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GREEN ENERGY FINANCE IN AUSTRALIA AND NEW ZEALAND

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Abstract

We explore the history and current status of green energy finance in Australia and New Zealand. Although both countries have enviable renewable energy resources with a 100% renewable mix considered feasible, the two countries present highly contrasting contexts for energy finance. Currently, and largely for historical reasons, renewables make up over 80% of the electricity capacity in New Zealand, whereas in Australia this is 17%. Interestingly, between them and over time, the two countries have employed most of the important policy tools available to incentivize renewables and green energy finance (e.g., carbon taxes, carbon trading, a green investment bank, a green certification market, and feed-in-tariffs). Despite this, we show that between 2004 and 2017 both countries did not meet their potential in terms of renewables and have lower levels of green energy investment relative to GDP per capita than many other developed countries. The Australian and New Zealand context provides many lessons for other jurisdictions—ranging from the need for cross-party and regulatory commitment to energy transition, to the need for policy stability. Indeed, a key issue in Australia and New Zealand is the challenge of designing electricity markets that support energy transition and the investment that it requires. Incumbents in both jurisdictions are fearful of a "death spiral" induced by distributed power, and in Australia political instability and market design issues contributed to a major energy crisis in 2017. However, the crisis, the Paris Agreement and the associated impetus of new governments in both countries suggest green energy investment is set to increase in the coming years.

Keywords: energy finance, energy transition, green investment bank, feed-in-tariffs, emissions trading, electricity markets, green certificate market

JEL Classification: F21, G20, H23, O13, Q40, Q42, Q48, Q54, Q55, Q58

Contents

1. INTRODUCTION

Energy transition seeks to embrace energy technologies and innovation to decarbonize, or at least reduce the environmental impacts of, energy systems. In addition, energy transition seeks to maintain energy security and ensure affordable energy to underpin broader (human) development goals. That energy policy has three major concerns (environmental, security and socioeconomic) is beyond question. What is open to much debate is the nature of how this transition might be achieved and how it will ultimately look (Battaglini et al. 2009 and Verbong and Geels 2010). Whatever shape the energy transition takes, another factor that is beyond question is that it will require significant investment. For instance, for Europe, the International Energy Agency (IEA) projects that up to $2.2 trillion of total power sector investment is needed in the EU between 2014 and 2035 (Tulloch et al. 2017). This in turn posits the question of how this investment can be mobilized or incentivized.

This paper explores the history and current status of green energy finance (and therefore energy transition more generally) in New Zealand and Australia. The focus is principally on electricity systems and energy generation, meaning that we do not focus on energy efficiency policies, although we acknowledge their importance. Further, the global push to electrify light-vehicle fleets means that energy for transport more generally is relevant, although not central to the paper.[1] Both countries have experienced supply interruptions in recent years that have highlighted the importance of energy security in transition; in 2017, a ruptured pipeline to Auckland Airport led to widespread flight cancellations over a prolonged period, while South Australia experienced blackouts between 2016 and 2017 which were part of Australia's border "energy crisis." Further, social and economic considerations are also prominent in both countries, with high energy costs contributing to concerns about fuel poverty.

These concerns come despite both countries having enviable renewable energy resources. Both have the potential to be world leaders in energy transition, yet the two countries present highly contrasting contexts for energy finance. Interestingly, between them and over time, they have employed most of the important policy tools available to incentivize renewables and green energy finance (e.g., carbon taxes, carbon trading, a green investment bank, a green certification market, and feed-in-tariffs).

New Zealand has a system that, through state investment and subsidies starting as early as the 1950s, and continuing through to the mid1980s, has high levels of large hydro power. More recently, there has been a growth of geothermal and wind power. That, coupled with relatively flat demand growth for electricity between 2006 and 2012, has contributed to a "hands-off" market approach by government, with no formal policies beyond the inclusion of transport and energy in the New Zealand Emissions Trading Scheme (NZ ETS). NZ ETS has come in for stringent criticism due to a collapse in carbon prices associated with imported allowances. Despite a lack of investment incentives and a hostile regulatory framework, distributed generation has experienced some growth. Most of the large energy incumbents fear the stranding of assets and ultimately a "death spiral" from the uptake of distributed power. This may be contributing to the reluctance of large incumbents to finance new energy projects.

[1] 2017 saw many countries set ambitious targets in terms of the use of electricity vehicles (EVs); see "These countries want to ditch gas and diesel cars" CNN, 26 July 2017. Available online: http://money.cnn.com [accessed 27 December 2017].

Australia, by way of contrast, has an energy system that has been dominated by coal. Thus, the more pressing need to decarbonize the energy system has been reflected in more interventionism. From a governance perspective, the Australian context is complicated by the dual layer of federal and state interventions. For instance, between 2008 and 2012 most states in Australia implemented some type of feed-in-tariff to incentivize rooftop solar PV systems. At the federal level, energy policy has lacked stability and, therefore, the certainty that investors desire. In 2011, Australia introduced a carbon tax with a view to transition to an emissions trading scheme in 2014. However, the legislation that enabled both was repealed in 2014. Despite the failure of the carbon tax, Australia has had a “green certification market” (Renewable Energy Target) since 2001 to incentivize the transition to renewables that has underpinned investment in renewables – but the scheme has also been hampered by political uncertainty. In 2012, the Australian government established a green investment bank called the Clean Energy Finance Corporation (CEFC).

From the above brief introduction, it is clear that New Zealand and Australia provide interesting contexts in which to explore various policies to promote investment in renewables. We do so as follows: Section 2 provides more background on the energy systems of Australia and New Zealand, Section 3 presents a simple analysis of green energy financial flows in both counties, which are subsequently understood in Section 4 in the context of the various financing policies, incentives, and barriers that exist in both jurisdictions. The experiences of the two counties provide valuable lessons for other jurisdictions wishing to mobilize investment in renewables – it is with these lessons that this paper concludes in Section 5.

