UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

INTERNATIONAL CENTER
ON SMALL HYDROPOWER

World Small Hydropower Development Report 2022

Australia and New Zealand

Disclaimer

The World Small Hydropower Development Report 2022 is jointly produced by the United Nations Industrial Development Organization (UNIDO) and the International Center on Small Hydro Power (ICSHP) to provide development information about small hydropower.

Suggested citation:

UNIDO, ICSHP (2022). *World Small Hydropower Development Report 2022*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR2022.

ISSN: 2406-4580 (print)
ISSN: 2706-7599 (online)

The digital copy is available at www.unido.org/WSHPDR2022.

Design: red not 'n' cool
Cover Picture: depostihphotos

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Acknowledgements

The World Small Hydropower Development Report 2022. was prepared under the overall guidance of Tareq Emtairah, Director of the Division of Decarbonization and Sustainable Energy, Petra Schwager-Kederst, Chief of the Division of Climate and Technology Partnerships at the United Nations Industrial Development Organization (UNIDO) and LIU Deyou, Director General of the International Center on Small Hydropower (ICSHP).

The preparation of this thematic publication was headed by LIU Heng, Senior Technical Advisor at UNIDO and consulted by HU Xiaobo, Chief of the Division of the Multilateral Development at ICSHP. The work was coordinated by Oxana Lopatina at ICSHP and Eva Krēmere at UNIDO. The publication is the result of three years of intense research work and was backed by a talented and indispensable team of researchers at ICSHP and a vast number of experts in the field of small hydropower

WSHPDR2022 team

Head	LIU Heng — Senior Technical Advisor, United Nations Industrial Development Organization (UNIDO)
Coordinators	Oxana Lopatina — International Center on Small Hydro Power (ICSHP)
	Eva Krēmere — United Nations Industrial Development Organization (UNIDO)
Team	UNIDO: Eva Krēmere, Sanja Komadina. Interns: LIU Fangjie, REN Wenxuan
	ICSHP: HU Xiaobo, Oxana Lopatina, Danila Podobed, Alicia Chen Luo, Veronika Spurna, Tamsyn Lonsdale-Smith, Bilal Amjad, Oluwatimilehin Paul Olawale-Johnson, Davy Rutajoga, Laura Stamm, Ruize Yuan, BAO Lina, ZHANG Yingnan, Yan Ding

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Australia and New Zealand

Countries: Australia, New Zealand

INTRODUCTION TO THE REGION

The electricity sector of Australia is spread over the expanse of the Australian mainland; the electricity grids of Queensland, New South Wales, Victoria, Tasmania and South Australia are interconnected into the National Electricity Market (NEM), but Western Australia is serviced by a separate Wholesale Electricity Market (WEM). There are many electricity transmission companies in the country, and market regulations as well as tariffs vary widely by territory. By contrast, the New Zealand electricity grid is fully interconnected. Even following a degree of decentralization, the nationwide transmission operator Transpower remains state-owned, the Government maintains a controlling stake in four of the five major electricity producers and there is little variation in electricity tariffs across the country.

Generation of electricity in Australia is dominated by fossil fuels, which accounted for 58 per cent of installed capacity in 2021 and 76 per cent of generation in 2020. Recent development in renewable energy sources has primarily targeted wind and solar power, which had both overtaken hydropower in electricity generation by 2020. Hydropower in Australia plays a supporting role. Despite considerable installed capacity, generation from hydropower has been on a continuous decline in recent years, decreasing by approximately 23 per cent between 2013 and 2020. In New Zealand, hydropower forms the mainstay of electricity generation, accounting for 57 per cent of installed capacity and 56 per cent of generation in 2020. Gas- and coal-fired thermal power plays a supporting role, with a significant share of its installed capacity on stand-by to balance loss of hydropower generation in dry years. New Zealand is also a leading global user of geothermal energy.

An overview of key indicators in the electricity sectors of Australia and New Zealand is provided in Table 1.

Table 1. **Overview of Australia and New Zealand**

Country	*Total population (million people)*	*Electricity access, total (%)*	*Electricity access, rural (%)*	*Total installed capacity (MW)*	*Electricity generation (GWh/year)*	*Hydropower installed capacity (MW)*	*Hydropower generation (GWh/year)*
Australia	26	100	100	56,284	265,232	8,130	14,807
New Zealand	5	99	99	9,505	42,845	5,389	23,988
Total	**-**	**-**	**-**	**65,789**	**-**	**13,519**	**-**

Source: *WSHPDR 2022*[1]

Note: Data in the table are based on data contained in individual country chapters of the *WSHPDR 2022*; years may vary.

REGIONAL SMALL HYDROPOWER OVERVIEW

The definition of small hydropower (SHP) in Australia includes plants with an installed capacity of ≤ 10 MW. In New Zealand, there is no formal definition of SHP and no regulatory measures governing SHP specifically, but plants with an installed capacity of ≤ 50 MW are customarily considered SHP plants.

A comparison of installed and potential SHP capacities in the region is provided in Table 2.

Table 2. Small Hydropower Capacities in Australia and New Zealand (MW)

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed capacity (<10 MW)*	*Potential capacity (<10 MW)*
Australia	≤ 10 MW	175.0	N/A	175.0	175.0*
New Zealand	≤ 50 MW	475.0	N/A	146.8	489.8
Total	-	-	-	**321.8**	**664.8**

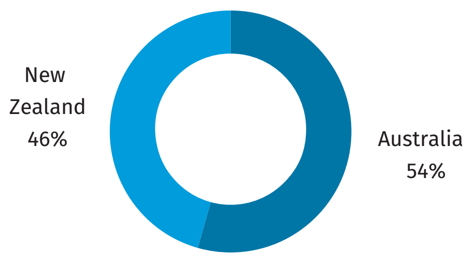
Source: *WSHPDR 2022*[1]

Note: *Based on installed capacity, as no data on potential capacity is available.

The total installed capacity of SHP ≤ 10 MW in Australia and New Zealand is 321.8 MW, while potential capacity is estimated at 664.8 MW. Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, the total installed SHP capacity in Australia and New Zealand has decreased by approximately 2 per cent, while the estimated potential capacity decreased by 16 per cent. In both countries, SHP accounts for only a small share of the total installed capacity of hydropower. For SHP ≤ 10 MW, this share is equal to 2 per cent in Australia and 3 per cent in New Zealand. However, given the greater prominence of hydropower in the energy mix of New Zealand, SHP plays a proportionately greater role in its electricity sector. Little or no new SHP development has occurred in Australia since 2014, while in New Zealand, recent activity has been mostly limited to the renovation of existing SHP plants rather than the construction of new plants. With no reliable data on remaining undeveloped SHP potential in Australia, the SHP sector in the country can be considered at full capacity, but considerable undeveloped SHP potential remains in New Zealand.

The national share of regional installed SHP capacity by country is displayed in Figure 1, while the share of total national SHP potential utilized by Australia and New Zealand is displayed in Figure 2.

