11.6	98-167	26-38	7-9	79
SO2	0.07-0.16	0.03	0.009-0.0024	0.20-0.34	0.13-0.27	0.02-0.09	0.02
NOX	1.1-2.5	0.07	0.003-0.006	0.18-0.30	0.06-0.13	0.02-0.06	0.28

Source: (Heath, 2002; adapted from IEA, 1998)**.**

5.2 Geothermal generation in the Waikato region

The first geothermal power station, at Wairākei, near Taupō, was completed in 1964, and a second opened at Ōhaaki in 1989 (McKinnon, 2009) . Currently in the Waikato region, eight of New Zealand's 10 geothermal power stations plants are producing electricity, with a total capacity in 2009 of 480 MW. There are plans to build at least three more stations within the Waikato region (Table 14).

[20] Note that these figures are based on 1998 data, and on practices as at 2002. More recent information may provide different results.

Table 14: Geothermal power stations in the Waikato region

Power station	Geothermal field	Owners	Average productive output GWh/ pa[21 22]	Capacity MW	Year commissioned
Wairakei A & B	Wairakei	Contact Energy	1250	180	1958-63/1996
Wairakei Binary			128		2005
Ohaaki	Ohaaki	Contact Energy	550[23]	57	1989
Poihipi Road	Wairakei	Contact Energy	350	50	1996
Rotokawa	Rotokawa	MRP / Tauhara North No. 2 Trust	270	35	1997/2003
Mokai A & B	Mokai	Tuaropaki Power Co	930	112	2000/2005/2007
Nga Awa Purua	Rotokawa	MRP / Tauhara Nth No. 2 Trust	1088 (est.)	138	2010
Te Huka Binary	Tauhara	Contact Energy	181 (est.)	23	2010
Te Mihi	Tauhara	Contact Energy	1734 (est.)	220[24]	Planned (consented)
Tauhara II	Tauhara	Contact Energy	1971 (est.)	250	Planned (consented)
Ngatamariki	Ngatamariki	MRP / Tauhara Nth No. 2 Trust	867 (est.)	110	Planned (consented)[25]
Tukairangi	Wairakei	Geotherm		55	Uncertain (consented)[26]

Source: (Ministry of Economic Development, 2010b; NZ Geothermal Association, 2010).

5.3 Value of geothermal generation in the Waikato region

Multiplier analysis has been used to calculate the contribution of geothermal generation to the regional economy. This method takes into account the backward linkages of electricity generation – that is, the value-added and employment generated within the electricity sector and in the industries that support the sector through supply of inputs. What is not included in the analysis is the contribution that generation of electricity from geothermal makes to the rest of the economy – the forward linkages (ie to dairying, manufacturing, retailing and other industries).

In 2009, Waikato geothermal generation was estimated at 3478 GWh, making up 76 per cent of national geothermal production (Ministry of Economic Development, 2010b). The estimated production from power stations added in 2010 will increase production to 4747 GWh, with planned and consented plants increasing productive

[21] NZGA figures are used here. Figures may differ between sources: NZGA provides productive output.

[22] If run for one year (24hr x 365), a 1 MW plant would produce 8760 MWh, or 8.76 GWh.

[23] End of 2007.

[24] By 2016 Wairakei is expected to be replaced by Te Mihi, which has an installed capacity of 220 MW, using the same steam field as Wairakei (Ministry of Economic Development, 2010b).

[25] Source: (Mighty River Power, 2010).

[26] In receivership (New Zealand Geothermal Association, 2009).

output to 8197 GWh (assuming average productive output is 90 per cent of installed capacity).[27]

Calculating the contribution of geothermal generation to the regional economy has been based on the electricity consumer price for 2009 of $48.15/MWh[28] (Energy News, 2011). The value-added multipliers have been calculated as 2.69 and 2.73 for Type I and Type II for the Waikato region.[29,30] The output to value-added ratio has been estimated at 0.34. Based on these figures, the direct contribution of the geothermal generation sector to GRP in 2009 was $56.9 million. The direct and indirect contribution to GRP in 2009 was $153.2 million, and the direct, indirect and induced contribution $155.4 million. Inclusion of the power stations installed in 2010 lifts the regional estimates to $77.7 million, $209.0 million and $212.1 million (based on 2009 figures), and with the implementation of currently consented stations, the value-added contribution of geothermal generation to the regional economy is estimated to be $134.2 million, $361.0 million and $366.3 million (Table 15). As discussed above, this analysis does not take into account the benefits that geothermal generation provides to industries it supplies.

Table 15: **Geothermal generation contribution to the regional economy (based on 2009 prices and production)**

	Energy supplied MWh (000)	Price per MWh 2009 $	Value-Added Multipliers		Output to value-added ratio ($m/$m)	Contribution to Waikato economy ($m)		
			Type I	Type II		Direct value-added	Direct and indirect	Direct, indirect and induced
2009 (est.)	3,478	48.15	2.69	2.73	0.34	56.9	153.2	155.4
With 2010 plants included	4,747					77.7	209.0	212.1
With additional consented plants	8,197					134.2	361.0	366.3

5.4 Geothermal generation – employment

Nationally in 2009, 5850 people were employed in the electricity sector, and of those, 880 (15 per cent) were in the Waikato region (Statistics New Zealand 2010b).[31] Using the assumption that the employment-output ratio for the electricity industry is applicable for geothermal, type I and type II employment multipliers for the Waikato region have been estimated at 8.48 and 8.84.[32] Based on these multipliers, the MEC estimate for the Waikato region in 2009 is 80. Direct and indirect impacts increase the MEC to 680, and direct, indirect and induced effects lift the estimate to 709 (Table 5). Inclusion of the 2010 commissioned plants lifts the MEC to 109, 928 and 968, and with plants consented but not commissioned, the MEC increases to 189, 1603 and 1671 (Table 16).

[27] This assumes that Wairakei is decommissioned when Te Mihi comes on-line.

[28] The final wholesale electricity price at WKM2201 – the main Waikato grid exit point (Source: http://www.stat.auckland.ac.nz/~geoff/elecprices/index.html.).

[29] Source of multipliers: Market Economics Limited, July 2011b.

[30] An important assumption is that the structure of geothermal generation is the same as total generation for the Waikato region.