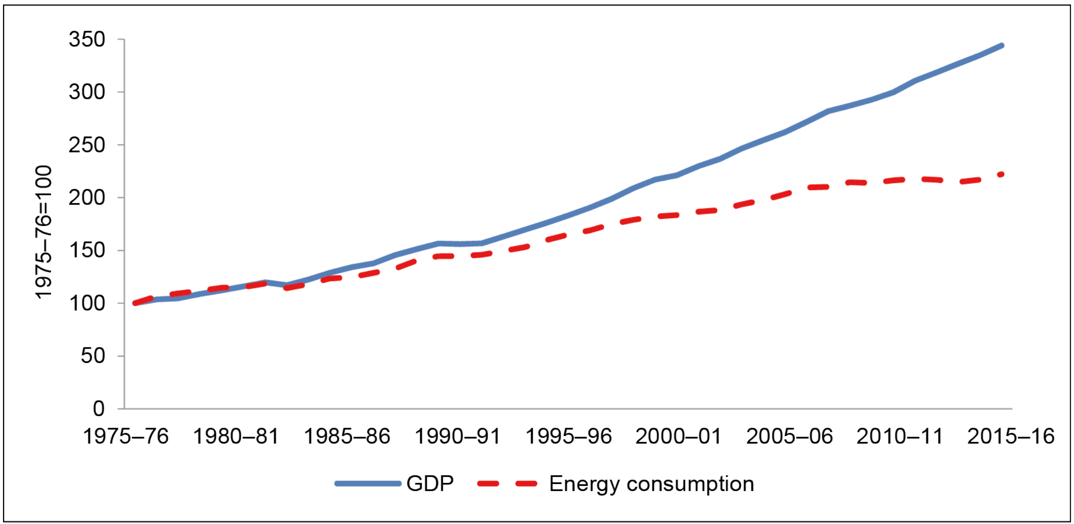
2. ENERGY SYSTEM AND EMISSIONS CONTEXT

2.1 Australian

The Australian economy has undergone a rapid transformation over the last five decades, turning it into one of the most advanced and wealthy countries in the world. As is apparent from Figure 1, this rapid GDP growth is associated with rising energy consumption; however, the rate of increase in energy consumption is lower than GDP growth due to increases in energy productivity.

Australia has an electricity generation system that has been dominated by coal, although this reliance on coal decreased from 80.18% in 1990/91 to 62.93% in 2016 (see Table 1). This reduction occurred over a period of rising demand (Figure 1) and was achieved through increased use of gas and renewable generation. The increased share of gas generation in the total generating mix over the period was 11.60% (from 6.88% in 1990/91 to 18.48% in 2016), which is more than double the increase of renewables of 5.51% over the period (from 10.77% in 1990/91 to 16.28% in 2016).

Figure 1: Australian GDP and Energy Consumption Indices



Note: Derived from Table B of Australian Energy Statistics, energy consumption measure used is equivalent to primary energy.

Source: Department of the Environment and Energy, Australian Energy Update 2017.

Table 1: Australian Electricity Generation

	1990–91	1995–96	2000–01	2005–06	2010–11	2015–16	2016
Black coal	57.16	59.78	60.04	55.93	46.12	44.40	44.72
Brown coal	23.02	22.22	23.35	23.43	21.81	18.96	18.21
Natural gas	6.88	7.01	7.72	9.76	19.32	19.63	18.48
Renewables	10.77	9.40	7.98	9.34	10.46	14.82	16.28
Other	2.17	1.58	0.91	1.54	2.29	2.20	2.31
	NSW	**VIC**	**QLD**	**WA**	**SA**	**TAS**	**NT**
Coal	76.95	84.66	73.39	28.76	10.90	0.00	0.00
Natural gas	5.10	3.03	18.35	55.03	41.22	7.58	82.00
Oil	0.46	0.25	1.75	9.16	1.32	0.65	15.75
Hydro	10.07	1.96	0.75	0.52	0.05	80.43	0.00
Other RE	7.42	10.10	5.76	6.53	46.52	11.34	2.26

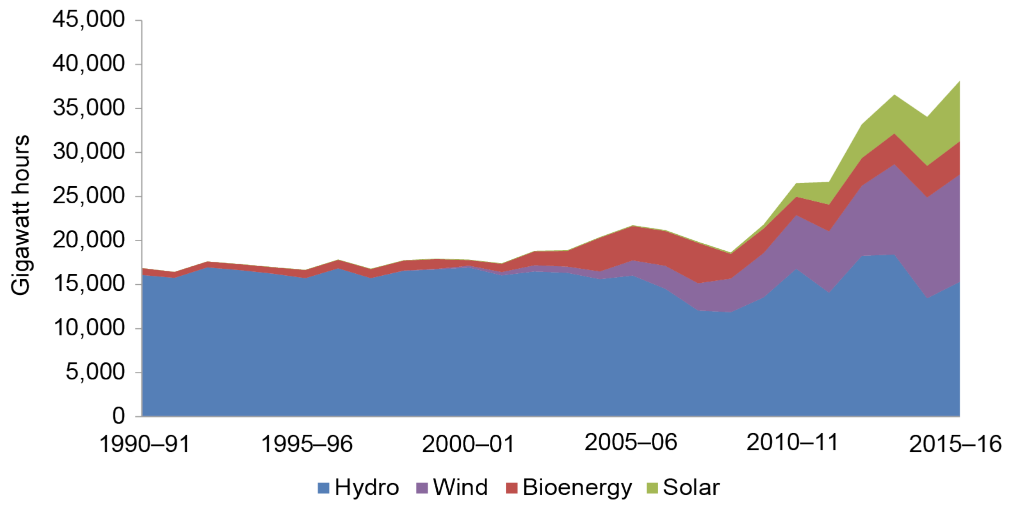
NSW = New South Wales, NT = Northern Territory, QLD = Queensland, SA = South Australia, TAS = Tasmania, VIC = Victoria, WA = Western Australia.

Notes: Due to rounding, totals may not equal 100% exactly. In the bottom panel "Other RE" includes bagasse (wood), biogas, wind, solar PV and geothermal. The top panel is the percentage mix by type of generation over time; the bottom panel is by state and data for 2016.

Source: Compiled from Department of the Environment and Energy, Australian Energy Update 2017.

Figure 2 breaks down the evolution of renewable generation in Australia highlighting the existence of hydropower pre-1990 and the use of wind energy starting in the early 2000s and its subsequent increase. The use of solar starts to be meaningful about a decade later, circa 2010/11.

Figure 2: Evolution of Renewable Energy Generation in Australia



Source: Compiled from Department of the Environment and Energy, Australian Energy Update 2017.

Another distinguishing factor of the Australian electricity system is the large differences across the seven large states, suggesting that state policies, as well as resource and geographical factors, play a role in generation mix choices. New South Wales, Victoria, and Queensland are dominated by coal, while Western Australia and Northern Territory are dominated by gas generation (see bottom panel of Table 1). Tasmania has a generation profile similar to New Zealand's (see Section 2.1), which is dominated by hydroelectricity.

South Australia has invested heavily in wind energy and distributed solar power, meaning a mix of about 45% renewables and 40% gas.

2.2 New Zealand

New Zealand's geology and location in the "roaring forties" has endowed the country with an abundance of renewable resources, including hydroelectricity, geothermal, and wind, and its forestry industry also provides a modest supply of waste wood that can be used for generation of heat, perhaps along with electricity. Hydroelectricity was first developed at Bullendale in Central Otago, in the lower South Island in the 1800s (Reilly 2008). The central government sought to consolidate control of the nation's waterways via the Public Works Amendment Act 1908 (Reilly 2008) and developed other hydroelectric projects and progressively developed the national grid to connect these projects. Table 2 charts this expansion of the largest hydropower project in the 20th century, with the largest project occurring in the 1960s, 1970s, and 1980s.

