CLEAN POWER

DOING LESS WITH MORE

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▶ Our energy target is achievable, thanks to flat demand and new supply.

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NEW ZEALAND HAS MAINTAINED a high share of renewable energy in the electricity sector during its transition from a state monopoly to a competitive electricity market. The development of hydro resources prior to industrial reform in the mid-1980s, coupled with the abundance of competitive low-carbon energy resources – especially geothermal and wind power – has certainly been an advantage. Currently, domestic fossil fuel resources offer opportunity for economic growth, while renewable energy resources present opportunities for green growth in both domestic and global markets. What is particular about New Zealand's case is the 'middle out' approach of its national renewable energy strategy. Rather than the top-down model often adopted elsewhere, consenting in this country is done on a case-by-case basis at regional level, which allows for wide community and stakeholder participation.

PROGRESS TOWARD RENEWABLE GENERATION

New Zealand has roughly 10 GW of total installed capacity (including co-generation) consisting of roughly 57 per cent hydro, 16.2 per cent geothermal, 16 per cent gas, 5 per cent wind, 4 per cent coal, and approximately 1.5 per cent biogas, wood, waste heat and oil combined, according to Ministry of Business Innovation and Employment (MBIE) data. The total share of renewable resources in 2014 was 80 per cent. The share changes annually, depending mainly on the hydro resource availability, which in turns depends on precipitation patterns, and to a lesser extent the inter-annual variability of wind.

Figure 1 shows demand growth and the generation mix since 1976. From 2005 demand plateaued at around 42,500 GWh. Figure 2 shows the share of hydro falling from around 80 per cent to slightly over 50 per cent, between 1974 and 2012, while geothermal grew to roughly 14 per cent and wind to 5 per cent over the same period.

HYDRO POWER

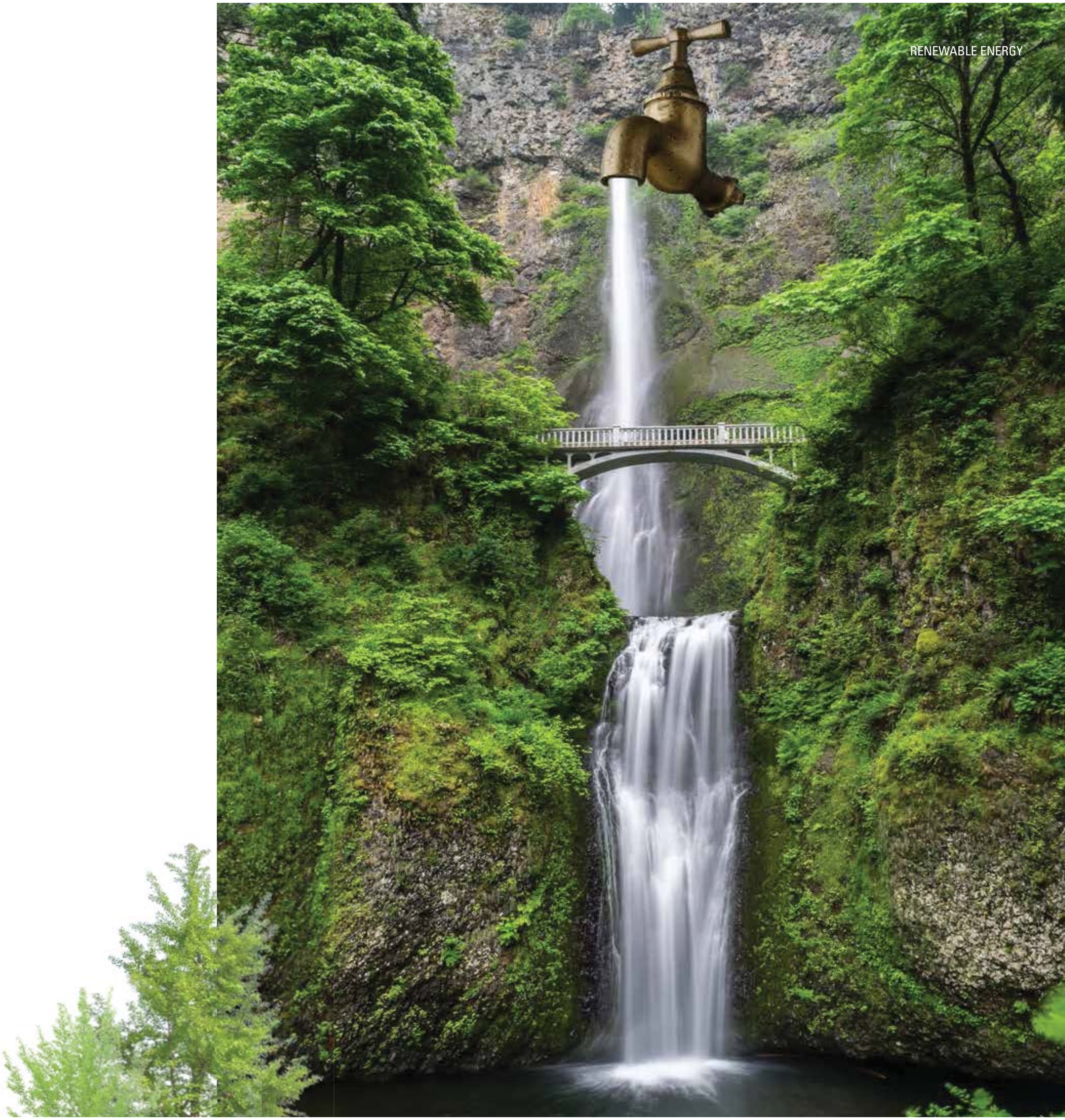
Current installed capacity for grid-connected hydro power is almost 5500 MW. Some 240 MW of hydro capacity is currently consented, the largest project being 70.5 MW. However, future energy scenarios developed by (MBIE) include almost 2700 MW of new hydro capacity available in the period 2015-2050. In these scenarios the largest hydro installations are pumped hydro stations of 300 MW each.