[31] ANSIC 06 code D26. These figures include the entire electricity sector, generation and supply.

[32] Multipliers provided by Market Economics Limited.

Table 16: **Geothermal generation contribution to regional employment**[33]

Year / generating plants	Geothermal generation output $m	Employment Multipliers Waikato region		Output to value-added ratio (MEC/$m)	Estimated contribution to regional employment (MEC)[34]		
		Type I	Type II		Direct impacts	Direct and indirect	Direct, indirect and induced
2009	167.5	8.48	8.84	0.57	80	680	709
With 2010 plants included	228.6				109	928	968
With additional consented plants	394.7				189	1603	1671

5.5 The future of geothermal generation

In 2005, the Ministry of Economic Development estimated that New Zealand's available geothermal resource base was 2600 MW of electrical equivalent, or about 75 per cent of the country's peak demand (Energy Efficiency and Conservation Authority, 2005). In 2010, geothermal electricity produced in the Waikato region accounted for 23 per cent of the 2600 MW estimate. With the addition of consented plants, the contribution of the Waikato region climbs to 45 per cent (Table 13). However, the 2005 estimate is not considered realistic for the following reasons:

1. The assessment is based on estimated calculated by Lawless and Lovelock (2001), which used a 50 year extraction period, after which the field is expected to be exhausted. Such a short-term extractive regime is unlikely to comply with the requirements of the Resource Management Act 1991 to provide for needs of future generations, or with the policies of the two regional councils that manage 95 per cent of the nation's geothermal resource, Waikato and Bay of Plenty Regional Councils, which both require longer-term sustainable management of geothermal resources.
2. The assessment takes into account all geothermal resources, regardless of whether they are protected from development by the regional council in question due to considerations such as hazard management, tourism, cultural values and biodiversity.
3. The assessment is based on a method that underestimates the capacity of some geothermal fields and overestimates others.
4. The assessment was not done with the intention of setting government policy, or categorically defining the size of the nation's geothermal resource, but to generate discussion and encourage more detailed assessment.
5. The authors acknowledge that this estimate needs updating to take account of new exploration data, changes in technology and in economics.

An alternative estimate, which takes into account environmental constraints among other things, is 1115 MW (New Zealand Geothermal Association, 2009). The Draft New Zealand Energy Strategy states the government's goal is to achieve 90 per cent renewable energy by 2025 (Ministry of Economic Development, 2010c), and this has been reaffirmed by the National Policy Statement for Renewable Electricity Generation

[33] The Purchasing Parity Index (PPI) has been used to transform output from $2007 to $2009 to estimate employment within the geothermal generation sector.

[34] Assumes that interrelationships within the sector do not exist or are negligible, and therefore double counting is not an issue.

2011 (New Zealand Government, 2011d) . Geothermal will have a role in attaining this target.

5.6 Benefits and costs of geothermal generation

Geothermal resources currently have high economic worth regionally and nationally as a source of low-carbon energy with significant potential for growth. Other benefits from geothermal electricity generation include:

- A stable baseload electricity supply without seasonal, weather or climate change impacts (International Energy Agency, 2010)
- Long run marginal costs (LRMC) lower than other electricity options. Up to 1000 MW, LRMC are estimated to be equal to wind, but still significantly lower than hydro and coal (White, 2007).

However, the use of geothermal resources for the production of electricity can have negative impacts on other valued uses, such as tourism, cultural, social, and on environmental values. The following describes the negative effects of unsustainable geothermal use:

> *Drawing off geothermal steam and water for power has reduced natural geothermal activity. The Wairākei station ended most geothermal activity there and at the nearby Spa field. The hydroelectric development at Ōhakuri on the Waikato River stopped most activity on the Ōrākei Kōrako field. Many scientists welcomed the research opportunities opened up by geothermal development, but others were more cautious, and locals were anxious about the impact on tourism. A controversial campaign in Rotorua in the 1980s saw bores closed to ensure the survival of some geothermal areas* (McKinnon, 2009).

Any large-scale extraction of geothermal fluid such as is required for electricity generation leads to pressure reduction in the geothermal aquifer and changes in the flow of geothermal fluid and heat to surface features. Negative externalities associated with geothermal electricity generation may include:

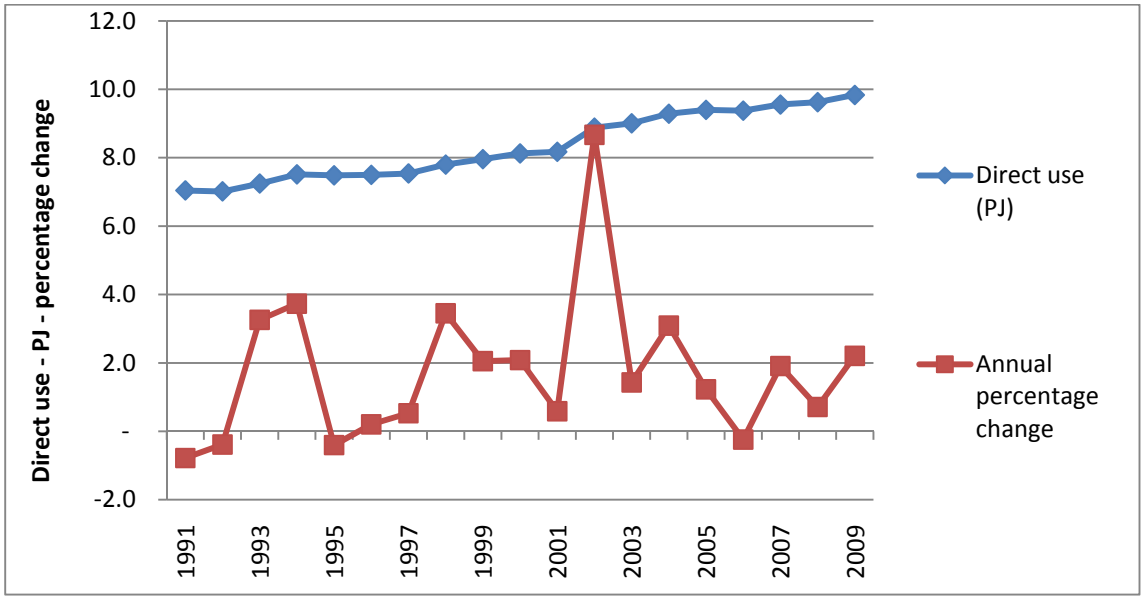
- Loss or reduction of flowing springs, geysers, and consequent loss of regeneration of sinter terraces
- Cracking of aquicludes leading to draining of geothermal and freshwater lakes and ponds
- Loss of tourism facilities and cultural uses and values
- Destruction or alteration of rare geothermal habitats
- Increase in steaming ground, reducing land productivity and value
- Land subsidence, leading to loss of land through flooding, and damage to buildings and infrastructure
- Slope instability and landslides
- Hydrothermal eruptions
- Reduction in the available geothermal energy for future generations
- Reduction in the available geothermal energy for more thermally efficient and employment-generating direct uses
- Discharge of geothermal contaminants including heat to land or surface fresh water and fresh water aquifers
- Discharge of steam and gases such as hydrogen sulphide to the atmosphere.

