On behalf of the New Zealand Geothermal Association, it is with pleasure that we publish the **Geothermal Electricity Generation Activities report 2023** for the 2022 calendar year.

Aotearoa New Zealand's geothermal resources are widely used to generate low-carbon electricity to supply for national demand, and geothermal heat is also used directly to support residential, recreational, tourism, commercial and industrial-scale uses regionally.

This report covers the geothermal electricity generation activities for the 2022 calendar year.

Geothermal Electricity Activities in Aotearoa New Zealand

Aotearoa New Zealand has over 62 years of geothermal operations including electricity generation. Steam and power production has grown periodically with current development focused on reducing carbon emissions as part of Aotearoa New Zealand's energy transition.

1. Electricity Generation

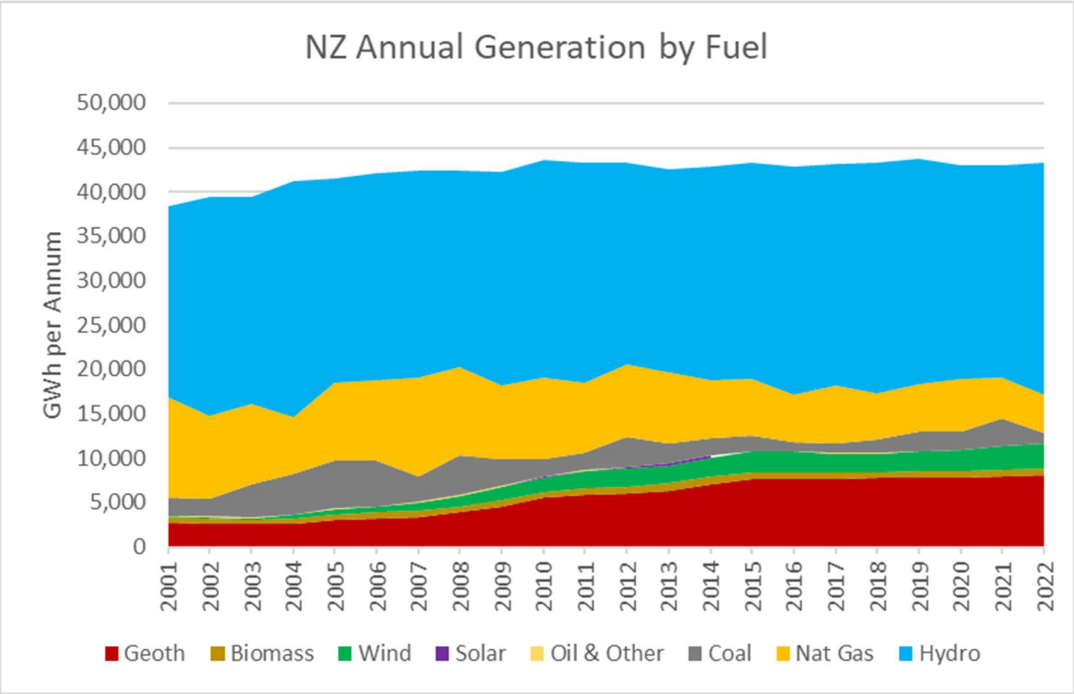
During the 2022 calendar year, geothermal operators in Aotearoa New Zealand generated 8.06 TWh from 20 power plants located over eight high-temperature fields. For this same year, geothermal resources contributed 18.5% of Aotearoa New Zealand's total electricity supply while all renewables generated 87% (Figure 1.1).

As temperature and conditions vary, the types of geothermal generation technologies employed to produce electricity span the spectrum from brine, heat-recovery binary plants, to 2-phase binary, to condensing steam turbines (single, double, and triple flash), and back-pressure turbines. Individual generation unit sizes range from 3.5 MWe up to 140 MWe (Ngā Awa Purua, Rotokawa – at one time the largest single-shaft geothermal turbine in the world).

Among the original equipment manufacturers for remaining operating plant, Ormat is the New Zealand market leader (384 MWe), followed by Fuji (300 MWe), Toshiba (160 MWe), British Thomson-Houston (139 MWe), Mitsubishi (42 MWe), and Others (8 MWe).

In 2022, geothermal electricity generation comes from five operators: Mercury NZ Ltd. (481 MWe), Contact Energy Ltd. (431 MWe), Ngāwhā Generation Ltd. (Top Energy) (56 MWe), Eastland Generation Ltd. (57 MWe), and Others (8 MWe). Three fields (Mōkai, Rotokawa, and Kawerau) have operations that are co-owned by local iwi (the Tuaropaki Trust, Tauhara North No 2 Trust, and Kawerau A8D Trust respectively). In addition, Ngāti Tūwharetoa Geothermal Assets (NTGA) own and operate part of the Kawerau steamfield and supply steam/heat to direct users, including the TOPP1 and GDL power stations (Eastland Generation Ltd.) and the KGL power station (Mercury NZ Ltd.).