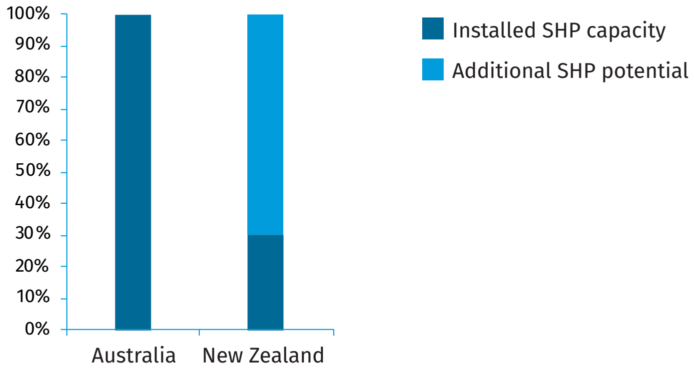
Figure 1. **Share of Regional Installed Capacity of Small Hydropower by Country in Australia and New Zealand (%)**



Source: *WSHPDR 2022*[1]

Note: For SHP ≤ 10 MW.

Figure 2. **Utilized Small Hydropower Potential by Country in Australia and New Zealand (%)**



Source: *WSHPDR 2022*[1]

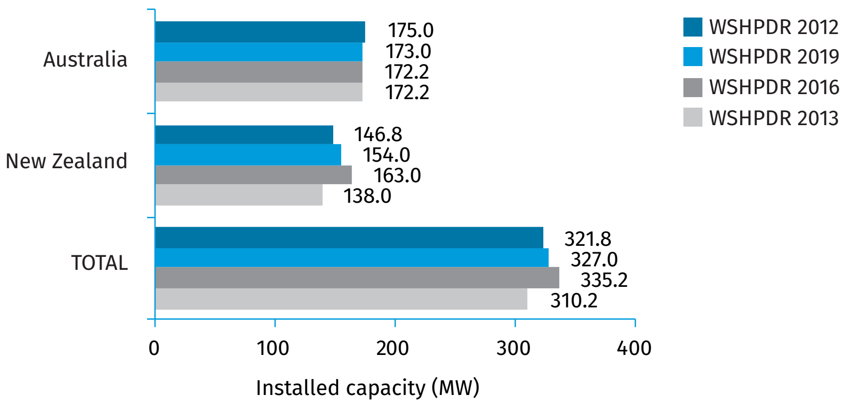
Note: For SHP ≤ 10 MW.

The total installed capacity of SHP ≤ 10 MW in **Australia** is 175 MW from approximately 65 plants. The installed capacity of SHP in the country has changed little since 2014, with different estimates contained in different editions of the *WSHPDR* reflecting differences in data quality rather than actual changes in installed capacity. No nationwide estimates of SHP potential in the country are available. Local inventories of hydropower potential on rivers undertaken by regional governments suggest a significant theoretical potential in parts of the country, for example, ≤ 1,000 MW in New South Wales. However, little or none of this potential is socially or environmentally feasible due to water scarcity issues and potential impacts on fish populations and the consequent social opposition to further hydropower development.

In **New Zealand**, the total installed capacity of SHP ≤ 10 MW is 146.8 MW, while under the local definition of SHP ≤ 50 MW, it is 475 MW. Undeveloped potential for SHP ≤ 10 MW has been estimated at 343 MW, bringing the total potential capacity to 489.8 MW if existing installed capacity is included. This suggest that approximately 30 per cent of the existing potential for SHP ≤ 10 MW has been developed so far. The SHP sector of New Zealand had once seen robust development, driven in part by the efforts of local communities to build and operate SHP plants for their own needs. However, in recent years, activity in the sector has been scarce and mostly focused on the renovation or reconstruction of existing SHP plants, with total installed capacity decreasing by approximately 10 per cent relative to the *WSHPDR 2016* as part of this process. In 2020, one new SHP plant with an installed capacity of 4 MW was commissioned and another 1.9 MW project was approved for construction.

Changes in the installed SHP capacities of countries in the region are displayed in Figure 3.

Figure 3. **Change in Installed Capacity of Small Hydropower from *WSHPDR 2013* to *WSHPDR 2022* by Country in Australia and New Zealand (MW)**



Source: *WSHPDR 2022*,[1] *WSHPDR 2013*,[2] *WSHPDR 2016*,[3] *WSHPDR 2019*[4]

Note: For SHP ≤ 10 MW.

Climate Change and Small Hydropower

Climate change presents an additional challenge to SHP development in the region. Australia concentrates hydropower generation in the south-eastern region and Tasmania. These regions have experienced a 25 per cent decrease in rainfall since 1970. However, the net summer rainfall has increased across the country, increasing the regional and seasonal differences. Similarly, New Zealand expects to experience increased variability in precipitation and inflow. The higher variability could challenge SHP plants' performance and lead to generation shortfalls in the summer months, while still meeting the electricity demand in winter.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Renewable energy projects in **Australia** are incentivized through the sale of renewable energy generation certificates by generators to electricity retailers, but no measures target SHP development specifically. While future SHP development on natural watercourses in Australia is unlikely, hidden SHP potential exists on manmade water supply infrastructure including irrigation canals, existing non-powered dams, water mains, pressure break tanks, and outflow from industrial sites. The development of SHP at such sites could be attractive for commercial and non-commercial entities for the purpose of self-consumption. However, no estimates of such hidden SHP potential are available.

The biggest obstacles to further SHP development in **New Zealand** are environmental considerations and restrictive environmental legislation in particular. Incentives exist in the form of a carbon trading scheme for financing renewable energy investments, as well as an Avoided Cost of Transmission (ACOT) payments available to SHP producers in particular. These, coupled with rising electricity prices stemming from the ban on gas exploration, could energize future SHP development in the country.

References

1. UNIDO, ICSHP (2022). *World Small Hydropower Development Report 2022*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
2. UNIDO, ICSHP (2013). *World Small Hydropower Development Report 2013*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
3. UNIDO, ICSHP (2016). *World Small Hydropower Development Report 2016*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
4. UNIDO, ICSHP (2019). *World Small Hydropower Development Report 2019*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.

Australia

Niels Nielsen, Kator Research Services, and Danila Podobed, International Center on Small Hydro Power (ICSHP)

KEY FACTS

Population	25,739,256 (2021)[1]
Area	7,688,287 km^2 (including islands)[2]
Topography	There are few mountains in Australia, with the exception of the Great Dividing Range, which reaches from Queensland to Victoria, with other parts of the country situated at low elevations. The highest point in the country is Mount Kosciusko (2,228 metres) and the lowest is Lake Eyre (-15 metres).[3]
Climate	The climate in the central part of Australia is arid, temperate along the southern coastal regions and tropical in the north of the country. Conversely, some mountainous regions experience cool winters and snow. The maximum temperature ranges from 18 °C to 40 °C and minimum temperature ranges from 3 °C to 21 °C, with a mean of 12–27 °C and a minimum range of 3–21 °C.[4]
Climate Change	The annual average temperature in Australia has increased by 1°C since 1910, with much of the increase having taken place since 1950. The period of 2013–2016 was marked by four of the five warmest years on record in the country. Projected climate change includes an increase in the number of extremely hot days and days conducive to wildfires, especially in southern and eastern Australia, while rainfall is expected to decrease across the southern part of the country in the winter and spring seasons.[5]
Rain Pattern	Rain patterns are monsoonal in the north and variable elsewhere.[3] Annual rainfall ranges from more than 3,000 mm to less than 100 mm.[6]
Hydrology	The largest water system in Australia is the Murray-Darling basin, which rises in New South Wales and Queensland, flows through Victoria and enters the sea in South Australia. Hydropower plants have been built along the Snowy River system in New South Wales and Victoria, as well as in Tasmania, but many of the country's rivers are ill-suited for major hydropower development.