6 Direct use of geothermal energy

The New Zealand Geothermal Association defines direct use of geothermal energy as use of geothermal heat without first converting it to electricity, such as for space heating and cooling, food preparation, industrial processes, or bathing. It excludes nature tourism as this does not involve the transfer of heat to another medium.

There is significant commercial potential in geothermal energy. In addition to electricity generation, there are already commercially available technologies using stable ground temperatures to boost heating and cooling for buildings or industrial uses (for example, ground source heat pumps). Other emerging technologies aim to access deep geothermal resources and to expand the use of geothermal energy for direct heat application (Ministry of Economic Development, 2010c).

The data collected by MED regarding direct use of geothermal energy highlights the importance of geothermal for uses other than electricity generation. Direct use of geothermal resources (by petajoules (PJ)) has risen by 39 per cent over the past 20 years by (Figure 6). The substantial increase in the percentage change over 2001 to 02 is due to the commencement of the use by Netcor of separated geothermal water from the Wairakei borefield, to create and maintain artificial silica terraces. This use amounts to 820 TJ/year.

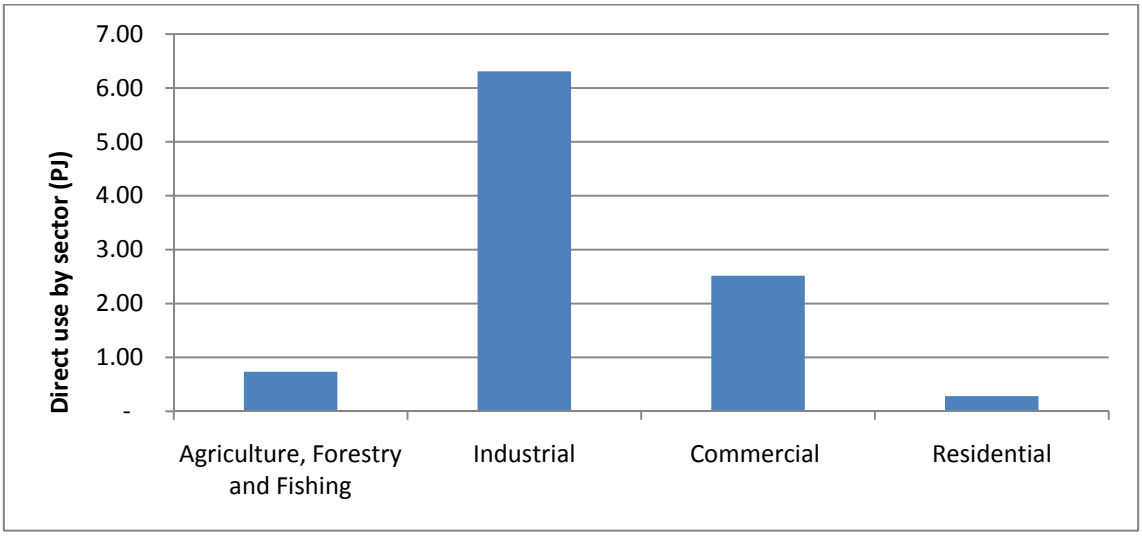


Source: (Ministry of Economic Development, 2010b)[35]

Figure 6: **Direct use (excluding electricity generation) of geothermal energy (PJ) and annual percentage change (1991 to 2009)**

Increases in population, changes in agricultural methods and increasing awareness of the potential for geothermal energy are likely to have an impact on geothermal direct use. Geothermal energy is applicable across a range of activities. Examples include: residential – heating homes; agriculture – glasshouses for horticulture, fish farming; commercial – hot pools; and industrial – timber drying kilns. New Zealand use by sector (2009) is recorded in Figure 7.

[35] Direct use figures based on report (White, 2009)

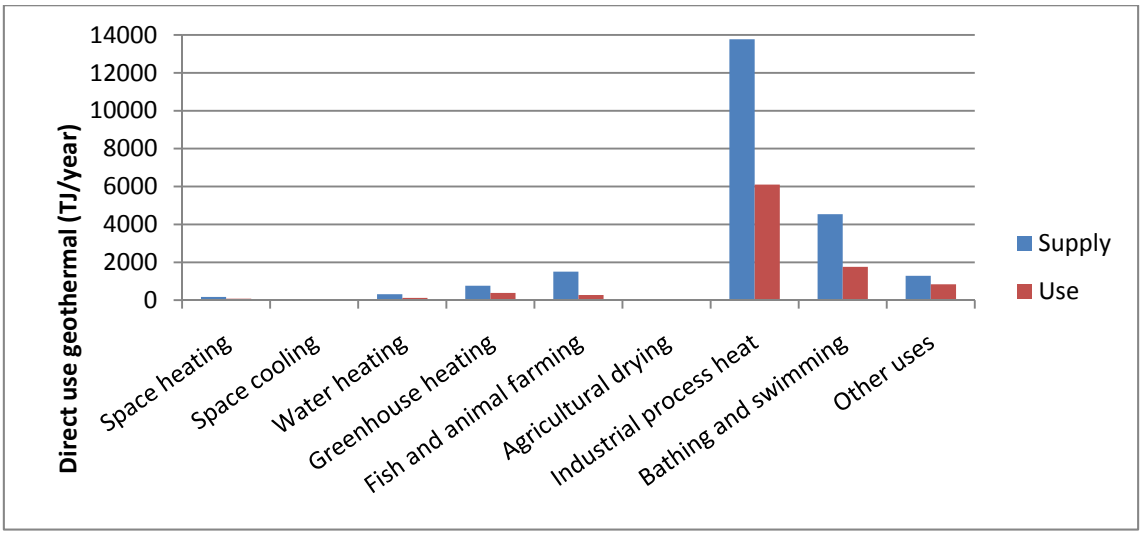


Source: (Ministry of Economic Development 2010b).