Figure 1.1: Aotearoa New Zealand Annual Generation by Fuel (calendar years)



Source: Ministry of Business, Innovation, and Employment (MBIE)

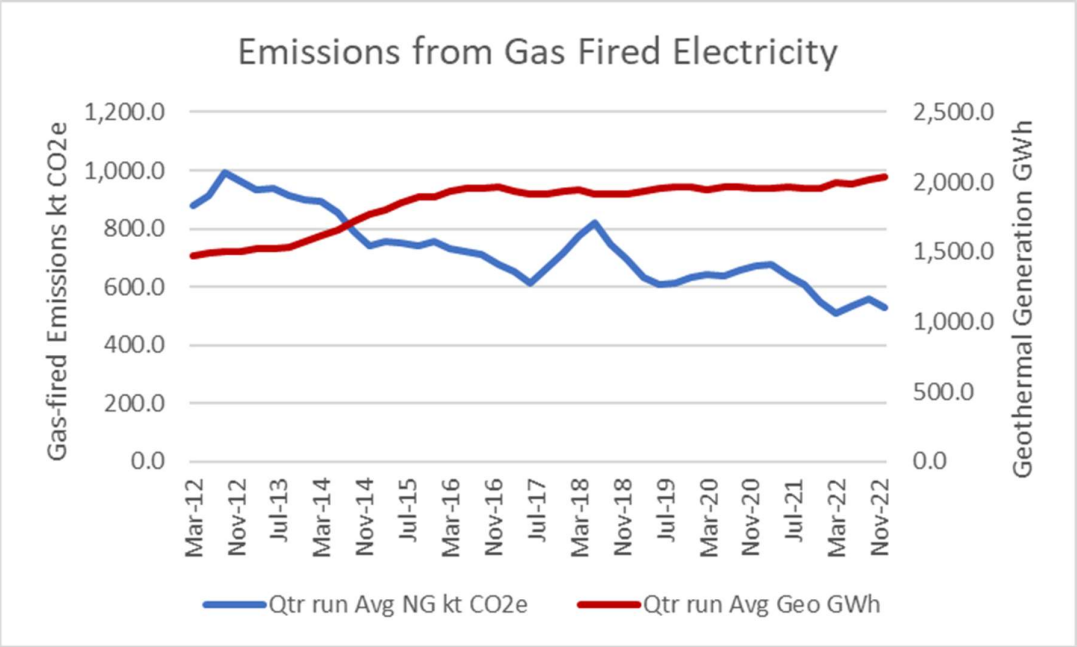
2. Decarbonising the Aotearoa New Zealand Electricity Market

In the Aotearoa New Zealand electricity market, new geothermal generation mainly displaces natural gas fired generation while coal generation mainly compensates for hydro flow variations.

In 2014, geothermal electricity generation overtook natural gas as the second largest source of electricity supply after hydro generators. Since that time, the incremental growth in geothermal electricity generation (and concurrent declines in geothermal emission intensity) has lowered the contribution of natural gas fired carbon emissions in electricity generation (Figure 2.1).

The base load character of geothermal electricity generation also helps stabilise system dispatch during periods of weather variability (affecting hydro, solar and wind).

Figure 2.1: NZ gas fuelled electricity emissions (running quarterly average) vs geothermal generation (same basis).



Source: Ministry of Business, Innovation and Employment (MBIE)

Note: the marked increase in quarterly adjusted emissions correspond to low hydro levels.

3. Evolution of Geothermal Electricity Generation Capacity

In 1958 the New Zealand Electricity Department commissioned the first turbine-generator at Wairakei. This was the second, large-scale geothermal electricity plant in the world and the first to exploit two-phase fluid via a flash plant (rather than dry steam). The impetus to develop Wairakei arose from severe electricity shortages caused by restricted hydro generation in the late 1940s, rapidly growing electricity demand, as well as a policy decision by the New Zealand Government to invest in generation that did not rely on imported fuel.

Geothermal development stagnated in the 1970s and 1980s, due to the emergence of the Maui Gas Field as a more economical fuel source for thermal generation. New capacity investment resurged in the 1990s with the corporatisation and subsequently deregulation of the New Zealand electricity market. The electricity reforms brought new parties to the geothermal industry including Māori enterprises, who own, develop, and operate geothermal assets.

Since 2000, geothermal operators have both refined (through de-rating and re-rating) and expanded the generation fleet in response to market and resource conditions. The activities under this adaptive philosophy are summarised in the table below.

Table 3.1: History of Geothermal Generation Capacity

Geothermal Plant Name	Current Owner	Commissioning Date	Installed Capacity (MWe)	Cumulative Capacity (MWe)
Wairakei	Contact Energy	1958-63	193	193
Kawerau	NST & NTGAL	1966	8	201
Wairakei	Contact Energy	1982	-36	165
Kawerau Binary (TG1)	Nova Energy & NTGAL	1989	2.4	167
Ohaaki	Contact Energy	1989	108	275
Kawerau Binary (TG2)	Nova Energy & NTGAL	1993	3.5	279
Wairakei BPT	Contact Energy	1996	5	284
Ohaaki Rerating	Contact Energy	1996	-10	274
Poihipi Road	Contact Energy	1996	50	334