A relevant characteristic of the New Zealand hydro generation system is its relatively low storage capacity of 4900 GWh (EA, 2013), which roughly corresponds to 38 peak demand days (which in winter generally do not exceed 130 GWh).

GEOTHERMAL ENERGY

Geothermal has played an important role in New Zealand's electricity mix since the 1950s. Currently, about 16.2 per cent of annual power generation is provided by thirteen geothermal stations, with direct heat being used in the paper and pulp, dairy, agriculture, and fishery industries. Along with wind power, geothermal is among the most economic sources of electricity in New Zealand, although future large-scale projects may become more cost-intensive than previous ones as the most attractive geothermal sites have now been tapped.

The degree of renewability of a geothermal resource depends on the rates of extraction and heat regeneration. Excessive extraction of heat can speed depletion, reduce reservoir productivity, and in some cases lead to subsidence. The previous 'single-tapper' policy, which allowed only one developer per



geothermal reservoir, was aimed at avoiding the 'tragedy of the commons'– a situation in which several developers exploit a resource at an unsustainable rate to gain economic advantage, in the process depleting it and causing damage that affects all users. Regional councils have now adapted their policies to allow multi-tapping, while insisting on joint-management plans to ensure sustainable use of the resource. At the time of writing, a 166 MW project is under construction, a 250 MW project is consented, and resource consent has been applied for in relation to several other projects totalling in 190 MW.

GEOTHERMAL HAS PLAYED AN IMPORTANT ROLE IN NEW ZEALAND'S ELECTRICITY MIX SINCE THE 1950S. CURRENTLY, ABOUT 16.2 PER CENT OF ANNUAL POWER GENERATION IS PROVIDED BY THIRTEEN GEOTHERMAL STATIONS...

WIND ENERGY

Currently, there are 19 operational wind farms totalling 683 MW of installed capacity that supply some 5.2 per cent of national electricity demand, with a further 66.6 MW under construction. An additional 12 wind farms projects, totalling up to 1670 MW of capacity, hold consents. The consenting process itself has ranged from four to 40 months, with one of the longest involving Project Hayes, a 634 MW project planned for the South Island. The applications for the relevant resource consents for Project Hayes were submitted in October 2006, with the process continuing in the Environment Court, and then in the High Court. The developer withdrew its applications in 2012, announcing that other projects had higher commercial priorities. Given changes in the global economy during the consenting period, and the flattening of electricity demand in New Zealand, it is possible that the economic viability of the project altered significantly during this time.