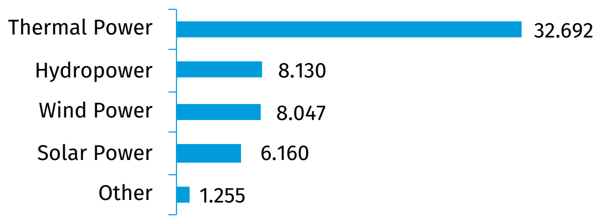
ELECTRICITY SECTOR OVERVIEW

The electricity sector of Australia is undergoing a paradigm shift. New wind and solar photovoltaic (PV) power capacity is being built at a rate of approximately 5 GW per year, which is sufficient to exceed the target of 70 per cent of total installed capacity to be provided by renewable energy sources (RES) by 2030. Wind and solar power comprise virtually 100 per cent of newly commissioned generation capacity and are replacing retiring coal and gas power plantss.[7,8] Despite these developments, as of 2021 generation from fossil fuels still formed the mainstay of the electricity sector.[9]

The contribution of hydropower to the country's total renewable energy generation has fallen significantly in recent years, largely due to the rapid rise of wind and solar power. However, with several large pumped storage projects being planned or already under construction as of 2022, the technology will continue to play a vital role in the clean energy future of Australia.[8]

The total installed capacity of producers operating within the National Electricity Market (NEM) of Australia amounted to 56,284 MW at the end of 2021, with thermal power including coal-fired, gas-fired and oil-fired power plants contributing 32,692 MW (58 per cent) of the total, hydropower contributing 8,130 MW (14 per cent), wind power contributing 8,047 MW (14 per cent), solar power contributing 6,160 MW (11 per cent) and other sources contributing 1,255 MW (2 per cent) (Figure 1).[9] However, some additional capacities operate separately on the Wholesale Electricity Market (WEM), with a total registered generation capacity of approximately 6 GW.[10]

Figure 1. **Installed Electricity Capacity by Source in Australia in 2021 (MW)**

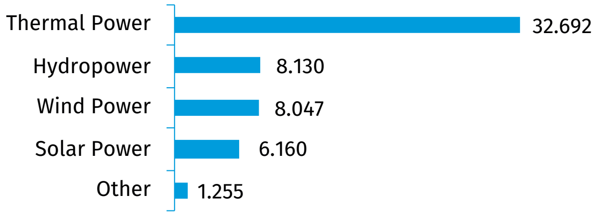


Source: AER[9]

Note: Data on NEM only.

Electricity generation in Australia reached 265,232 GWh in 2020, with thermal power from fossil fuels providing 200,566 GWh (nearly 76 per cent) of the total, large- and small-scale solar power providing 23,842 GWh (9 per cent), wind power providing 22,607 GWh (9 per cent), hydropower providing 14,807 GWh (6 per cent) and bioenergy providing 3,410 GWh (1 per cent) (Figure 2). A significant portion of the generated electricity, 16 per cent nationwide and ≤ 55 per cent in certain regions, was generated off-grid by self-consumers, including households, mining and manufacturing.[11]

Figure 2. **Annual Electricity Generation by Source in Australia in 2020 (GWh)**



Source: Department of Industry, Science, Energy and Resources[11]

Generation from hydropower has been steadily declining in recent years, decreasing by approximately 23 per cent between 2013 and 2020. At the same time, the hydropower sector plays a critical role in Australia in balancing generation from variable energy sources. Several large pumped-storage hydropower (PSH) projects are currently in development or planning stages, the most significant being the 2,000-MW Snowy 2.0 PSH plant and the Battery of the Nation PSH project with a planned capacity of approximately 2,500 MW.[8,12,13] The prospects for the development of additional river-based hydropower plants in Australia are quite limited.

Many coal-fired power plants in Australia are reaching their end of life and at least two thirds are expected to be retired within the next 20 years.[14] The cheapest replacement is likely to be solar and wind power, which means that the current high deployment rates of these technologies are likely to increase.[15, 16] At the end of 2020, 76 new large-scale wind and solar power projects were under construction in the country, representing 8 GW of planned capacity.[8]

The rate of electricity access in Australia is 100 per cent.[17] During the 2020–2021 financial year, domestic consumption of electricity in the NEM amounted to 188.6 TWh, decreasing from 192.4 TWh in the 2019–2020 financial year, while peak demand reached 31,945 MW.[18,19]

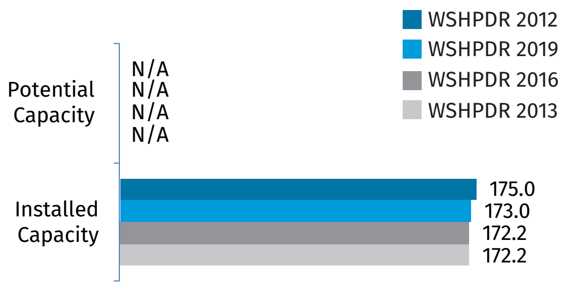
Tariffs for electricity consumers in Australia are highly variable and depend on the territory, provider and category of consumer, typically including a fixed charge and a variable charge based on consumption volume. The electricity market is deregulated in some regions but regulated in others where Government-owned companies act as the primary electricity provider (such as Western Australia and the Northern Territory). Tariffs in New South Wales, south-east Queensland and South Australia are partially regulated by the Electricity Retail Code, introduced in 2019. The Code provides a reference price for consumers, thus informing the retail prices set by providers.[20,21,22]

The NEM of Australia previously operated with a 30-minute settlement window. Many industry players lobbied for this window to be shortened to five minutes, arguing the change will result in lower prices for wholesale electricity and eventually lower prices for consumers, which would favour new market entrants. The switch to 5-Minute Settlement (5MS) took place on 1 October 2021. It is expected that the change will additionally favour certain fast-response energy technologies, including hydropower, that can increase or decrease output within a five-minute window, at the expense of existing coal- and gas-fired power plants which cannot.[23,24]

SMALL HYDROPOWER SECTOR OVERVIEW

Small hydropower (SHP) is defined in Australia as hydropower plants with an installed capacity of ≤ 10 MW. While more than 75 per cent of the installed hydropower capacity of Australia comes from large hydropower, there were approximately 65 SHP plants operating in the country as of 2014, with a total installed capacity of slightly over 175 MW.[25] No new data on SHP capacities in the country have been made publicly available since then. The 1 per cent increase in installed capacity of SHP relative to the *World Small Hydropower Development Report (WSHPDR) 2019* is a result of access to more accurate data. No reliable estimates of SHP potential in the country are available (Figure 3).[26]

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Australia (MW)**



Source: Geoscience Australia & BREE,[25] *WSHPDR 2019*,[26] *WSHPDR 2013*,[27] *WSHPDR 2016*[28]