Figure 7: **Geothermal direct use by sector 2009 (PJ) - New Zealand**

However, figures for use by sector may be misleading. It is contended that the primary energy supply is likely to be more accurate than use, given that 'few users of [direct] geothermal energy are aware of their full usage' because having made the initial capital investment, low operating costs make monitoring unwarranted unless it is a condition of consent (White, 2009).[36] Annual figures for New Zealand supply and use across a range of uses are provided in Figure 8.

There is a wide range of efficiencies across direct use applications. For New Zealand, the average conversion factor for geothermal energy to consumer energy is 43 per cent (White, 2009). Data suggests that fish and animal farming is least efficient, using just 18 per cent of supply, while 'other uses' and greenhouse heating use 65 per cent and 49 per cent of supply respectively. Conversion efficiency is also dependent on source – for low temperature sources the conversion factor may be as low as 20 per cent (White, 2009). Taking this into consideration, it may be useful to design future policy to allow the most efficient uses as resources become scarce relative to demand.



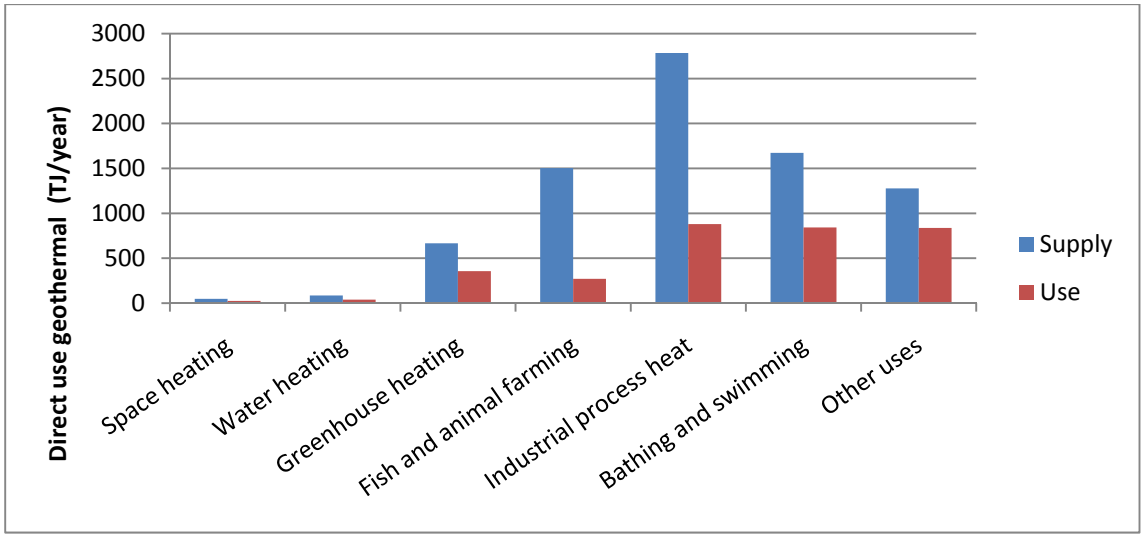
Source: (White 2009).

Figure 8: Assessed primary energy supply and direct use for geothermal for New Zealand (TJ/year)

[36] Data on supply for direct use is not included in the MED data tables, in which the data provided has been sourced from those provided by White (2009).

6.1 Direct use in the Waikato region

Geothermal resources in the Waikato region include those in the Hauraki and the Rotorua-Taupo areas. Direct use of geothermal resources across the Waikato region is shown in Figure 9. As with the New Zealand data (Figure 8), wide differences between supply and use are obvious, with use an average of 41 per cent of supply. However, the variation between different uses is interesting: Space heating, water heating, greenhouse heating and bathing and swimming each hover around 50 per cent efficiency, whereas fish and animal farming use just 18 per cent of supply. As with the national figures, this may have implications for future policy as demand increases relative to supply.



Source: (White, 2009).

Figure 9: Assessed primary energy supply and direct use for geothermal for the Waikato region (TJ/year)

In addition to the above uses of direct geothermal energy in the Waikato region, an estimated 520 domestic consumers use 6.1 million tonnes of geothermal water or 1724 TJ of geothermal energy per annum. This equates to 30 per cent of geothermal water used, and 17 per cent of geothermal energy. Domestic use is mostly covered by a Permitted Activity Rule, so a resource consent is not required (McLeod, 2010).

6.2 Value to the Waikato region

The value of direct use of geothermal resources has not been assessed in this report. It would be possible to estimate the value by separating out use categories, surveying users and developing multipliers.[37] As commercial use increases this may to be useful for policy decision-making. It will be important to differentiate between commercial uses that exist because geothermal is available (eg prawn farming) and those uses where geothermal is an input with viable substitutes (eg irrigation and frost protection).

Survey participants were asked how useful geothermal resources were to their operation (Table 17). The one glasshouse owner who answered the question considered it to have no overall benefit. They cited problems with corrosive fluids leading to higher maintenance cost, and with having to buy carbon dioxide for the glasshouse atmosphere, whereas if they were obtaining heat from the burning of natural gas, this would provide sufficient carbon dioxide for free.

The process heat and commercial space heating users found the resource somewhat useful.

[37] The survey split geothermal users into three categories based on their responses as to how useful geothermal was to their activities (not important; somewhat important; and essential). This could be a useful starting point for deciding which industry sectors to develop multipliers for in order to estimate benefits.