One possible way to overcome the challenge of expanding wind power at a time of softening national electricity demand lies in distributed generation. Unlike large grid-connected wind farms that sell all their power output in the wholesale electricity market, small-scale distributed generation is generally consumed locally, or eventually partly sold to the grid at a buy-back rate determined by the retailer or distribution company. In the distributed-generation model, the owner of a small-scale wind farm would not be directly concerned with the slow growth of national electricity demand. Indirectly however, flattened demand and potentially low electricity prices in the wholesale market would be reflected in the buy-back rate that the producer would receive for any power sold to the grid.

Empirical evidence of community preferences regarding wind farm development in New Zealand is limited. Two quite different approaches have been used to estimate the external impacts of such development. Researchers Martin Barry and Ralph Chapman identified two main factors limiting the potential of wind generation in New Zealand: a trend towards large-scale installations, leading to increased opposition; and a small number of investors. Their survey of 338 rural landowners found a significant preference for small (2-turbine) projects as opposed to a large (14-turbine) projects, suggesting that in rural areas, at least, small-scale projects might face less opposition.

Analysing 4,800 property transactions near New Zealand's largest wind farm, the 134-turbine Tararua wind farm, T Nguyen estimated the external affects during three stages of development: pre-announcement of development, transition, and post-construction. He found that negative effects on property prices were only significant during the pre-announcement period. The study by Barry and Chapman adopted a stated-preference approach and the sample was obtained from rural landowners in two regions, whereas Nguyen's study was based on market transactions, with location and view controlled for in the analysis. The significance of the pre-announcement affect and the preference for small-scale development suggest that developers could speed up the consenting process by engaging with local communities early in the development process, as they place great value on spatial location. Evidence to date suggests that after development has occured, negative external impacts associated with large-scale development fade.

MARINE ENERGY

As part of its New Zealand Energy Strategy 2007, the government established a four million dollar Marine Energy Deployment Fund (MEDF). The fund was designed to accelerate innovation and assist with concept testing and device deployment. The grants were allocated to six proposals in four annual rounds, between 2007 and 2011.

The largest proposed project involved 200 submerged turbines capable of generating 200 MW of electricity from tidal currents in the Kaipara harbour. The project received a conditonal resource consent in March 2011, which allowed the project to start with 3 MW, after which a favourable environmental impact assessment would enable it to transition to a full-scale project. As at March 2015 the project had not proceeded.

None of the other five projects were successful. The funding was subject to conditions, such as indivdual projects obtaining resource consents and meeting milestones, and as a result very little funding was actually spent. Government support for marine energy projects has not been continued.

In addition, there were two projects outside the government funding scheme. A 12 MW tidal-stream project involving 10 turbines was proposed for the Cook Strait. A similar project, involving just one 1 MW turbine to be installed off the south coast of Wellington,

Figure 1: Annual electricity generation by fuel type (MBIE, 2015).

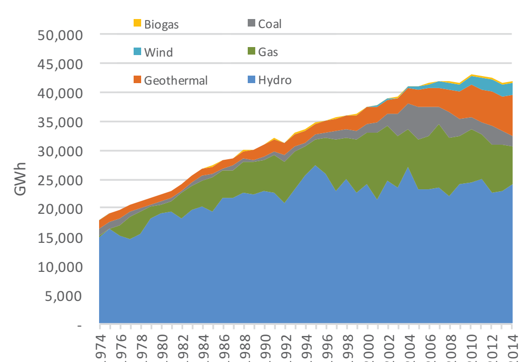
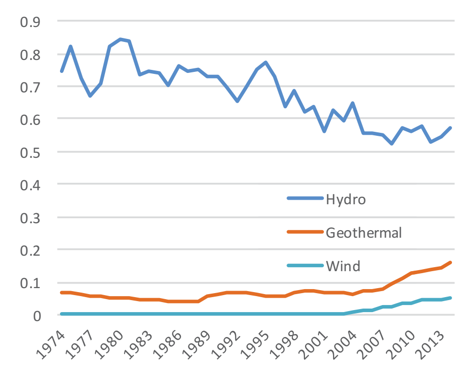


Figure 2: Share of renewables in the electricity mix (MBIE, 2015).



receiving a resource consent in 2008. To date, neither project has proceeded and little information is available on their current status.