In addition to hydroelectricity, the government proceeded to develop the Wairakei geothermal station in 1958, the Ohaaki geothermal station in 1989, and the Meremere, Huntly, New Plymouth, Whirinaki, and Stratford fossil-fueled power station between 1958 and 1985. In the late 1980s, the government acted to introduce greater commercial discipline into decision-making in the power sector by creating the Electricity Corporation of New Zealand (ECNZ), which was required to act in the same way as a successful business would. Then, in 1996, the competitive, deregulated, wholesale market was set up. At this point, renewable generation comprised 80% of the mix.

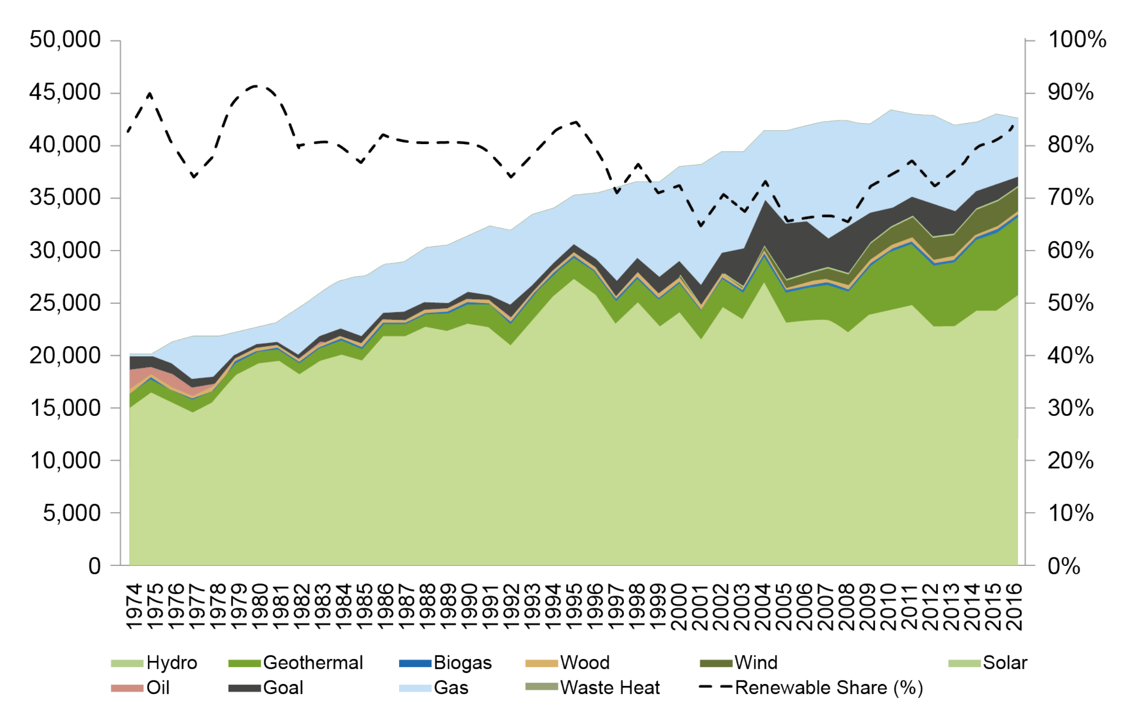
Table 2: Introduction of Generating Plant in New Zealand
(90 MW or larger)

Station	Type	Date	Installed Capacity MW	Typical Annual GWh
Waitaki	Hydro	1935	105	500
Arapuni	Hydro	1946	197	805
Karapiro	Hydro	1948	90	525
Roxburgh	Hydro	1956	320	1,610
Whakamaru	Hydro	1956	100	494
Wairakei	Geothermal	1958	175	1,310
Ohakuri	Hydro	1962	112	400
Aratiatia	Hydro	1964	90	330
Benmore	Hydro	1965	540	2,500
Aviemore	Hydro	1968	220	930
Maraetai	Hydro	1971	360	885
Manapouri	Hydro	1972	850	5,100
Tokaanu	Hydro	1973	240	763
Tekapo B	Hydro	1977	160	800
Ohau A	Hydro	1980	264	1,150
Huntly	Thermal	1983	1,000	5,695
Rangipo	Hydro	1983	120	580
Ohau B	Hydro	1984	212	970
Ohau C	Hydro	1985	212	970
Ohaaki	Geothermal	1989	116	300
Clyde	Hydro	1992	432	2,050
Southdown	Thermal	1996	175	1,400
Glenbrook	Cogeneration	1997	112	550
Taranaki Comb. Cycle	Thermal	1998	385	3,350
Otahuhu B	Thermal	2000	380	2,380
Mokai I, II & III	Geothermal	2000	112	900
Te Apiti	Wind	2004	91	258
Huntly e3p	Thermal	2007	400	2,410
Tararua Stage 3	Wind	2007	93	375
Kawerau Geothermal	Geothermal	2008	100	800
West Wind	Wind	2009	143	550
Nga Awa Purua	Geothermal	2010	140	1,100
Stratford Peaker	Thermal	2011	200	350

Source: Compiled from “Generating Stations” dataset 2012, Electricity Authority.

As New Zealand’s reliance on hydroelectricity increased during the 20th century, so did reliance on inflows into the hydro catchments. However, the stream of inflows is highly volatile (potentially increasingly so due to climate change and irrigation schemes), and the nation’s hydro storage lakes are relatively small compared with total demand, so it was recognized that backup generation or more storage was required.

Figure 3: RE Generation in New Zealand
(GWh and %)



Source: Compiled from "Energy in 2017" data, Ministry of Business, Innovation and Employment (MBIE).

Ultimately, a competitive electricity industry met this challenge by the development of the fossil-fueled thermal generation – this was facilitated by the development of gas fields in Taranaki, on the west cost of the North Island. It is clear from Table 2 and Figure 2 that the introduction of competition altered the nature and scale of generation projects, with the construction of several large thermal plants between 1996 and 2007. In 1995, renewables comprised 84.5% of generation, with this subsequently dropping to around 65.4% in 2008. However, after 2008, the share of renewables in the generation mix starts to increase again, but this time due to wind and geothermal power rather than hydrogeneration.