Table 17: Usefulness of geothermal water and energy

Direct Users	Not useful (%)	Useful (%)	Essential (%)
Glass houses	100	0	0
Primary and industrial processes	0	100	0
Commercial heating	0	100	0

6.3 Direct use – employment

Geothermal direct use includes primary production and industrial processes. All large-scale direct heat users were surveyed for employment numbers. Most staff figures were supplied by the companies, with some obtained from the internet and other sources. Numbers for individual businesses are not identified to preserve confidentiality. Accuracy is estimated to be about 20 per cent. The employment count (EC) is reported to be 184 and 366 respectively[38] (Table 18). Employment figures were not surveyed in the 2002 survey, so no comparison can be made.

Because the geothermal source of space heating and non-tourism bathing are not key drivers of employment for the sites that use them, they are not accounted for here. Because the Prawn Park is included in the tourism figures it is not counted here.

The categories are:

- **Glasshouses:** There are four glasshouse complexes in the region that use geothermal heating.
- **Primary and industrial processes:** There are three sites in this category, processing wood products and honey using geothermal resources.

Table 18: Employment by geothermal direct use

Employment by geothermal direct use	Total staff	EFTS
Glass houses	184	166
Primary and industrial processes	366	366
TOTAL	**450**	**532**

Multipliers for employment in these sectors have not been developed, given the current levels and diversity of resource use. It may be beneficial to do this in the future to provide additional information to policy makers.

6.4 The future of geothermal direct use

The use of geothermal energy looks set to increase both for domestic and commercial purposes. White noted that ground-sourced 'geothermal heat pumps are at an early adoption phase of the product uptake curve' (White, 2009, p3). Internationally, TJ/year climbed nearly sixfold over the 20 years to 2005 (White 2007). Investigations in 2009 revealed that ground-sourced geothermal heat pumps were being used in a few significant commercial projects in New Zealand (Dunedin airport; South Christchurch City Library), but at that time there remained a low level of residential uptake (Beca, 2009). Findings were that the net present value of ground-sourced geothermal heat pumps was likely to be lower than competing heating methods in colder regions of New Zealand. In the more northern regions geothermal heat pumps were likely to be less competitive (Beca, 2009). The domestic use of geothermal water and energy in Taupo and Tokaanu has been estimated at 30 per cent of the geothermal water used and 17 per cent of the geothermal energy. While it is argued that geothermal heating, whether from ground-sourced heat pumps or geothermal water, is not a good investment for

[38] It is not known whether working proprietors are included in this employment figure.

domestic use in the warmer regions of New Zealand, it may become so when groups of home owners share the capital and operating costs.

> *… a green opportunity for both stunning water and island views with geothermal amenities already in place…The geothermal bore gives odorless, clear hot water for your pool, spa and under-floor heating. The hot water infra-structure is installed to the property line. The great savings in energy costs will be yours!* (Hodges, 2011).

In addition to domestic use, geothermal energy is being investigated for potential use by industry, for example Fonterra undertook a feasibility study for the Waitoa dairy factory in 2009 for the use of geothermal heat and power (East Harbour Energy Limited, 2009). Expansion by current commercial users elsewhere also contributes to increasing commercial use (White, 2009).

With direct use increasing, potential users, particularly industry sectors, can see benefits in terms of reduced long run costs. White (2009) contends that '…a number of Maori Trusts will become cash-rich through Treaty settlements and will be evaluating investment options, some of which could include the labour-intensive direct heat projects such as greenhouses or timber drying kilns.

6.5 Benefits and costs associated with direct use

Positives associated with geothermal direct use include (Beca, 2009; White, 2007):

- Potential use of lower temperature fluid (than electricity generation)
- Further heat can be extracted from geothermal fluid once the fluid has passed through the geothermal power station
- Reduced carbon dioxide emissions compared to fossil fuels
- Employment – direct uses are generally more labour-intensive than electricity production.

Costs associated with direct use include:

- Sometimes due to chemical changes associated with cooling, the water becomes less suitable for reinjection, leading either to greater reinjection costs, or to surface discharge with possible contamination of fresh water
- If the water is not reinjected this can lead to depletion of the reservoir
- Plant maintenance can be more expensive than with other heat sources

7 Geothermal ecosystem services

The pressures from a growing population and development have increased the need to understand the value of the natural environment, and in doing so, to take account of this value into account in decision making at local, national and international levels. Much of the current thinking and definitions around ecosystem services has been influenced by Costanza et al. (1997). The definition is:

> *The services of the ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare both directly and indirectly, and therefore represent part of the total economic value of the planet* (1997, p253).

7.1 Geothermal and ecosystems

Geothermal ecosystems rely on geothermal energy, minerals, and water as the primary inputs, and these geothermal ecosystems contribute to ecosystem services. Geothermal ecosystems may be classed as thermotolerant (able to tolerate heat), thermophilic (needing heat for survival), and/or extremophilic (needing extremes of pH or chemical concentration) (Luketina, 2010). While geothermal tourism and the cultural values associated with geothermal resources are ecosystem services, geothermal energy is not. Geothermal energy comes from the earth's interior and therefore is not the product of an ecosystem, which has been defined as:

> *…a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functioning unit* (Alcamo J. et al., 2003).

Based on the categories of provisioning, regulating, supporting and cultural services used in the Millennium Ecosystem Assessment (2005), the ecosystem services contributed to by geothermal ecosystems include (Table 19):

Table 19: Ecosystem services contributed to by geothermal resources

Ecosystem service class	Ecosystem service	Application to geothermal resources
Provisioning services	Genetic resources	Genes and genetic material that can function at the high temperatures found in industrial processes, for example: The polymerase chain reaction (PCR), using enzymes found in geothermal bacteria, amplifies a specific target DNA fragment from a pool of DNA so that a sample large enough for testing can be created for e.g. forensic use. Geothermal bacteria are used in industrial applications for biodegradation, capturing precious metals from water, and production of biomass fuels.
Regulating services	Water purification and waste treatment	Geothermal microbes reduce the concentration of heavy metals and other chemicals in the geothermal water before that water flows into the wider environment. The minerals are captured by microbes into sinter deposits. The sinter is deposited as terraces that slow the flow of the geothermal water and increase surface contact and residence time in the geothermal ecosystem, cooling the water through evaporation and allowing the microbes a greater opportunity to further cleanse the water so that thermal and chemical shock to receiving environments is reduced.
Cultural services	Recreation Spiritual values	Geothermal tourism Traditional Maori spiritual beliefs and uses, Pakeha historical associations, belief in balneology (bathing