The theoretical SHP potential for Australia has not been quantified, though it is understood that some individual energy companies have undertaken local inventories. There are also some historic regional assessments of larger hydropower schemes that include some SHP sites. For example, the 2013 Renewable Energy Action Plan issued by the Government of New South Wales suggests a potential hydropower capacity of 1,000 MW in the state, mostly pertaining to small and mini-hydropower.[29] However, it is unlikely that any new hydropower plants will be developed in the country in the near future. This is primarily because of environmental and social considerations as well as the sporadic and unpredictable weather patterns in much of the country. As an example, the Murray-Darling River basin has many sites that could be suitable for SHP from a technical perspective, but the potential environmental impact (mainly on fish) precludes them from development.[30]

The most realistic direction for ongoing and future development of SHP in Australia lies in the so-called "hidden and untapped hydropower opportunities", referring to methods of increasing generation from hydropower at new and existing project sites that are often overlooked. These methods include development of new equipment in low-head applications, improvements to the efficiency of existing generating units as well as the addition of generating units to previously non-powered infrastructure including non-powered dams, drainage and irrigation canals, water distribution pipelines and outflow from industrial sites. One proposed application involves the addition of hydropower turbines at the inlets of pressure break tanks used in the mining sector to manage overpressure in the mine water supply system. Such units, representing an energy recovery system that would produce significant electricity cost savings for the operating company, could realistically possess an installed capacity of nearly 13 kW and generate as much as 110 MWh of electricity annually per unit, depending on the duration of tank inflow. Total energy recovery for a typical mining operation through the uniform application of this technology is estimated at ≤ 300 kW, translating into ≤ 2.5 GWh of electricity annually.[31]

RENEWABLE ENERGY POLICY

The development of RES in Australia is realized under the framework established by the Renewable Energy Target (RET), a set of mechanisms and thresholds for large- and small-scale RES promotion underpinned by the Renewable Energy Act 2000. The Large-scale Renewable Energy Target (LRET) incentivizes large RES projects through the creation and sale of large-scale generation certificates (LGCs), carried out by the licensed generators themselves and purchased by entities with liabilities under the LRET scheme, mainly electricity retailers. An analogous small-scale generation certificate (SGC) scheme is in place for small-scale RES producers such as individual households, who typically assign the right to issue certificates to an agent in return for a lower price on the RES system at the time of purchase.[32] The RET for annual generation from RES was set to increase steadily to 33 TWh by 2020 and is to be maintained at this level for the next decade (until 2030).[33]

In the absence of an updated Federal RET for 2020 onwards, several states and territories have legislated their own RETs. Table 1 displays the RET of each territory or state, expressed as a share of generation produced by RES.

Table 1. **Renewable Energy Targets in Australia**

State or territory	*Renewable Energy Target (%)*	*Year*
Australian Capital Territory	100	2020
Victoria	50	2030
Queensland	50	2030
Northern Territory	50	2030
South Australia	75 (RET), 25 (Storage)	2025
New South Wales	No RET, but has a target for zero emissions	2050
Western Australia	No target adopted	N/A

Source: ACT Government,[34] State Government of Victoria,[35] Queensland Government,[36] Territory Renewable Energy,[37] Slezak,[38] Parkinson,[39] Perpitch[40]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Climate change in Australia has led to significant drying in parts of the country, particularly in southern Australia, with a 19 per cent decrease in rainfall observed since 1970 and a 25 per cent decrease since 1996, relative to the long-term average. At the same time, net summer rainfall across the continent has increased over the last 30 years, particularly in the northern part of the country. The ongoing changes are likely to increase the regional and seasonal differences in rainfall in a country that already experiences high levels of variability in precipitation.[5]

Hydropower generation in Australia has been experiencing a steady decline since the early 2000s due to drought and variability in rainfall, decreasing at a rate of over 4 per cent a year between 1999 and 2008, while the hydropower share in total generation has been declining since the late 1970s. According to one study, generation from hydropower in 2029-2030 is expected to remain at 2007–2008 levels but will continue to lose ground to other energy sources as a share of total generation, making up just over 3 per cent of generation by 2030 despite ongoing development.[41]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Opportunities for SHP development on rivers and streams in Australia are limited. The barriers to the development of SHP in the country include the following:

- Small hydraulic heads lead to expensive generation that is unable to compete with wind and solar power;
- Negative environmental impacts, such as the impact on aquatic flora and fauna, restrict the availability of sites for SHP development;

- Hydrology is unpredictable and unsuitable for SHP, with unreliable river flows, droughts and floods;
- No reliable nationwide data on SHP potential;
- Climate change causing a decrease in overall hydropower generation potential;
- Social opposition to dam construction.

Enablers for SHP development in Australia include:
- The potential for the development of off-river SHP, particularly on existing water supply infrastructure in municipal systems, the mining sector and elsewhere;
- Progressive regional policies favouring RES development;
- Demand for SHP development by commercial and non-commercial entities for self-consumption.