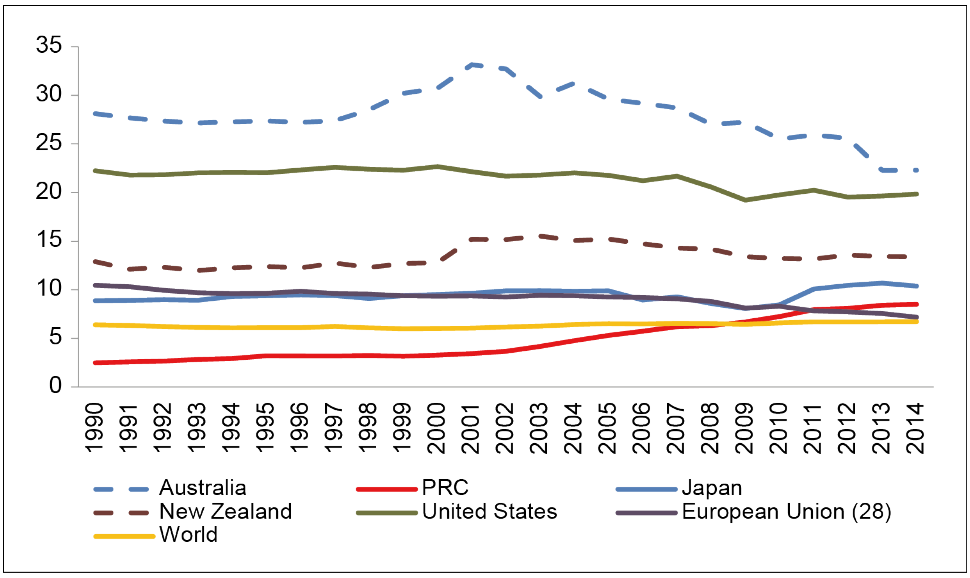
Although growth in the geothermal sector halted after 1989, it then reignited in 1997 with the development of better turbine technology and the recycling of geothermal fluids. Since 1997, over 770 MW of new capacity has been added and the sector contributed 17% of generation in 2015; only 2% behind the fossil-fueled thermal sector. The wind sector also grew quickly starting with the 32 MW Tararua Stage 1 wind farm in the lower North Island in 1999; by 2014 the total installed capacity exceeded 670 MW, and in 2015 the sector generated 5% of total generation. Total renewable generation now supplies in excess of 80% of the electricity market, as shown in Figure 1.

2.3 Emissions Profile

New Zealand's electricity sector remains dominated by large hydroelectric schemes, all built prior to 1992, which currently produce about 56% of all generation for a total annual demand of just over 40 TWh. Further, the construction of geothermal and wind projects since the turn of the century means NZ has a very "clean" energy generation system. However, due to agricultural emissions and emissions from transport (by developed country standards, the country has an aging and inefficient light-vehicle fleet); New Zealand's greenhouse gas emissions per capita are high by international standards (see Figure 4). Electrifying transport, especially the light-vehicle fleet, and reaching 100% renewable generation (see Mason et al. 2010; Mason et al. 2013) present realistic and considerable opportunities to reduce emissions for New Zealand.

By way of contrast to New Zealand, Australia's electricity sector remains dominated by coal despite increased use of gas and renewables in recent years. Unsurprisingly, Australia's greenhouse gas emissions per capita are among the highest in the world (see Figure 4). Emissions per capita have declined since the peak of 33.1 tCO_2e per capita in 2001 to 22.3 tCO_2e per capita in 2014. This still represents three times the emissions per capita of the EU 28 countries or twice those of Japan. Studies suggest that Australia, like New Zealand, could conceivably achieve 100% renewables (Elliston et al. 2012; Elliston et al. 2013). Indeed, modeling by Vithayasrichareon et al. (2015) suggests that a generation portfolio with 75% renewables in 2030 is the most optimal in terms of cost, cost risk, and emissions. In this context, one would expect that Australia would have had, by international standards, heavy investment in renewables in recent years. As we will see in Section 3, this is in fact not the case.

Figure 4: Total GHG Emissions per Capita
(tCO_2e per Capita)



PRC = People's Republic of China, tCO_2e = ton of carbon dioxide equivalent for greenhouse gases.

Note: Data are inclusive of Land-Use Change and Forestry.

Source: Compiled from CAIT Climate Data Explorer, World Resources Institute.

Overall, it is clear from Figure 4 that both Australia and New Zealand have high greenhouse gas emissions per capita and they have not met their potential in terms of harnessing renewable energies. Both have abundant renewable resources with which to reduce emissions and the potential to reach 100% renewables in generation (Elliston et al. 2012; Elliston et al. 2013; Mason et al. 2010; Mason et al. 2013). This will require investment in renewable energies, networks, and electrification of transport. Clearly, the challenge for Australia is much greater than that faced by New Zealand.

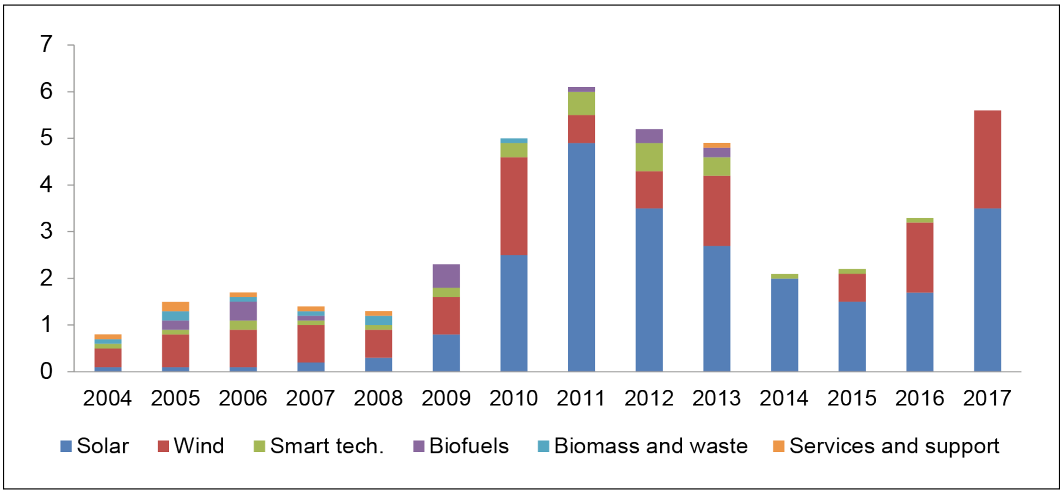
3. GREEN ENERGY FINANCE FLOWS

In this section, we analyze the flow of money toward green energy (green finance), which explains the current state of renewables in the two countries described above. Our focus is on financial flows since 2004. This is a precursor to exploring, in Section 4, the policies, incentives, and barriers that have contributed to these flows.

Figure 5 and Figure 6 show the pattern of financial flow to the various green energy technologies respectively in Australia and New Zealand. Both suggest a boom-bust type cycle in investment. In Australia, most of the investment has gone to wind and solar power, with the latter dominating. There have been suggestions that the volatile investment pattern in Australia is the result of political instability and lack of commitment by some administrations. Indeed, Australia has seen five changes in Prime Ministers since 2007.

Cheung and Davies (2017) test the hypothesis that different administrations have had contrasting commitments to climate change and energy transition by employing a mixed methods case-study and multi-criteria analysis to develop performance ranking scores for the four administrations between 1996 and 2015. The ranking scores achieved by the four administrations were 0.43 for John Howard (11/03/1996–03/12/2007), 0.89 for Kevin Rudd (3/12/2007–24/06/2010), 0.99 for Julia Gillard (24/06/2010–27/06/2013) and 0.11 for Tony Abbott (18/09/2013–15/09/2015). These scores would seem to be reflected in investment patterns (Figure 5); there was an increase in investment from 2009 following the election of Kevin Rudd (Labour) in December 2007 and a reduction in investment following the election of Tony Abbott (Liberal) in September 2013.