	Aesthetic values	for health), bathing for recreation; Geodiversity (landscape diversity).
Supporting services	Mineral cycling	Deposition of minerals including metals and sulphur for use in industrial applications

Source: (Luketina, 2010)**.**

The special types of plants or biota that occupy geothermal ecosystems include (Waikato Biodiversity Forum, 2006):

- prostrate kanuka shrubland over a turf of unusual mosses, liverworts, and lichens;
- low fertility shrubland of mingimingi, manuka, and monoao;
- ferns, fern allies, and orchids rare in New Zealand but more common in the tropics;
- thermophilic (heat-loving) microorganisms such as blue green algae;
- subtropical fungi attached to plant roots that assist plant survival;
- species of invertebrates and algae that occur only in thermal pools and springs; and
- coastal plants found around geothermal sites (such as arrow grass and Triglochin striata).

7.2 Value to the region

As can be seen from Table 17, there are a wide variety of ecosystem services that geothermal ecosystems contribute to. In this report we have estimated the 2009-10 value of geothermal tourism to the Waikato region, but the remainder of ecosystem service contributions from geothermal resources have not been monetarily valued. The development of indicators for monitoring the health of geothermal ecosystems would be useful for informing policy. This may fit well with the strategic direction of the Waikato Regional Council that identifies the mission of the council

> *To provide regional leadership to balance economic and environmental outcomes to enable social, economic, environmental and cultural wellbeing of current and future generations* (Waikato Regional Council 2010b)*.*

but acknowledges that gaps exist in outcome indicator information to effectively track progress (or otherwise) and values of ecosystem services.

In terms of cultural values, heat from the geothermal springs and waters had long been used by Māori. In 1869, geologist Ferdinand Hochstetter described separate springs for bathing, cooking and laundry, and vapour baths and winter huts that had been built on the warm sinter terraces. In the past, baths have provided communal meeting places, especially in winter months (McKinnon, 2009).

The estimated value of cultural services for traditional Maori spiritual beliefs and uses, Pakeha historical associations and similar, and to landscape diversity could be assessed using methods such as revealed or stated preference techniques (contingent valuation, travel costs etc).

Multi-criteria analysis, which uses input from a wide variety of stakeholders, has recently been used to determine the efficiency of alternative policies using an ecosystem services framework (Department of Conservation, 2001; Hearnshaw et al., 2010). Within this analysis both qualitative and quantitative inputs can be compared across policies. This may be a useful way forward in the future when policy choices have to be made.

7.3 The future of ecosystem services from geothermal resources

The Waikato Biodiversity Forum (2006) identified the following threats to geothermal ecosystems in the Waikato region and other areas:

- trampling by tourists and other visitors. Both soils and plants are easily destroyed by repeated pedestrian traffic with extremely slow recovery times;
- weed invasion of areas of low to moderate geothermal influence, particularly by pines and blackberry;
- rubbish dumping;
- stock grazing and trampling;
- clearance of plants for land development;
- unsustainable use of geothermal resources for provision of electricity generation; and
- unsustainable use of geothermal resources for other direct uses.

While robust policy protects geothermal features from harmful effects in the Waikato region, in practice full implementation of the policy does not occur due to limited enforcement resources. While some areas are being enhanced through targeted weed and animal pest control others are being adversely affected through cumulative effects and unconsented activities.

8 Other economic values

Other economic values contributing to the total economic value of the geothermal resources in the Waikato region include option, existence, bequeath and altruistic values. While the economic value of current use can be measured relatively easily, the values that people hold for resources they do not use are much more complex and controversial. These values are defined here; however no attempt has been made to assess them. Exploring these values through stated preference techniques (for example willingness to pay/accept; choice modelling) may be a useful area for more research in the future, and may make a useful contribution to policy decisions.

8.1 Option values

The option value is a use value, and is the value an individual places on a resource they may or may not currently use, but may want to use in the future (Pearce et al., 2006). This is likely to be important for geothermal resources, where unsustainable use has the potential to deplete the resource which may exclude other potential uses. Indeed, this has already occurred, with a reported 75 per cent of New Zealand's geysers lost through excessive electricity development (McLeod, 2010). In terms of tourism, there may be many millions of people who have not visited New Zealand's geothermal resources but value the option of visiting in the future. Similarly, individuals may be prepared to pay a premium for the availability of geothermal production of electricity in the future.

Quasi-option values should also be considered. This is the value of preserving the resource for future uses, which are as yet unknown, and therefore the benefits and costs of this use are also unknown (Pearce et al., 2006). This is particularly relevant where uncertainty exists, or where decisions on resource use may result in irreversible outcomes. An example of a future use of geothermal resources would be the potential pharmaceutical uses of plants within the systems.

8.2 Existence, altruistic and bequeath values

Existence, bequest and altruistic values are non-use values. Existence value is the value attached to knowing the good or resource exists. Under existence value, a person has no actual or planned use for the resource for themselves or others, but values the fact that it exists (Pearce et al., 2006). In this way, people within and outside New Zealand who may never visit or use geothermal resources may still value its existence.

Altruistic values are based on the belief that the resource should be available for others (of the current generation) (Pearce et al., 2006). Bequest values are similar to altruistic, but it is the value attached to leaving a legacy for future generations (Pearce et al., 2006).

9 Allocation of geothermal water and energy

All known direct uses of geothermal water and energy in the Waikato region are assessed in this section. This has not been reported before in detail so no comparison is made with previous years.

Where a site has a resource consent to take geothermal water, the consented amount of water is used in the calculation. For small takes, where there is no resource consent, the maximum allowable take is identified under the permitted activity rules of section 7 of the Waikato Regional Plan. In most cases this is 30 tonnes per day for takes of water. Most sites will not take the full allocated amount, and therefore our results will be higher than those by other agencies that assess actual use. However, for resource management purposes it is important to assess the allocated amount so that over-allocation does not occur.

Some larger takes at Wairakei and Ohaaki obtain water from Contact Energy and therefore do not have their own consents. In these cases most of the figures are taken from White (2009).