REFERENCES

1. Australian Bureau of Statistics (2021). *National, state and territory population*. Available at https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/jun-2021 (Accessed 7 February 2022).
2. Geoscience Australia (n.d.). *Area of Australia - States and Territories*. Available at http://www.ga.gov.au/scientific-topics/national-location-information/dimensions/area-of-australia-states-and-territories (Accessed 7 February 2022).
3. Commonwealth of Australia (n.d.). *The Australian continent.* Available at https://www.australia.gov.au/about-australia/our-country/the-australian-continent (Accessed 7 February 2022).
4. Australian Government Bureau of Meteorology (2016). *Average annual & monthly maximum, minimum, & mean temperature*. Available at http://www.bom.gov.au/jsp/ncc/climate_averages/temperature/index.jsp?maptype=3&period=an#maps (Accessed 7 February 2022).
5. Department of the Environment and Energy (2017). *Australia's 7th National Communication on Climate Change.* Available at https://unfccc.int/sites/default/files/resource/0512739_Australia-NC7-BR3-3-Aus%20NC7%20BR3.pdf (Accessed 7 February 2022).
6. Australian Government Bureau of Meteorology (2020). *Average annual, seasonal and monthly rainfall.* Available at http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp (Accessed 7 February 2022).
7. Blakers, A. & Stocks, M. (2018). *Solar PV and wind are on track to replace all coal, oil and gas within two decades*. Available at https://theconversation.com/solar-pv-and-wind-are-on-track-to-replace-all-coal-oil-and-gas-within-two-decades-94033 (Accessed 7 February 2022).
8. Clean Energy Council (2021). *Clean Energy Australia Report 2021*. Available at https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2021.pdf (Accessed 7 February 2022).
9. Australian Energy Regulator (AER) (2021). *Registered capacity by fuel source – regions*. Available at https://www.aer.gov.au/wholesale-markets/wholesale-statistics/registered-capacity-by-fuel-source-regions (Accessed 7 February 2022).
10. Australian Energy Market Operator (AEMO) (n.d.). *About the Wholesale Electricity Market (WEM).* Available at https://www.aemo.com.au/energy-systems/electricity/wholesale-electricity-market-wem/about-the-wholesale-electricity-market-wa-wem (Accessed 18 May 2022).
11. Department of Industry, Science, Energy and Resources (2021). *Australian Energy Update 2021*. Australian Energy Statistics, September 2021, Canberra. Available at https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Statistics%202021%20Energy%20Update%20Report.pdf (Accessed 7 February 2022).
12. SnowyHydro (n.d.). *About Snowy 2.0.* Available at https://www.snowyhydro.com.au/snowy-20/about/ (Accessed 18 May 2022).
13. Australian Renewable Energy Agency (ARENA) (n.d.). *Battery of the Nation – A Concept Study of Tasmanian Pumped Hydro Options*. Available at https://arena.gov.au/projects/battery-of-the-nation/ (Accessed 18 May 2022).
14. Commonwealth of Australia (2017). *Retirement of coal fired power stations Final report*. Available at https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Coal_fired_power_stations/Final_Report (Accessed 7 February 2022).
15. Australian Energy Market Operator (AEMO) (2018). Generation information. Available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information (Accessed 7 February 2022).
16. Parkinson, G. (2017). *Solar's trillion-dollar market: Driven by EVs, microgrids and cost parity for storage*. Available at http://reneweconomy.com.au/solars-trillion-dollar-market-driven-evs-microgrids-cost-parity-storage-13315/ (Accessed 7 February 2022).
17. World Bank (n.d.). *Access to electricity (% of population) – Australia*. Available at https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=AU (Accessed 7 February 2022).
18. Australian Energy Regulator (AER) (2021). *Annual electricity consumption - NEM*. Available at https://www.aer.gov.au/wholesale-markets/wholesale-statistics/annual-electricity-consumption-nem (Accessed 7 February 2022).
19. Australian Energy Regulator (AER) (2021). *Seasonal peak demand - NEM*. Available at https://www.aer.gov.au/wholesale-markets/wholesale-statistics/seasonal-peak-demand-nem (Accessed 7 February 2022).
20. Australian Energy Regulator (AER) (n.d.). *Tariff and fees explained*. Available at https://www.aer.gov.au/consumers/my-energy-bill/tariff-and-fees-explained (Accessed 7 February 2022).
21. Australian Competition and Consumer Commission (ACCC) (n.d.). *Electricity prices & plans*. Available at https://www.accc.gov.au/consumers/health-home-travel/electricity-prices-plans#more-about-the-electricity-retail-code (Accessed 7 February 2022).
22. Compare the Market (n.d.). *Explaining energy deregulation.* Available at https://www.comparethemarket.com.au/energy/understanding-deregulation/ (Accessed 7 February 2022).

23. Parkinson, G. (2017). *AEMC confirms 5-minute settlement to begin in 2021*. Available at http://reneweconomy.com.au/aemc-confirms-5-minute-settlement-to-begin-in-2021-2021/ (Accessed 7 February 2022).
24. Australian Energy Market Operator (AEMO) (n.d.). *Five Minute Settlement and Global Settlement*. https://aemo.com.au/initiatives/major-programs/nem-five-minute-settlement--program-and-global-settlement (Accessed 8 February 2022).
25. Geoscience Australia & the Bureau of Resources and Energy Economics (BREE) (2014). *Australian Energy Resource Assessment, Second Edition*. Available at https://arena.gov.au/assets/2018/08/australian-energy-resource-assessment.pdf (Accessed 8 February 2022).
26. UNIDO, ICSHP (2019). *World Small Hydropower Development Report 2019*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
27. UNIDO, ICSHP (2013). *World Small Hydropower Development Report 2013*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. (2013). Available at www.unido.org/WSHPDR.
28. UNIDO, ICSHP (2016). *World Small Hydropower Development Report 2016*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
29. New South Wales Government (2013). *NSW Renewable Energy Action Plan*. Available at https://energy.nsw.gov.au/sites/default/files/2018-09/nsw-renewable-energy-action-plan_2013.pdf (Accessed 18 May 2022).

New Zealand

Bryan Leyland, Consulting Engineer

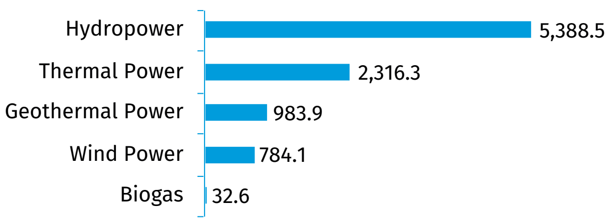
KEY FACTS

Population	5,000,000 (2020)[1]
Area	268,838 km^2[2]
Topography	The country comprises the North and South Islands, Stewart Island, the Chatham Islands and some small islands further north and south. The topography is generally hilly with several volcanoes and associated features such as hot springs. There is a major mountain range (the Southern Alps) running the length of the South Island. Mount Cook, the highest mountain, is 3,724 metres high.[2]
Climate	The climate of New Zealand is complex and varies from warm subtropical in the far north to cool temperate in the far south, with severe alpine conditions in the mountainous areas. The mean annual temperatures vary from 10 °C in the south to 16 °C in the north and temperatures generally drop by 7 °C for every 100 metres in altitude.[3]
Climate Change	The effects of climate change in New Zealand have already been felt in the form of rising sea levels. Under severe climate change scenarios, the country would experience increased periods of heavy rainfall and more variation in mean precipitation, an increase in the number of dry and hot days as well as a decrease in the number of cold nights (minimum temperature of 0 °C or lower). By 2040, mean temperatures are projected to increase by 0.7-1 °C and by 0.7-3 °C by 2090.[4]
Rain Pattern	Rainfall is reasonably steady during the year and usually reaches a maximum in late winter and early spring. Autumn and early winter are often dry. Rainfall ranges from 600 mm to 1,600 mm per year. There is little indication that it is affected by climate change.[5]
Hydrology	The Waikato River is the main river in the North Island. Its source is Lake Taupo with an altitude of 356 metres in the centre of the North Island. The river runs generally north from Lake Taupo and its mouth is on the north-western coast. In the South Island, the major rivers from a hydropower point of view are the Waitaki, which has its source in Lakes Tekapo and Pukaki and the Clutha, which has its source in Lake Whakatipu. All three lakes have glacial origins.

ELECTRICITY SECTOR OVERVIEW

In 2020, New Zealand had an installed capacity of 9,505 MW (Figure 1) and peak demand of approximately 7,000 MW.[6] Hydropower provides the majority of the electrical energy in the country. The remainder is predominantly provided by geothermal power, gas, wind power and coal, with minimal contributions from solar power and waste heat.[6] Due to its isolated location, there are no interconnections to other countries. Since 2014 the load has flattened off and is now steady at approximately 45,000 GWh per year. In 2020, electricity generation totalled 42,845 GWh (Figure 2).[6] New Zealand was a pioneer in rural electrification. For many years, more than 99 per cent of the population has had access to the grid.

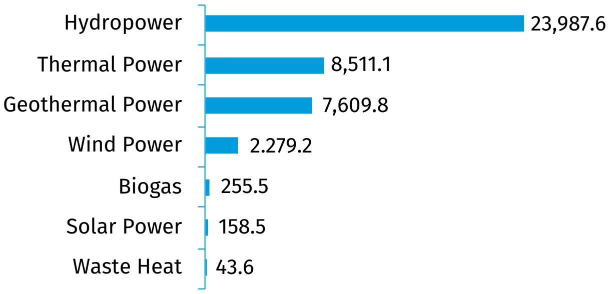
Figure 1. **Installed Electricity Capacity by Source in New Zealand in 2020 (MW)**



Source: MBIE[6]

Note: Small-scale sources such as solar power are not included.