Figure 5: Australian Green Energy Investment 2004 to 2017
(US$ billion)



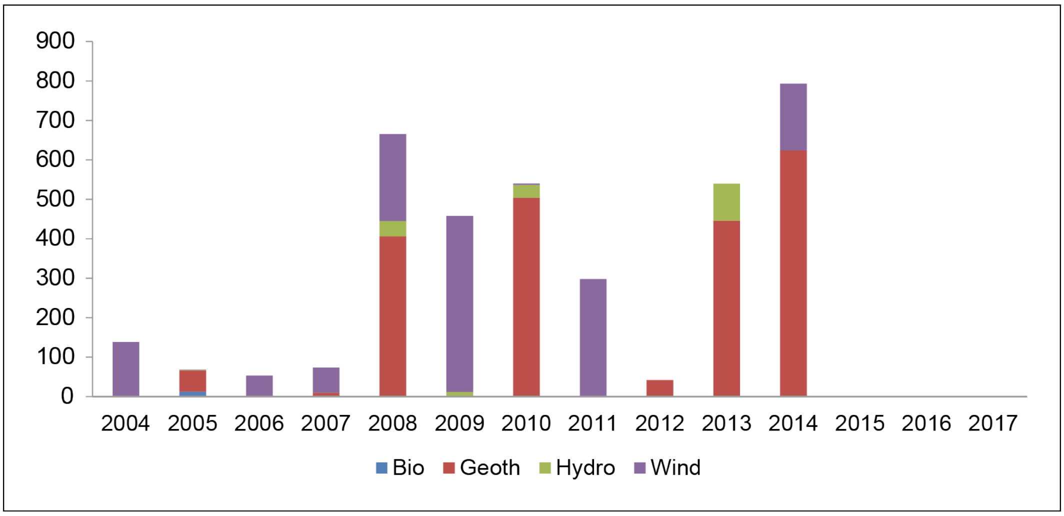
Note: 2017 data cover up to Q2 only.

Source: Compiled from Bloomberg New Energy Finance (BNEF) data. Chart excludes geothermal, marine, and small hydro, all of which were < 0.5 $US billion over the period.

Overall, the tumultuous political context in Australia has produced a range of policy interventions, which have included a thwarted carbon tax/trading scheme, a green investment bank, a green certification market, and feed-in-tariffs – these are discussed individually in Section 4. Historically, there would seem to be divergent commitments to tackling climate change and energy transition across Labour and Liberal political lines. However, bucking this trend, there seems to be an up-tick in investment since Malcolm Turnbull (Liberal) came into office in September 2015. Indeed, the Turnbull administration has undertaken a range of policy measures and interventions in part prompted by the "energy crisis" that has seen electricity supply interruptions and large rises in electricity costs (ACCC 2017). The measures include the National Energy Productivity Plan and the Snowy 2.0 pumped hydro energy storage project, which is set to be the largest "battery" in the Southern Hemisphere. This follows the high-profile and politicized construction, in less than 100 days, of the world's largest lithium-ion battery (129-megawatt-hour) in South Australia by Tesla and its founder Elon Musk.

Moreover, the Turnbull administration has recently announced the "National Energy Guarantee," which seeks to solve the crisis and add coherence to energy and environmental policies, thereby dealing with the energy "trilemma" of affordability, reliability, and emissions.[2] While its details are still awaited, the policy places obligations both in terms of the reliability and emissions of the electricity supply. Some commentators suggest the latter amounts to a carbon price via an emissions-intensity trading scheme.[3]

Figure 6: New Zealand Green Energy Investment 2004 to 2017
(NZ$ million)



Note: 2015 to 2017 there was no investment in new generating capacity.

Source: Compiled from Energy Link Ltd. Data.

2 DoEE (nd) "A better energy future for Australia", web page, Department of the Environment and Energy. Available from https://www.energy.gov.au [cited 17 December 2017].

3 Murphy, K. (2017) "What is the national energy guarantee and is it really a game changer?", web page, The Guardian. Available from https://www.theguardian.com. [cited 17 December 2017].

New Zealand, by way of contrast, has had political stability, yet it too displays a stop-start pattern to green energy investment (Figure 6). The two technologies that have received investment have been wind and geothermal. Of note are the 2008 boom in investment co-indices with the election of John Key (National) and the passing of the legislation by the previous Labour administration to establish the NZ ETS (see Section 4.2). However, the up-tick in investment, at least for wind, is likely the result of the Ministry for the Environment's Projects to Reduce Emissions (PRE) scheme, which provided credits for wind farms between 2002 and 2004.[4] Under the PRE scheme, the units issued were Kyoto-compliant and were issued to projects that would not have been initiated without the PRE units (Jamieson et al. 2005).

Beyond the short-lived PRE and the NZ ETS, and in contrast to Australia, there has been little in the way of policy. In 2007, a target to have 90% renewable energy generation by 2025 was put in place (MoED 2007) and in 2011 the National Policy Statement for Renewable Electricity Generation (NPS-REG) (MfE 2011) sought to provide a consistent approach to planning for renewable electricity generation in New Zealand, requiring local government to incorporate policy statements for the "development, operation, maintenance and upgrading" of new and existing energy generation activities "to the extent applicable to the region or district" (MfE 2011). However, the policy statement does not specify the actual extent to which renewable energy should be supported in any particular region.

Epitomizing a lack of ambition in energy policy and commitment, neither the NPS-REG nor the 90% renewable energy generation target by 2025 came with any substantive policy measures (over and above the ETS) that might have increased investment. After the election of September 2017, a Labour–NZ First–Greens government led by Jacinda Ardern has gained power from the "National" government of 2008–2017. The new government intends to establish an independent Climate Commission, implement a Zero Carbon Act, and requests that it "plan the transition to 100% renewable electricity by 2035 (which includes geothermal) in a normal hydrological year" (NZLP and GPANZ 2017, p.3). In the meantime, the ETS remains the only policy mechanism that is firmly established and functioning at the national level.

3.1 International Comparisons

The above discussion shows that despite the global context of rising investment in energy transitions, relative to other nations, the policy and political context in Australia and New Zealand would seem to be lagging behind most of the rest of the world. However, no country can claim to have an ideal context, as interventions and policies throughout the world are subject to imperfections and political changes (see, for instance, Davies and Diaz-Rainey 2011). As such, we conduct a simple analysis in Table 3 to place Australian and New Zealand investment in green energy in an international context.

[4] NZWEA (nd) "Tararua wind farm", web page. Available from http://www.windenergy.org.nz/tararua-wind-farm. [cited 10 December 2017].