SOLAR ENERGY

New Zealand has an accumulated installed capacity of 34.5 MW of solar power. All solar power installations are small-scale distributed generation, the largest reaching 240 kW. Like other renewable energy sources, solar power does not receive any government subsidy in New Zealand. There has been a recent drop in buy-back rates, as several retailers have decided to cut their rates for new PV installations, in an effort to avoid subsidising solar power at the expense of other consumers. Current buy-back rates, as of January 2016, ranged from nothing to eight cents per kWh. However, the lines company in Auckland announced that it would guarantee a price of 16 cents per kWh for new installations for a limited time, by covering the difference between retailers and solar power suppliers.

REACHING THE ENERGY TARGET

The Ministry of Business, Innovation and Employment has presented four plausible future scenarios for the New Zealand electricity system, with an additional three demand sensitivities. In the "Mixed Renewables" scenario, also known as the "business-as-usual" scenario, total electricity demand grows on average by 1.1 per cent each year, reaching approximately 45.6 TWh in 2025. The demand sensitivity with the lowest demand outcome assumes a gradual shut-down of the Tiwai Aluminium Smelter by 2018, reaching a total demand of approximately 40.5 TWh in 2025. The highest-demand scenario results in a total electricity demand of approximately 46.8 TWh in 2025.

To estimate how much existing and consented renewable energy power stations could potentially contribute to the 90 per cent renewable energy target by 2025, we calculated the total annual supply from hydro, wind and geothermal power, and compared the results with the total-demand projections. Assuming that consented stations will have the same capacity factor as existing renewable energy stations, we calculate that the total annual renewable energy supply would reach roughly 46.4 TWh. Even factoring in a 10 per cent decrease in productivity for new stations due to the best resource locations having been already taken, and a similar decrease in the productivity of existing generation due to aging equipment or, in case of geothermal, subsidence, the total renewables annual output would still be roughly 41.8 TWh (See Table 1).

ALL SOLAR POWER INSTALLATIONS ARE SMALL-SCALE DISTRIBUTED GENERATION, THE LARGEST INSTALLATION REACHING 240 KW. LIKE OTHER RENEWABLE ENERGY SOURCES, SOLAR POWER DOES NOT RECEIVE ANY GOVERNMENT SUBSIDY IN NEW ZEALAND.

Table 1: Potential total supply for existing and consented renewable energy.

	Operating	Typical annual output	Capacity factor	Consented	Expected annual output	Total annual output
	MW	GWh		MW	GWh	TWh
Geothermal	840.7	6345	0.86	250.0	1886.8	8.2
Wind	683	2434	0.41	2725.5	9712.9	12.1
Hydro	5469.5	24900	0.52	244.5	1113.1	26.0
Total						46.4
Total with 90 per cent productivity						41.8

These simplified calculations show that existing and currently consented renewable energy projects have the potential to meet demand projections in 2025. Thus, in terms of of renewable energy resource availability, reaching the 90 per cent target is viable. This exercise does not take into account grid restrictions, peak load capacity, and other technical restrictions which may limit the share of certain renewables, such as wind, in the system. However, the results do illustrate the potential for renewable energy development in New Zealand.

THE ECONOMICS OF RENEWABLES

The Levelised Cost of Electricity (LCOE) is a common metric used to compare the production cost of a unit of electricity derived from different energy sources and technologies. The LCOE for a given technology will typically depend on the scale and resource availability (location dependence), which is why a range of values are often presented. In terms of LCOE, the most common renewable energy technologies have become cost competitive compared to fossil fuel technologies. Even solar technologies are reaching cost-competitive levels, although concentrating solar power (CSP) still has a higher cost range than fossil fuel. Marine energy technologies, both wave and tidal, remain comparatively expensive, with an LCOE in the range of 0.25 to 1.06 USD/kWh.

However, it is important to understand that a lower LCOE does not directly translate to competitiveness in the electricity market. Wholesale market electricity prices vary significantly throughout the year depending on demand and eventual constraints in supply. There may be few hours of very high wholesale prices each year, and the ability to generate power at such times thus has a direct impact on the profitability of new generation plants. In New Zealand, where nodal pricing differentiates the wholesale prices across the country, location is also a factor in the profitability of new investments.