Figure 2. **Annual Electricity Generation by Source in New Zealand in 2020 (GWh)**



Source: MBIE6

Most of the hydropower generation in New Zealand is owned by four large generators, three of which are 50 per cent Government-owned. Generating plants are well maintained and there is a regular programme of refurbishment of plants that vary in age from 30 to 90 years. No new large hydropower developments are under construction or contemplated even though the undeveloped potential is at least 2,000 MW.[7] The lack of action in the sector is influenced by the vagaries of the electricity market, which make it impossible to predict how much a power plant might earn in the long term, and by environmental activism demanding the rivers to remain in their natural state.

One of the key factors in power supply in New Zealand is ensuring that sufficient electricity is available during low rainfall years when hydropower generation drops by approximately 4,000 GWh — roughly 10 per cent of annual generation. Traditionally, the shortfall has been made up by a coal-fired power plant at Huntly and by increasing gas-fired generation.[8]

New Zealand already has a considerable amount of geothermal generation, which provides a low-cost, continuous and reliable supply. It is believed that the geothermal power resource could support approximately 2,000 MW of new generation. Some wind power capacity is under construction but at least 5,000 MW will be needed to achieve the country's electrification policy goals. However, this might make the dry year situation even worse because wind power in New Zealand is at a minimum in the autumn/winter when inflows are low and the demand peaks. However, with new gas exploration banned by the Government and existing fields declining rapidly, it is not yet clear what source of generation will replace the wind shortfall during peak periods. In an emergency, New Zealand has very large amounts of coal and a 750 MW gas- and coal-fired steam power plant that can burn coal when necessary to keep the lights on. Load growth is expected to accelerate in the future because more new houses will be built and the Government is keen on a significant switch to electric cars and increased use for industrial heating.

Up until 1991, most of the electricity distribution and all of the electricity transmission was carried out by the New Zealand Electricity Department, a government organization. Distribution was carried out by approximately 60 local Electric Power Boards. Many of them originated when local people got together to build a small hydropower (SHP) plant to supply electricity to the locality. Virtually all of these small plants have been connected to the grid. Between 1989 and 1991, it was decided that power supply should be corporatized under Government ownership and the Electricity Corporation of New Zealand was set up.[9] Not long after the transmission line section was split off as Transpower. The changes resulted in considerable improvements in efficiency and reduction in bureaucracy.

An electricity market was set up in 1993 with generators bidding into the market at the price at which they were prepared to generate. All generators were paid the price bid in by the most expensive generator. As it turned out, this market was not suited to a system where the cheapest generation was old and depreciated but perfectly good hydropower plants. Since the market became fully operational, electricity prices steadily increased at a rate well above inflation. Between 2018 and 2021 wholesale electricity prices have more than doubled and hydropower generators have made windfall profits at the expense of the consumer.

New Zealand has a 1,200 MW direct current link between the North Island and the South Island. In normal years it transmits surplus hydropower from the South Island to the North Island. In years when the rainfall in the South Island is low, it transmits power south from thermal stations in the North Island. The New Zealand electricity grid operates at 220 kV AC and +/-350 kV DC. Sub-transmission is at 110 kV. Distribution voltages are 66 kV, 33 kV 11 kV and 400/230 V.

There are five major generators in New Zealand. Three of them — Genesis Energy, Mercury Energy and Meridian Energy have 51 per cent Government ownership, with the remaining shares being held by public and various corporations. Contact Energy, the fourth major generator in the country, is 100 per cent public-owned. The fifth major generator, Pioneer, is smaller than the other four and was formed by aggregating the ownership of most of the SHP plants (less than 50 MW) previously owned by distribution authorities. There are also a number of individual generators who own geothermal power, wind power, SHP or gas-fired plants. Most generators are also retailers who sell to individual consumers; they also sell into the spot market. Experience shows that selling into the spot market is often the best option for a small generator in the long run.

The electricity industry in New Zealand is supervised by the Electricity Authority. However, there is no entity responsible for ensuring that the country has an adequate and reliable electricity supply. New power plants are built by generators if they believe that there is a reasonable chance that they will be profitable over the next 10–20 years. Economics favour building plants that can be built quickly rather than investing long term.

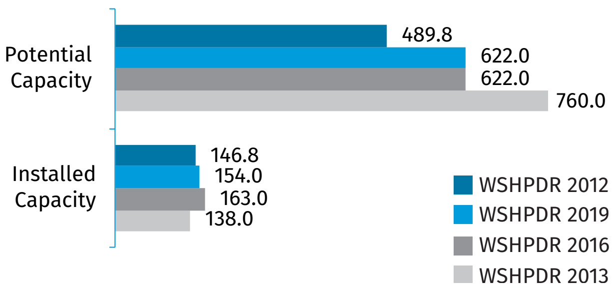
Domestic electricity tariffs are made up of charges for kWh, transmission and distribution. The average domestic tariff is approximately 0.20 US$/kWh.[10] ≤ a few years ago the spot price averaged 0.05 US$/kWh, but between 2018 and 2021 it has more than doubled even though little new capacity has been added. This increase has not yet showed up in the domestic price. Market prices are affected by the amount of water stored in the hydropower reservoirs, the state of the coal stockpile, the availability of gas and whether or not the wind is blowing. In general, prices vary little over the whole country but there can be major disparities at times due to transmission constraints.[11,12]

SMALL HYDROPOWER SECTOR OVERVIEW

In New Zealand there is no official definition for SHP, although a de facto definition is usually regarded as 50 MW or less. The lack of a need for a strict definition can be explained by the fact that SHP receives no special treatment. For the purposes of comparison, the present Report uses the ≤ 10 MW definition.

SHP ≤ 10 MW contributes 146.8 MW of installed capacity to the country's energy mix (Table 1) or 475 MW if the definition of 50 MW is being considered.[13] The SHP potential is estimated at 489.8 MW, of which 343 MW is undeveloped. Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity has decreased by approximately 10 per cent due to the replacement of a few aging projects with new ones. The change in potential capacity from the *WSHPDR 2019* is due to the availability of new geospatial data (Figure 3).[14]

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in New Zealand (MW)**



Source: Leyland,[13] MBIE,[14] *WSHPDR 2013*,[15] *WSHPDR 2016*,[16] *WSHPDR 2019*[17]

Note: Data for SHP ≤ 10 MW.