Table 3: Green Energy Investment by the World's Largest Economies and New Zealand

Country	Total Spend ($US Billion between 2004 and Q2 2017)	Standard Deviation of Annual % Change Over 13½ Year Period	Population 2017, Thousands	Spend per Cap	GDP per Cap, Nominal US$ 2016	Spend on RE Over 13½ Year Period as % of 2016 GDP per Cap	Spend Relative to Mean Spend (=5%) for 13 Largest Economies
PRC	702.7	0.49	1,409,517	499	8,113	6.1%	23%
US	605.5	0.39	324,459	1,866	57,436	3.2%	–35%
Germany	298.9	0.26	82,114	3,640	41,902	8.7%	74%
Japan	266.1	0.31	127,484	2,087	38,917	5.4%	7%
UK	163.1	0.49	66,182	2,464	40,096	6.1%	23%
Italy	107.9	0.85	59,360	1,818	30,507	6.0%	19%
Spain	101.7	0.68	46,354	2,194	26,609	8.2%	65%
India	100.5	0.43	1,339,180	75	1,723	4.4%	–13%
Brazil	95.5	0.71	209,288	456	8,727	5.2%	5%
France	71.0	0.61	64,980	1,093	38,128	2.9%	–43%
Canada	57.7	0.41	36,624	1,575	42,210	3.7%	–25%
Australia	*44.9*	*0.46*	*24,451*	*1,836*	51,850	*3.5%*	*–29%*
Rep. of Korea	20.5	0.42	50,982	402	27,539	1.5%	–71%
Other	530.8	0.23					
NZ	*2.6*		*4,706*	*545*	38,345	*1.4%*	*–72%*

PRC = People's Republic of China, NZ = New Zealand, UK = United Kingdom, US = United States.

Notes: Green energy investment data from BNEF for all countries except NZ where data came from Energy Link. BNEF data include measurement of "smart technologies" and "services and support," whereas the Energy Link data were purely focused in generating plants. Further, NZ investment was converted from NZ$ using the exchange rate as at 20 December 2017.

Source: Compiled from Bloomberg New Energy Finance (BNEF), Energy Link Ltd., IMF and UNPD data.

The second column of Table 3 presents the total investment in green energy between 2004 and Q2 of 2017 for the 13 largest economies in the world and New Zealand. This shows that among the large economies, Australia ranks near the bottom in investment – but this does not take into account the scale of the energy system or the economy. To explore whether Australia's investment instability (see Figure 5) is pronounced relative to other large economies, we calculate for each country the standard deviation of annual % change in investment over the 13-and-a-half-year period. We use the annual percentage to adjust for different scales. The results are reported in the third column and show that Australia has had more variable green finance flows than Germany, Japan, and the US. However, flows have been more stable in Australia than in France, Spain, and Italy. This suggests that policy stability may not be the only or even main issue in the Australian context.

Next, we calculate in column five the spend or investment per capita (dividing total investment over the 13-and-a-half-year period by population). Here too Australia fares reasonably well, being behind Germany, Japan, and the UK but ahead of many developed countries. On this measure, New Zealand fares poorly, having invested per capita amounts equivalent to developing countries such as Brazil and the People's Republic of China (PRC). This measure has two issues, however; it does not account for the wealth of the country (hence developing countries doing so poorly with it), and it does not account for the energy context of the country (e.g., generating mix). To address the first problem, we developed what might be termed an "energy-transition-intensity measure" – dividing total investment over the 13-and-a-half-year period by GDP per capita.

Our energy-transition-intensity measure suggests that both Australia and New Zealand have lower levels of green energy investment relative to GDP per capita than many other developed countries. This is an intuitive number and tells us how much of per annum and per capita wealth is spent on renewables investment over a prolonged period (looking over a 13-year window means that the measure is not biased by a short-term boom or bust in investment). For the largest 13 economies in the world, Australia has the third-lowest measure, being only ahead of the Republic of Korea and Canada, and representing under half the investment of Spain and Germany. Australia has a similar measure to Canada and France; however, both the latter have high penetration rates of "clean" (in the case of France, nuclear) or renewable energy.

New Zealand's investment under this measure is the lowest of all the countries sampled. This poor performance is mitigated to some degree by the already high levels of renewable energy and low demand growth for electricity in recent years (the latter is discussed further in Section 4.1). Also, some caution should be attached to interpreting the New Zealand numbers relative to the other countries since they come from different datasets and there may be measurement differences (see notes to Table 3).

4. POLICIES, INCENTIVES, AND BARRIERS

From the preceding discussion, it is evident that the Australian and New Zealand electricity sectors stand in stark contrast to each other. Australia, on the one hand, is dominated by fossil fuels, coal in particular, but increasingly by gas, whereas New Zealand, on the other hand, is dominated by renewables (see Section 2). Both countries, however, have not met their potential in terms of renewables and have lower levels of green energy investment relative to GDP per capita than many other developed and indeed developing countries (see Section 3). In this section, we seek to understand why this is.

4.1 Electricity Markets

Another similarity that both Australia and New Zealand share is that they were earlier adopters of electricity industry reform. In 1996, a competitive, deregulated wholesale market was set up in New Zealand, and in 1998, Australia introduced the National Energy Market (the market currently covers five of the seven large states – it does not cover Western Australia and Northern Territory). Further, both countries have embraced retail competition. The motivations for the establishment of electricity markets were to increase competition and to improve the overall economic efficiency of the market, placing the risk for investment in new generation more with private investors, and to put downward pressure on prices. Furthermore, it was argued that liberalized markets would generally deliver service improvement and foster innovation.

The interplay between electricity markets and investment in green energy is complex. It is safe to say that this topic could be the subject of a paper in its own right and, as such, the discussion here is deliberately very general. In both countries, there are clearly tensions between electricity markets that were designed to squeeze efficiencies out of "steady state" systems with a linear supply chain architecture (generation, transmission, distribution) and the transformation required by electricity systems with a flexible network and bidirectional architecture that accommodates demand response, prosumers (distributed supply), electric vehicles, and large levels of intermittent renewables (Battaglini et al. 2009; Biggs 2016; Verbong and Geels 2010). These pressures are not unique to Australia and New Zealand, and the competing energy "trilemmas" have more generally raised questions of how electricity markets and networks can evolve and how utilities can adapt to these changing risks (Newbery 2018; Tulloch et al. 2017).

It would seem, however, that electricity industries/markets and their designers (politicians and regulators) have been particularly slow to embrace the change and to understand the challenges in Australia and New Zealand. This is epitomized by the recent Australian energy crisis. As conceded by the Turnbull administration in its "National Energy Guarantee":

South Australia's state-wide blackout in 2016 and the February 2017 load-shedding events in New South Wales and South Australia were wake-up calls. They threw the spotlight on the energy challenges facing Australia with a greater reliance on intermittent sources of generation and a more decentralized grid. They indicated that the National Electricity Market (NEM), designed in 1998, was no longer fit for purpose.[5]

The causes of the crisis have yet to be fully analyzed. Commentators opposed to renewables have pointed out that the blackouts were most severe in South Australia, a state where high levels of grid-level wind power and distributed solar have been installed (see Table 1). In this context, the assertion that the NEM is not fit for purpose by the Turnbull administration is striking, as it points to a failure of the market and regulators to adapt to a new reality.