This report continues the practice followed by White (2009) of assessing all heat takes relative to 0 °C, as is the convention with other fuels.

The categories are:

- **Bathing as part of tourist accommodation facilities:** The amount of geothermal water and energy used at tourism sites whose visitor numbers are counted above in section 4 is assessed here. Other tourism sites that use the geothermal resources for space and water heating purely as an alternative to other forms of energy and not as a specifically geothermal tourist attraction are considered elsewhere.
- **Tourist pay bathing:** All commercially operated tourism-oriented geothermal bathing facilities as listed in section 4.3.2 above. There are nine sites in this category. Excluded are bathing facilities that are not tourism-oriented, such as Matamata Sports Centre.
- **All other geothermal tourism sites:** There are four sites in this category. Two pay nature tourism sites at Orakeikorako and Waiotapu use a very small amount of geothermal energy for heating. Two technology-related tourism sites, The Prawn Park and Wairakei Terraces both use a large amount.
- **Glasshouses:** There are four glasshouse complexes in the region that use geothermal heating.
- **Primary and industrial processes:** There are three sites in this category, processing wood products and honey using geothermal resources.
- **Irrigation and frost protection:** This category has two sites, which use geothermal water for irrigation because they cannot readily access fresh water. One of the sites also uses it for frost protection.
- **Commercial heating:** This category comprises all other commercial facilities that use geothermal water and energy for space and water heating. It includes motels, hospitals, schools, offices buildings, and retirement homes. All sites are in the Taupo and Wairakei areas.
- **Domestic heating:** This category consists of the approximately 500 homes in Taupo and 20 homes in Tokaanu that have geothermal bores, according to WRC bore consents and bore use surveys.

Table 20: Allocation of geothermal water and energy

Direct Users	Geothermal water allocated p.a. (tonnes)	Geothermal energy allocated (TJ)
Tourist accommodation bathing	834,000	271
Tourist pay bathing	3,592,000	1231
All other geothermal tourism sites	5,581,900	2800
Tourism subtotal	**10,007,900**	**4302**
Glass houses	55,780	1014
Primary and industrial processes	2,606,750	2800
Irrigation and frost protection	584,000	86
Commercial heating	1,252,000	320
Domestic heating	6,132,000	1724
Direct use subtotal	**10,630,530**	**5944**
TOTAL	**20,638,430**	**10,246**

10 Discussion

Geothermal resources in the Waikato region offer a range of benefits to local, national and international communities, and contribute to the economic, social, cultural and environmental wellbeing of the current and future generations. There is potential for tension between uses of geothermal – the most obvious being the generation of electricity and geothermal tourism – both of which contribute significantly to the Waikato regional economy.

In 2009 geothermal generation contributed $57 million (0.3 per cent) directly to GRP[39], and as geothermal power stations continue to be commissioned, this contribution will increase proportionately, along with the indirect and induced effects in the regional economy. Geothermal generation contributed to employment, with an estimated 80 jobs in the Waikato region, but with high indirect effects creating an additional 600 jobs through the impact of geothermal generation on other businesses. Other benefits of geothermal generation include reliability and consistency of supply, and relatively low long run marginal costs. These attributes will offer direct benefits to the national economy through security of supply and lower costs relative to other generation options (assuming a competitive market).

Geothermal tourism contributed an estimated $63 to $121 million (0.4 to 0.7 per cent) directly to GRP in 2009. Tourism numbers collected through surveying support assumptions underlying the multiplier analysis that produced these results. As with geothermal generation, the indirect and induced effects more than double this contribution. Modest tourism increases are forecast for 2016. Unlike geothermal generation where additional power stations have immediate effects on production due to existing demand, geothermal tourism does not have the ability to gain direct effects from increases in infrastructure – and demand appears to be closely linked to wider economic conditions. Levels of direct employment in geothermal tourism are at least 16 times higher than those for geothermal generation – tourism being a labour intensive industry, versus electricity generation being capital intensive. Much of the employment within tourism may be part-time. The indirect and induced impacts from geothermal tourism on employment are just 3 to 6 times higher than these effects for generation.

That the resource is important to the local, national and international community is evidenced by visitor numbers. Many more non-visitors may hold existence, altruistic and bequest values, which have been briefly described in this report. This is an aspect of the total value of this resource that should be considered by policy makers when making decisions between competing and exclusive uses.

While the Draft New Zealand Energy Strategy (Ministry of Economic Development, 2010c) is focusing on increased renewable generation, particularly from geothermal and wind, the estimated value of geothermal tourism and the wide range of other values associated with the geothermal resources suggest that it is imperative to carefully manage the growth of geothermal generation. Unsustainable management has occurred in the past. Examples include Wairakei where effects include ‘loss of pressure in the Tauhara field and the formation of steam zones over a large portion of the field, especially in the Karapiti area in which the 'Craters of the Moon' thermal area is situated’ (New Zealand Geothermal Association, 2010). Similarly, generation at the Ohaaki geothermal plant has resulted in ‘significant environmental effects’ including subsidence leading to flooding (New Zealand Geothermal Association, 2009). Although installed capacity at the Ohaaki plant was 104 MW, it is unable to be run at this level due to ‘field limitations’ caused by cold-water intrusion resulting from early pressure draw-down (Ministry of Economic Development, 2010c; New Zealand Geothermal Association, 2009; New Zealand Geothermal Association, 2010). There is potential for irreversible effects that may impact directly on the regional economy through tourism losses. Less easily quantified will be impacts on the range of ecosystem services

[39] GRP in 2009 was estimated to be $16,887 million (Market Economics Limited, 2010).

provided by geothermal resources, including cultural values. Losses would be borne by current and future generations.

While geothermal tourism is potentially a sustainable use, poorly managed tourism can produce negative outcomes that deplete cultural and ecosystem values held by the community. The costs of these outcomes may also fall on the tourism operators. The New Zealand Tourism strategic vision should assist in policy development, with its focus on New Zealand as a sustainable economy.

The relatively small amount of geothermal energy used for other direct uses continues to increase. Within these uses there is a wide range of efficiency of use. In the longer term, some of these direct uses may interfere with competing uses for this resource. Given the range of efficiency levels of different uses, the need for flexible policy that allows resource use to go to the highest value may need to be considered.