Table 1. **List of Selected Operational Small Hydropower Plants in New Zealand**

Name	*Location*	*Capacity (MW)*	*Operator*	*Launch year*
Matiri	Murchison	4.8	Pioneer Energy	2020
Normanby	Hawera, Taranaki	1.0	Renewable Power Ltd	1903, 2015
Amethyst	Westland	7.6	Westpower	2013
Rochfort	Westport, West Coast	4.2	Kawatiri Energy	2013
Rimu	Hastings	2.4	Trustpower	2013
Toronui	Hastings	1.4	TrustPower	2013
Talla Burn	Central Otago	2.6	Talla Burn Generation	2010
Kowhai	Central Otago	1.9	Pioneer Energy	2010
Cleardale	Ashburton	0.9	MainPower	2010
Matawai	Gisborne	2.0	Clearwater Hydro	2009
Deep Stream	Clutha	5.0	TrustPower	2008
Mangapehi	Waikato	1.6	Clearwater Hydro	2008
Feredays Island	Canterbury	0.3	Kea Energy	2005
Falls	Central Otago	1.3	Pioneer Energy	2003
Opuha	Mackenzie	7.5	Opuha Water / TrustPower	1999
Horseshoe Bend	Central Otago	4.3	Pioneer Energy	1999
Kaimai 5	Western Bay of Plenty	0.4	TrustPower	1994
Patea	South Taranaki	N/A	Trustpower	1984
Paerau	Central Otago	10.0	Trustpower	1984
Patearoa	Central Otago	2.3	Trustpower	1984

Source: Leyland[13]

There is some activity in the SHP business, which is benefiting from the 30 per cent increase in wholesale prices that took place in 2020 and can be expected to continue for at least three more years. In 2020, a 4 MW plant was commissioned in 2020 and a 1.89 MW plant was approved (Table 2).[18,19] As of early 2021, there were no other SHP plants in the planning stage.

Table 2. **List of Planned Small Hydropower Projects in New Zealand**

Name	*Location*	*Capacity (MW)*	*Plant type*	*Stage of development*
McCullochs Creek	Whataroa, South Westland	1.89	Run-of-river	Approved

Source: Hydro Review[19]

A GIS modelling study performed in 2020 identified 236 MW of theoretical SHP potential capacity (Table 3).[14] When comparing the results of the study with the existing literature, the total theoretical potential for sites from 1 MW to 10 MW was estimated at 343 MW. This study focused solely on run-of-river type sites.

Table 3. **List of Selected Small Hydropower Projects Available for Development in New Zealand as of 2021**

Name	*Location*	*Potential capacity (MW)*	*Head (m)*	*Type of site (new/refurbishment)*	*Type of project*
Site ID 73	Canterbury	8.5	20	New	Run-of-river
Site ID 60	West Coast	8.7	21	New	Run-of-river
Site ID 61	West Coast	8.3	20	New	Run-of-river
Site ID 31	Manawatu-Wanganui	7.4	20	New	Run-of-river
Site ID 50	Tasman-Nelson	6.5	42	New	Run-of-river

Source: MBIE[14]

RENEWABLE ENERGY POLICY

Several key policy measures have shaped the renewable energy landscape in New Zealand. The National Policy Statement for Renewable Electricity Generation, in force since 2011, guides local authorities on how renewable energy sources can be integrated into local planning documents. In 2018, a ban on new offshore oil and gas exploration was introduced. Climate Change Response (Zero Carbon) Amendment Act of November 2019, or the Zero Carbon Legislation, officially put into code the commitment to net zero emissions by 2050. In 2018, an independent review of the country's electricity market (Electricity Price Review) recommended better integration of independent generators, aggregators of storage and controllable demand into the spot market. The Government has taken measures to implement these recommendations.[20]

The Government intends to decarbonize the economy as rapidly as possible and effectively eliminate fossil fuels from electricity generation, electrifying transport and reducing methane emissions from agriculture. In 2019, it published a report from the Interim Climate Change Committee (ICCC) advocating massive changes to the industry, transport and the economy over a short timescale.[21] ICCC has proposed an electrification policy that makes maximum use of electricity in transport and industry, which would allow reducing emissions of carbon dioxide at a substantially lower cost than eliminating fossil fuel generation altogether. However, this would require a large-scale increase in renewable energy generating capacity. The report has been met with criticism, due to the negligible impact of the emissions of New Zealand's emissions on the changing climate as well as the opinion that some changes proposed in the report could increase net worldwide emissions. Overall, some energy sector actors doubt whether the Government's objective can be achieved within the timeframe and at an acceptable cost and many experienced engineers believe that the proposals do not take sufficient account of the engineering challenges that they pose.

Furthermore, it is predicted that in the next few years there will not be enough reserve capacity to avoid blackouts and high prices in a dry hydrological year. It is not clear where the generation needed for the predicted load increase will come from. The risk of blackouts in a dry year is exacerbated by a ban on new gas exploration imposed by the Coalition Government. At the same time, as the ICCC report points out, the Resource Management Act (RMA) of New Zealand makes it extremely difficult to build new power plants.[22] Although it started off with the intention of establishing a reasonable trade-off between development and the environment, recent legal rulings appear to ban any development whose environmental effects cannot be avoided.

The need to obtain environmental approvals is a major hurdle to power project development that needs to be overcome by those proposing new generation. SHP developers are particularly affected because even a small plant can be very difficult and expensive to get through the environmental process. The risk of Government intervention also exists, which was highlighted a few years ago when a minister cancelled an SHP project that had obtained all its environmental approvals.[23] The RMA demands that developers provide virtually complete final designs before an application will be considered.[24] If, after approval is granted, it transpires that major changes are needed to the design, there is a risk that the whole environmental approval process will have to restart. The report concludes that major changes to the RMA are needed if the electrification policy is to proceed.

There are no direct subsidies for renewable energy generation. The Government under Jacinda Ardern has established a US$ 100 million Green Investment Fund (launched in 2018), a US$ 27 million National New Energy Development Centre (launched in 2020) and multiple renewable energy investments through the US$ 3 billion Provincial Growth Fund.[25] The costs imposed on the power system resulting from the intermittent and unpredictable generation from wind and solar power are carried by the consumers, rather than the owners of the power plants. Additionally, SHP projects can be eligible for Avoided Cost of Transmission (ACOT) payments. Finally, the New Zealand Emissions Trading Scheme has been a key driver in renewable energy investments, obliging thermal power generators to purchase and surrender emissions units to match the emissions of the plant, with these units increasing in cost over time.[24]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

There are no special inducements for SHP. However, if recent high electricity prices continue, a number of potential SHP projects are likely to become economic. There are no special grants available for SHP projects.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

A number of computer modelling exercises have indicated that climate change will have an effect on rainfall patterns, although these effects are likely to take hold in the latter part of the century.[26,27] According to simulations produced by the TopNet hydrological model, annual lake inflows will increase. However, a degree of seasonal variation will be introduced, resulting in increased flows in winter and early spring and decreased summer flows as a result of increasing temperatures and greater winter rain with less snowfall. The model shows that overall hydropower generation could increase as a result of these increased flows, with electricity demand being met in winter and spring yet revealing potential shortfalls in the summer and autumn months. Flood and drought risk can also increase for several downstream locations.[28]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

In New Zealand, the SHP sector contributes 147 MW of installed capacity (475 MW if plants ≤ 50 MW are considered). It is in a healthy situation and its biggest challenge is restrictive environmental legislation, which makes obtaining environmental approvals extremely difficult.[29]

The main enabler is the current high electricity prices resulting from a ban on gas exploration and low rainfall in hydropower catchments.[30,31] New Zealand also has a number of financing options for renewable sources, which SHP projects can benefit from.