A central concern, perhaps over and above the blackouts, has been the rising cost of electricity for Australians. An Australian Competition and Consumer Commission Inquiry (ACCC 2017) into the NEM noted the following:

- Electricity prices have more than doubled in the last 10 years, with these increases dramatically outpacing inflation and wage growth.
- The increase in residential electricity costs was primarily driven by higher network costs (which accounted for 48% of bills, while environmental costs accounted for 7% of bills).
- Higher network costs were largely the result of a network regulation framework that allowed for over-investment (See also Simshauser (2014) for a discussion of how network cost rises occurred).
- Concerns about the effect of market concentration, both at the wholesale and retail level, was having on prices and competition. The three large "gentailers" (generators and retailers), namely AGL, Origin, and EnergyAustralia, supply around 70% of retail customers in the NEM and control approximately 48% of generating capacity.

Some of the concerns raised by the ACCC 2017 Inquiry would seem to echo across the Tasman Sea in New Zealand. As in Australia, there are concerns about energy affordability and that the New Zealand Electricity Markets (NZEM) remain highly concentrated with the four largest "gentailers" (Contact Energy, Genesis Energy, Mercury NZ, and Meridian Energy) accounting for 87% of all generation and 77% of all metered installations in 2017 (Diaz-Rainey et al. 2018). Similar to Australia, distribution

[5] DoEE (nd), *op. cit.*

and transmission costs make up a large proportion of electricity cost in New Zealand (around 42% excluding tax).[6]

Further, in the NZEM, uncertainty around demand growth appears to have put a dampener on investment. For instance, there are 17 wind farms operating on mainland New Zealand, with a total capacity exceeding 380 MW; however, another 15 wind farms, which are consented, with a total potential capacity of 2,363 MW, are not being built due to a lack of demand.[7] New Zealand had demand growth of approximately 700 GWh per annum from 1996 to 2006, but between 2006 and 2016 demand fell by just under 300 GWh (MBIE 2017). The average residential demand per household has fallen from an average of 8,101 kWh per annum for the years 1991 to 2006, to an average of 7,441 kWh per annum for the three years 2013 to 2015 (residential demand was 31% of total demand in 2016 – MBIE 2017). However, perhaps the greatest uncertainty concerns the demand from industrial load (37% of total demand). Between 2005 and 2016, the wood, pulp, and paper processing sector shed 1,428 GWh of annual demand, and the Tiwai aluminum smelter located near Bluff, although accounting for 12% of total annual demand in New Zealand, is running only three of its four pot lines.

Overall, the incumbents and regulators in both Australia and New Zealand are fearful of a "death spiral" induced by distributed generation (DG) and low prices from intermittent renewables leading to stranded (uneconomic) thermal plants. A death spiral occurs when an increasing number of customers install DG and disconnect from the network, raising the cost of those that remain on the network, thereby inducing even more installation of DG and disconnection from the network (see for instance Simshauser 2014).

Concerns about death spirals and stranded assets were also voiced in Europe over a decade ago. They represent opposition to change, yet politicians and regulators (largely through EU policies), with their eye firmly on the public interest, pressed ahead. This imposed real costs and risks on energy utilities (Tulloch et al. 2017), which have been forced to adapt – many EU utilities are changing their business models |by divesting thermal plants and focusing increasingly on services for smart grids as a way of dealing with DG, EVs, and lower demand. Ultimately, the commitment to energy transition in the EU has led to a cut in emissions from a relatively low base (see Figure 4). This has been done with electricity prices that are not too dissimilar (and by some estimates lower) to those in Australasia (ACCC 2017, pp. 24–25). The fact that Australia and New Zealand are islands with networks covering big distances does suggest there are contextual differences that may imply greater cost. This is counterbalanced to some extent by excellent renewable resources (see Section 3). Indeed, as noted earlier, modeling for Australia done by Vithayasrichareon et al. (2015) suggests that a generation portfolio with 75% renewables in 2030 is the most optimal in terms of cost, cost risk, and emissions.

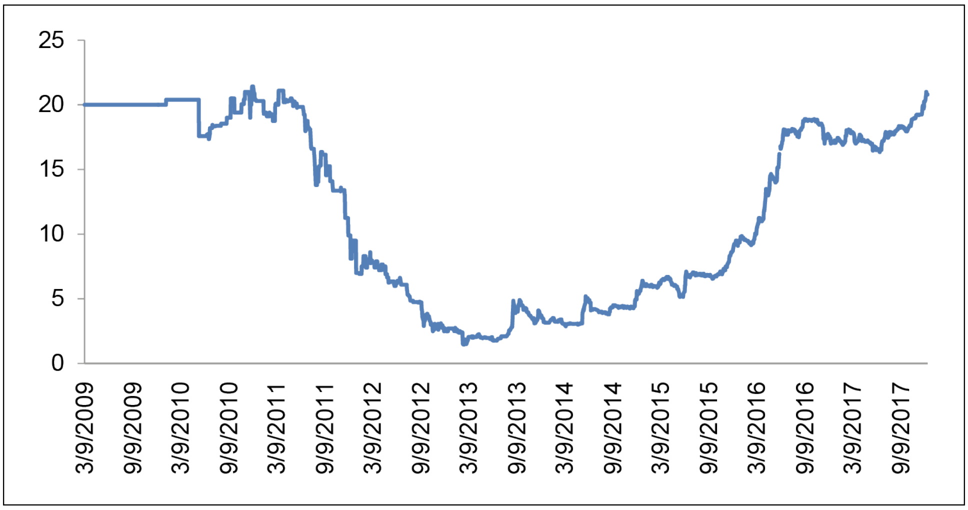
[6] Own calculations based on Energy Link data, excludes GST in total costs to make comparison possible with ACCC (2017).

[7] NZWEA (nd) "Consented Wind Farms", web page. Available from http://www.windenergy.org.nz. [cited 10 December 2017].

4.2 Carbon Markets and Taxes

Both countries have had policies that sought to price carbon via Emissions Trading Schemes (ETSs), and their experience has highlighted the political and technical challenges of designing effective ones. Australia's scheme was to start as a carbon tax and evolve into a trading scheme after three years. More specifically, from mid-2012 to mid-2015, the scheme was to operate with a fixed price of AUD$23 per ton, which would have risen to AUD$25.40 by the end of the three years (Jotzo 2012). After that point, a "collar" (a price cap and price floor) that would gradually rise would be imposed on the market. The initial collar in 2015 was set to be AUD$15 per ton floor and an AUD$20 ceiling. The legislation to enact the scheme was passed in the Gillard government and had followed some 20 years of discussion of carbon pricing at political levels (see Crowley 2017). However, the scheme was repealed in its infancy by the Abbot government, shortly after winning the 2013 election (see Section 3). The short life of the Australian ETS/tax and its historical context highlights the need for a cross-party consensus if credible carbon pricing mechanisms are to be implemented. As noted in Section 3, the "National Energy Guarantee" of the Turnbull administration seems to be providing a new impetus to carbon pricing in all but name. Notwithstanding this, Australia's climate change policies can only be described as "erratic" (Nelson 2015).