Rotokawa A	Mercury NZ Ltd & TNT2	1997	29	353
Ngawha	Top Energy	1998	10	363
Mokai A	TPC	1999	55	418
Ohaaki Derating	Contact Energy	2001	-28	390
Rotokawa Upgrade	Mercury NZ Ltd	2003	6	396
Kawerau TA3 Decom	NST & NTGAL	2004	-8	388
Kawerau TA3a	NST & NTGAL	2004	8	396
Wairakei Binary	Contact Energy	2005	14	410
Mokai B	TPC	2005	39	449
Ohaaki Derating	Contact Energy	2005	-11	438
Mokai upgrade	TPC	2007	18	456
Ohaaki Rerating	Contact Energy	2007	11	467
Kawerau KGL	Mercury NZ Ltd	2008	100	567
KA24	Eastland Generation	2008	8	575

Ngawha OEC3	Top Energy	2008	15	590
Rotokawa Nga Awa Purua	Mercury NZ Ltd & TNT2	2010	140	730
Tauhara Te Huka	Contact Energy	2010	24	754
Te Huka upgrade	Contact Energy	2012	2	756
Kawerau TOPP1	Eastland Generation	2013	24	780
Nga Tamariki	Mercury NZ Ltd & TNT2	2013	82	862
Wairakei Te Mihi	Contact Energy	2014	160	1,022
Wairakei A derate	Contact Energy	2014	-34	988
Kawerau TG1 Retire	Nova Energy	2014	-2.4	985
Kawerau TG2 retire	Nova Energy	2017	-3.5	982
Ohaaki derate	Contact Energy	2017	-11	971
Kawerau KGL rerate	Mercury NZ Ltd	2017	7	978
Ohaaki derate	Contact Energy	2017	-6	972

Kawerau TAOM	Eastland Generation	2018	25	997
Ngawha OEC4	Top Energy	2021	31	1028
ROK NAP upgrade	Mercury NZ Ltd	2021	3	1031
ROK A upgrade	Mercury NZ Ltd	2021	2	1033

BPT – Back Pressure Turbine

KA – Kawerau

KGL – Kawerau Generation Limited

NAP – Nga Awa Purua

NTGAL – Ngati Tuwharetoa Geothermal Assets Ltd.

OEC – Ormat Energy Converter

ROK – Rotokawa

TA – turbo-alternator

TAOM – Te Ahi O Māui

TG – Tarawera Generation

TOPP – Tarawera Ormat Power Plant

TPC – Tuaropaki Power Company

TN2T – Tauhara North No. 2 Trust

NST – Norske Skog/Tasman Pulp and Paper

4. New Geothermal Electricity Generation Developments

Responding to Aotearoa New Zealand's decarbonisation strategy, geothermal developers have 371 MWe either in construction or in development (see tables 4.1 and 4.2 below). This potentially will increase geothermal power generation by 36% to 11 TWh.

The announcements of Resource Management Act reform and the development of New Zealand Energy Strategy to adapt to the impacts of climate change and reduce greenhouse gas emissions domestically, is stimulating the exploration of greenfield projects and supporting High-Voltage transmission expansion to allow new capacity.

Table 4.1: Projects Under Construction

Field/Project	Capacity (MWe)	OEM	Forecast COD	Developer	Comments
Tauhara	184 CST-TF	Fuji Electric	2023	Contact Energy	Commissioning to begin in June
Tauhara Te Huka U3	50 ORC	Ormat	2024	Contact Energy	Civil works and design underway.

COD – Commercial Operation Date

CST-TF – Condensing Steam Turbine – Triple Flash

OEM – Original Equipment Manufacturer

Table 4.2: Projects Under Development

Field/Project	Capacity (MWe)	Forecast COD	Developer	Comments
Nga Tamariki OEC5	37 ORC	2026	Mercury Energy Ltd.	FEED ongoing
Ngawha OEC5	30 ORC	2025	Ngawha Generation Ltd.	FEED ongoing
Wairakei repower	45 ?	2026	Contact Energy Ltd.	WRK A & B to retire; new plant at Te Mihi; FEED ongoing
TOPP2	25 ORC	2025	Eastland Generation ltd. & Ngati Tuwharetoa Geothermal Assets	FEED ongoing

Table 4.3: Potential Greenfield Projects

Field/Project	Capacity (MWe)	Forecast COD	Developer	Comments
Taheke A	30	2027	Eastland Generation Ltd. & Taheke 8C Inc.	Concept design & permitting
Tikitere A	45	2028	Ormat & Tikitere Power Company	Awaiting litigation
Rotoma A	15	2029	Tuara Matata collective	Recon exploration

In addition to these specific projects, the Ministry of Business Innovation and Employment is funding studies on the merits of using additional geothermal resources to back-up hydro generation during dry years, as part of the "New Zealand Battery" project. The concept contemplates installing up to 400 MWe of new geothermal generation (ahead of planned market supply) for dry year operation.

Acknowledges

The New Zealand Geothermal Association wish to express our gratitude to all those who guided us in preparing for this annual report. We would like to thank those who provided information, data, knowledge during meetings, discussions, and reviews. The insight and expertise have been invaluable to us.

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