CHALLENGES AND OPPORTUNITIES

New Zealand comprises two main islands and is approximately 1,600km long, with a population of about 4.5 million. The location of generation assets, the pattern of supply from renewable sources, and the location of major centres of demand create challenges for distribution and security of supply. In 2014, 44 per cent of total electricity was generated in the South Island, with hydro accounting for about 98 per cent and wind less than 2 per cent. By contrast, 56 per cent was generated in the North Island, with geothermal and gas contributing 29 per cent and 28 per cent respectively. Supply originating in the South Island is therefore predominantly hydro, whereas in the North Island geothermal has recently surpassed natural gas in total generation.

FORTUNATELY, THE COUNTRY HAS CONSIDERABLE RENEWABLE ENERGY RESOURCES INCLUDING WIND, HYDRO, GEOTHERMAL, SOLAR, BIOMASS AND MARINE ENERGY, SOME OF WHICH ARE ALREADY PRICE COMPETITIVE.

During years of normal rainfall, power flows from hydro assets in the South Island to the North Island through the High Voltage DC link. The link was recently upgraded to a capacity of 1,200 MW at a cost of $672 million. However, the frequency of dry years has increased, resulting in power flows in the other direction. Changes in recent years to the frequency distribution of rainfall suggest that conditions will become more favourable for investment in renewable sources of electricity in the South Island. On the demand side, changes in industrial demand at the Tiwai Aluminium Smelter could shorten the period that electricity flows from the North Island to the South Island. In addition, increased competition for water may pose a challenge – especially given that in dry years hydro power stations may save water in the expectation of higher electricity prices, while that retained water is also needed for irrigation downstream.

Fortunately, the country has considerable renewable energy resources including wind, hydro, geothermal, solar, biomass and marine energy, some of which are already price competitive. The recent drop in solar photovoltaic (PV) panel prices has also led to new developments in the small scale installations of PV panels. However, emerging technologies appear to experience difficulty in demonstration and deployment, and to date New Zealand has not proven to be a particularly attractive location for renewable energy technologies that are in the development phase. Nevertheless, there may be significant opportunities in distributed generation, as already mentioned. In addition to the growth of solar power installation in new residential and commercial buildings, and the potential for small-scale wind farms in rural communities, both technologies have been deployed in small, organised communities that choose to collectively invest in technology which permits a more sustainable and environmentally responsible way of living. Along with renewable energy resource opportunities on the supply side, the demand side offers opportunities for energy conservation and strategic planning. Smart metering and smart grids are still in their infancy in New Zealand, and the increase in solar power installations in the residential sector is opening a new market for smart metering diffusion and technology learning.

The uptake of emerging technologies such as solar PV and electric vehicles has however been slower in New Zealand than in other OECD countries. Solar PV prices have fallen and an increased uptake can be seen in small scale installations, indicating that recent uncertainty in buy-back rates has not had a direct effect on the adoption of solar power in this country.

Similarly, the uptake of electric vehicles has been slow at the national level, but significant advances have occurred at the municipal level. In fact, due to the availability and competitiveness of renewable resources for power generation, New Zealand has an opportunity to transition the transport sector towards carbon neutrality. Coordination between municipalities and regions could further aid the deployment of electric vehicles and other low-carbon solutions in this sector.

In the medium- to long-term, taking advantage of the wide range of green growth opportunities will require supporting demonstration projects to allow for development in emerging technologies, creating an entrepreneurial environment that promotes experimentation and allows ideas to be developed for wider markets.

The further evolution of New Zealand's energy system will be conditioned by market forces. The development of renewable sources will continue, provided they meet commercial criteria, while investment in demand-side management technology is likely to moderate growth in demand. Domestic sources of gas will continue to play an important role in providing security of supply and will offer the opportunity for short-term economic growth. Meanwhile, already consented low-carbon electricity projects, currently suspended due to stagnated demand, have the potential to meet the 90 per cent renewables target by 2025. ■

KEY TAKE-OUTS

- **Leveraging green growth opportunities will require support for demonstration projects that showcase emerging technologies and foster experimentation.**
- **The competitiveness of New Zealand's renewable power sources may boost the transition to transport-sector carbon neutrality.**
- **Consented projects, now on hold, have the potential to meet the national target of 90 per cent renewable energy by 2025.**

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