REFERENCES

1. Stats NZ. (2020). *New Zealand's population passes 5 million*. Available at https://www.stats.govt.nz/news/new-zealands-population-passes-5-million (Accessed 2 April 2021).
2. Index Mundi. (n.d.). *New Zealand Area*. Available at https://www.indexmundi.com/new_zealand/area.html (Accessed 2 April 2021).
3. National Institute of Water and Atmospheric Research (NIWA) (2001). *Overview of New Zealand's climate*. Available at https://niwa.co.nz/education-and-training/schools/resources/climate/overview (Accessed 8 May 2021).
4. National Institute of Water and Atmospheric Research (NIWA) (n.d.). *Climate Change Scenarios for New Zealand*. Available at https://niwa.co.nz/our-science/climate/information-and-resources/clivar/scenarios (Accessed 6 May 2021).
5. National Institute of Water and Atmospheric Research (NIWA) (2001). *Overview of New Zealand's Climate*. Available at https://niwa.co.nz/education-and-training/schools/resources/climate/overview (Accessed 2 April 2021).
6. Ministry of Business, Innovation and Employment (MBIE) (2020). *Electricity Statistics*. Available at https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/ (Accessed 8 May 2021).
7. Te Ara - The Encyclopedia of New Zealand (2010). *Page 5. Hydro, 21st century*. Available at https://teara.govt.nz/en/hydroelectricity/page-5 (Accessed 8 May 2021).
8. Leyland, B. (2021). Expert insight provided by the author.
9. Electricity Authority (n.d.). *What we do – History of government involvement in electricity*. Available at https://www.ea.govt.nz/about-us/what-we-do/our-history/ (Accessed 8 May 2021).
10. Ministry of business, Innovation and Employment (MBIE) (2021). *Electricity cost and price monitoring*. Available at https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-prices/electricity-cost-and-price-monitoring/ (Accessed 8 May 2021).
11. Electricity Authority (2020). *Haast Energy Trading, Ecotricity, Electric Kiwi, Flick Electric, Oji Fibre, Pulse Energy Alliance and Vocus claimed that an Undesirable Trading Situation (UTS) began on 10 November 2019 and was continuing as at 12 December 2019*. Available at https://www.ea.govt.nz/code-and-compliance/uts/undesirable-trading-situations-decisions/10-november-2019/ (Accessed 8 May 2021).
12. Electricity Authority (n.d.). *Our role in the electricity industry*. Available at https://www.ea.govt.nz/about-us/what-we-do/our-role-in-the-electricity-industry/ (Accessed 8 May 2021).
13. Leyland, B. (2021). Expert insight provided by the author.
14. Ministry of Business Innovation and Employment (MBIE) (2020). *Embedded Hydro Generation Opportunities in New Zealand*. Available at https://www.mbie.govt.nz/assets/embedded-hydro-generation-opportunities-in-new-zealand.pdf (Accessed 8 May 2021).

15. UNIDO, ICSHP (2013). *World Small Hydropower Development Report 2013*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
16. UNIDO, ICSHP (2016). *World Small Hydropower Development Report 2016*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
17. UNIDO, ICSHP (2019). *World Small Hydropower Development Report 2019*. United Nations Industrial Development Organization, Vienna, Austria; International Center on Small Hydro Power, Hangzhou, China. Available at www.unido.org/WSHPDR.
18. Stuff (2020). *Matiri hydro scheme officially opens near Murchison*. Available at https://www.stuff.co.nz/business/123658280/matiri-hydro-scheme-officially-opens-near-murchison (Accessed 8 May 2021).
19. Hydro Review (2020). *New Zealand DOC approves small 1.89-MW hydro power scheme in South Westland*. Available at https://www.hydroreview.com/hydro-industry-news/new-zealand-doc-approves-small-1-89-mw-hydro-power-scheme-in-south-westland/ (Accessed 8 May 2021).
20. The Law Reviews (2021). *The Renewable Energy Law Review: New Zealand*. Available at https://thelawreviews.co.uk/title/the-renewable-energy-law-review/new-zealand (Accessed 30 May 2021).
21. Interim Climate Change Committee (2019). *Electricity inquiry – Final report*. Available at https://www.iccc.mfe.govt.nz/what-we-do/energy/electricity-inquiry-final-report/ (Accessed 8 May 2021).
22. Interim Climate Change Committee (2020). *Final Progress Report*. Available at https://www.iccc.mfe.govt.nz/what-we-do/final-progress-report/ (Accessed 8 May 2021).
23. Radio New Zealand (2019). *Decision to block West Coast hydro scheme absolute madness, says Ngāti Waewae*. Available at https://www.rnz.co.nz/news/te-manu-korihi/397955/decision-to-block-west-coast-hydro-scheme-absolute-madness-says-ngati-waewae (Accessed 8 May 2021).
24. New Zealand Legislation (1991). *Resource Management Act 1991*. Available at https://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html (Accessed 8 May 2021).
25. New Zealand Trade & Enterprise (n.d.) *New Zealand: Renewable Energy*. Available at https://www.nzte.govt.nz/page/renewable-energy (Accessed 30 May 2021).
26. University of Otago (2011). *An acceleration in New Zealand's sea level record?* Available at https://ourarchive.otago.ac.nz/handle/10523/628 (Accessed 8 May 2021).
27. National Institute of Water and Atmospheric Research (NIWA) (n.d.). *'Seven-station' series temperature data*. Available at https://niwa.co.nz/our-science/climate/information-and-resources/nz-temp-record/seven-station-series-temperature-data (Accessed 8 May 2021).
28. Caruso, B.S., King, R., Newton, S. & Zammit, C. (2016). *Simulation of Climate Change Effects on Hydropower Operations in Mountain Headwater Lakes, New Zealand*. Available at https://onlinelibrary.wiley.com/doi/abs/10.1002/rra.3056#:~:text=Therefore%2C%20New%20Zealand%20is%20very,ture%20(NIWA%2C%202013) (Accessed 30 May 2021).
29. New Zealand Government (2019). *Waitaha river hydro application declined*. Available at https://www.beehive.govt.nz/release/waitaha-river-hydro-application-declined (Accessed 8 May 2021).
30. Electricity Authority (2020). *Wholesale price trends*. Available at https://www.emi.ea.govt.nz/Wholesale/Reports/W_P_C?DateFrom=20110430&DateTo=20201231&RegionType=NZ&TimeScale=MONTH&_si=v|3 (Accessed 8 May 2021).
31. EcoWatch (2018). *New Zealand Ends New Offshore Oil and Gas Exploration*. Available at https://www.ecowatch.com/new-zealand-ends-new-offshore-oil-and-gas-drilling-2618531034.html (Accessed 8 May 2021).

Contributing organizations

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UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Vienna International Centre
P.O. Box 300 · 1400 Vienna · Austria
Tel.: (+43-1) 26026-o
E-mail: renewables@unido.org
www.unido.org

INTERNATIONAL CENTER
ON SMALL HYDROPOWER

136 Nanshan Road
Hangzhou · 310002 · P.R.China
Tel.: (+86-571) 87132780
E-mail: report@icshp.org
www.icshp.org