11 Conclusion

Geothermal resources are important to the people of the Waikato region. They contribute to economic, social, cultural and environmental wellbeing through a broad range of values. Demand for the resource is growing and supply is limited.

Geothermal generation and geothermal tourism each contributed to the regional economy both in terms of GRP and employment. The direct effects from these two uses are in terms of contribution to GRP and on a par, with generation contributing an estimated $56 million, and tourism contributing within a range of $38 to $70 million. The differences are more pronounced when indirect effects are taken into account. From tourism, these impacts are modest, increasing the contribution by 50 per cent. For generation, the increase is 173 per cent – indicating that the sectors directly connected to generation (for example supplying goods and services) also make an important contribution to the regional economy.

With employment, the differences between the two sectors in terms of direct effects are large – the MEC for tourism is 1298 to 2501, where for generation the MEC is just 80. Part-time work in the tourism sector may explain some of this difference. However, the difference is considerably reduced when indirect and induced effects are considered. The survey of employment in tourism showed considerably less that those estimated through the multiplier analysis – this is likely because of the wider range of tourism services included in the multiplier analysis.

The benefits of geothermal generation, including security of supply and relatively low long run marginal costs make it an attractive option for development to meet New Zealand's growing needs for electricity, however, while the operation of geothermal plants produces low levels of greenhouse gas emissions, the lifecycle emissions are high relative to other renewable energy sources.

Growth within the energy and tourism sectors will increase the monetary contribution to the regional economy. The increase in infrastructure in geothermal generation is likely to increase employment and the contribution of geothermal to the regional economy. However, increases in tourism infrastructure may not affect GRP.

While geothermal generation and tourism are not mutually exclusive, generation use has the capacity to impact on the value of the tourism, while increases in tourism spatially may impact generation development. Both uses produce negative externalities that can affect the wider values and benefits of the resource to the community at a local, national and international level.

The small but growing 'direct use' by industrial and domestic users also contributes to the regional economy. Direct uses of geothermal water and energy are a small but important economic factor for the Waikato region in terms of employment and a low-carbon energy source. While the value of these uses has not been assessed, the survey found that 544 people were employed through direct use. Monitoring direct uses will enable analysis of trends which could provide useful information to policy makers.

Ecosystem services and non-use values have been qualitatively described. Many of the ecosystem services have limited information available in terms of values, however monitoring indicators based on identified services will be useful to inform policy.

Twenty million tonnes of geothermal water and ten thousand TJ of geothermal energy are used in geothermal tourism, primary production, industry, and space heating.

The challenge for policy makers is in determining what combination of uses will achieve the highest level of net benefits, while avoiding irreversible effects that will impact negatively on the short- and long-term wellbeing of communities.

12 Glossary

Economic terms

Direct effects The activity of the sector (eg 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.

Load factor is the difference between how much the generator is designed to produce and how much it actually produces.

Modified employment count (MEC) Based on the EC and including estimates of the numbers of working proprietors for each industry type. Market Economics 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.

Energy terms

Gigawatt One billion watts or 1000 megawatts.

Gigawatt hours (GW h). A unit of energy (see MW h)

Kilowatt One thousand watts

Load factor Output compared to installed capacity.

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.[40]

Terajoule (TJ) A measurement unit of energy that is often used to express the energy content of fuels. 1 TJ = 0.278 GW h.[41]

[40] http://www.stat.fi/meta/kas/petajoule_en.html

[41] http://www.stat.fi/meta/kas/tj_en.html

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Appendices

Table 21: **Geothermal power stations in the Waikato region: Production as a percentage of capacity**

Geo-thermal system	Geo-thermal field	Owners	Capacity MWe	Average productive output[42] GWh/pa	Production /capacity %	Year built
Wairakei A & B	Wairakei	Contact Energy	143	1250		1958-63 / 1996
Ohaaki	Ohaaki	Contact Energy	114[43] (998.6 GW h)	550[44]	55.1	1989
Poihipi Road	Wairakei	Contact Energy	55 (481.8 GW h)	350	72.6	1996
Rotokawa	Rotokawa	MRP / Tauhara Nth no. 2 Trust	35 (306.6 GW h)	270	88.1	1997 / 2003
Mokai A & B	Mokai	Tuaropaki Power Co	111 (972.4 GW h)	930	95.6	2000 / 2005 / 2007
Wairakei Binary	Wairakei	Contact Energy	16 (140.2 GW h)	128	91.3	2005
Nga Awa Purua Plant	Rotokawa	MRP / Tauhara Nth No. 2 Trust	130 (installed capacity)	117 (est)	90.0	2010
Te Huka Binary (Tauhara I)	Tauhara	Contact Energy	23 (installed capacity)	21 (est)	90.0	2010
Te Mihi	Tauhara	Contact Energy	220[45]	198 (est)	90.0	Planned (consented)
Tauhara II	Tauhara	Contact Energy	250	225 (est)	90.0	Planned (consented)
Ngatamariki	Ngatamariki	MRP / Tauhara Nth No. 2 Trust	120	108 (est)	90.0	Planned (consented)46
Wairakei	Wairakei	Geotherm	55	50 (est)	90.0	[47] (consented)

Source: (New Zealand Geothermal Association 2010).

[42] Figures may differ between sources: NZGA provides actual average output; the power company provides installed capacity; WRC website provides estimate of output at time of installation. NZGA figures are used here.

[43] Although Ohaaki still has 114 MWe of plant installed on site, one turbine is now decommissioned, and others operate on restricted duty. Field limitations allow the station to generate around 60MWe (NZGA website http://www.nzgeothermal.org.nz/elec_geo.html 24 Feb 2011)

[44] End of 2007

[45] Proposed replacement plant for Wairakei, will generated an additional 60 MW, 220 MW (Installed capacity 250 MW). http://www.contactenergy.co.nz/web/pdf/our_projects/temihi/TeMihiFullTR1-ProjectDescriptionGeothermalPower.pdf

[46] Mighty River Power Annual Report 2010 http://www.mightyriver.co.nz/content/2557/Annual%20Report%202010%20FINAL.pdf

[47] In receivership (NZGE website http://www.nzgeothermal.org.nz/elec_geo.html 24 Feb 2011)