Figure 7: Price of NZUs in NZ$ from September 2009 to December 2017



Source: Compiled from Bloomberg Professional Terminal data.

New Zealand's experience of carbon pricing has, relative to Australia, been much more successful. The New Zealand Emissions Trading Scheme (NZ ETS) is the second-oldest national ETS in the world (Diaz-Rainey and Tulloch 2016). It is a complex scheme that has undergone numerous changes over the years and, as such, a full exploration of it is not possible here (see Diaz-Rainey and Tulloch 2016, and Kerr and Ormsby 2016, and references therein). The scheme is differentiated from other ETSs in several respects: (1) it initially allowed unlimited importation of Kyoto units; (2) it covers forestry, which can create units via afforestation; and (3) it is an intensity system rather than having a hard cap. Initially, it was also designed to include agriculture, which produces roughly half of New Zealand's total GHG emissions (see Section 2.2 and Diaz-Rainey and Tulloch 2016).

The legislation for the scheme was passed in 2008 by an outgoing Labour government. In 2009, the new National government introduced a number of "transitionary" measures that muted its impact, namely (1) a need to produce only one allowance for every two tons of emissions (this is now gradually being phased out), (2) a price ceiling of NZ$25 and (3) the exclusion of agriculture from the scheme.

The ETS trades in NZ units (NZUs) and, as noted above, in its early years allowed unlimited importation of Kyoto ERUs and CERs. As the price of these Kyoto units fell, so did the price of NZUs. From an initial level above $20 in 2011, NZU prices dipped below $3 in 2013 (see Figure 7 and Diaz-Rainey and Tulloch 2016). The government, following stringent criticism of the nature of some the imported allowances, ultimately prohibited the use of the Kyoto units from 2015 (it did so by not entering into the second compliance period of Kyoto, known as CP2). However, by the time it had exited CP2, companies affected by the scheme, had "banked" a large amount of units (Kerr and Ormsby 2016). Since exiting CP2, the price of NZUs has recovered to almost $21 (see Figure 7).

Electricity generators are covered by the scheme and are required to surrender NZUs each year in proportion to their total emissions. In New Zealand's electricity market, gas and coal-fired generation plays a key role in setting the marginal price, so in theory the addition of a carbon price to the overall fuel price should be reflected in higher spot prices in the wholesale market, leading to higher prices overall, thus making DG more competitive. Modeling shows that with the current contribution of fossil-fueled generation to meet overall demand, there should be a rise in the average spot price of approximately $0.4/MWh for every $1 of carbon cost (modeling by Energy Link).

However, even as carbon prices have risen over the last two years, this signal has been muted for two reasons. Firstly, the ETS has still not moved out of its "transitionary" phase, so that in 2017 only one NZU must be surrendered by emitters to the government for every 1.5 tons of emissions. Secondly, it would appear that large emitters took the opportunity to purchase and "bank" NZUs while they were very cheap and importation of units for compliance was possible, and in some cases have enough NZUs to last several years without purchasing additional NZUs (see Diaz-Rainey and Tulloch 2016; Kerr and Ormsby 2016; Mercury 2017).

The scheme is currently under review and the election of the Ardern government, with its Green Party coalition partner (see Section 3), raises the prospect that the scheme could be further strengthened; and, critically, it seems that the high-emitting agricultural sector will be finally added to the scheme in the future.

4.3 Green Certificate Markets

Green certificate markets (GCMs), or mandatory renewable energy targets, impose obligations on electricity retailers to source increasing proportions of total electricity sales from renewable energy sources over a fixed time frame. Since those with surplus renewable certificates can sell them to those with a shortfall (much like carbon markets), it has been argued that they produced more effective and cost-efficient outcomes than subsidies such as feed-in-tariffs (Davies and Diaz-Rainey 2011; Diaz-Rainey and Ashton 2008). The actual evidence does not necessarily support this assertion, with evidence pointing to them being less effective in promoting renewables (see for instance, Davies and Diaz-Rainey 2011 and related references), yet they have been implemented widely, including in Australia and the UK.

Australia's Renewable Energy Target (RET) was introduced 2001 (Simpson and Clifton 2014). The scheme was materially expanded in 2009 to incorporate state and federal efforts and to give effect to a 20% target by 2020; however, in 2011 the scheme was split into two parts: a large-scale renewable energy target and a small-scale renewable energy target (Nelson et al. 2013; Simpson and Clifton 2014). In June 2015, the obligation was reduced from 41,000 GWh to 33,000 GWh in 2020, while the Turnbull administration has recently announced that the scheme is not being extended beyond 2020.[8]

Although the various incarnations of the RET have unquestionably supported renewables expansion in Australia, most notably wind energy and with some support for solar via the RET integration with FIT (see Figure 2 and Section 4.5), the frequent changes to the scheme have undermined confidence in it – ultimately limiting its impact (Nelson et al. 2013; Nelson 2015).

4.4 Green Energy Tariffs

The combinations of retail competition in electricity markets and the use of GCMs as incentives for renewables has meant that green energy tariff markets have proliferated around the world (see for instance Diaz-Rainey and Ashton 2008, Diaz-Rainey and Ashton 2011 and Diaz-Rainey and Tzavara 2012). Green energy tariffs are an innovation where consumers choose to have "green electricity" and often pay a premium for it. They are an attempt to reap the policy benefits of green consumerism (Diaz-Rainey and Ashton 2008) and can provide additional incentives over and above those provided by government to invest in renewables. Certification systems ensure there is MWh of renewables electricity for each MWh of green electricity sold by retailers. Since renewable source certificates are routinely created as part of GCMs, GCM systems facilitate the creation of compliance systems that allow for the certification that tariffs are "derived" from renewables (see Diaz-Rainey and Ashton 2008).

Given that New Zealand's electricity system is dominated by renewables and there are no GCM incentives in place, green tariffs are not relevant. In Australia, however, a green tariff market exists. In 2016, according to the Clear Environment (2017, p. 9) there were 30 accredited products offered by 29 providers in the National GreenPower Accreditation Program, with 759,293 MWh of green electricity sold in 2016: 367,324 MWh to residential customers and 391,968 MWh to business customers. This represents about a quarter of a million customers, with most of them being residential households. Although some research on the Australian market has been conducted (for instance, Ma and Burton 2016 and Hobman and Frederiks 2014), establishing the additional benefits to renewables investment is not straightforward in any context.

4.5 Distributed Generation and Feed-in-Tariffs

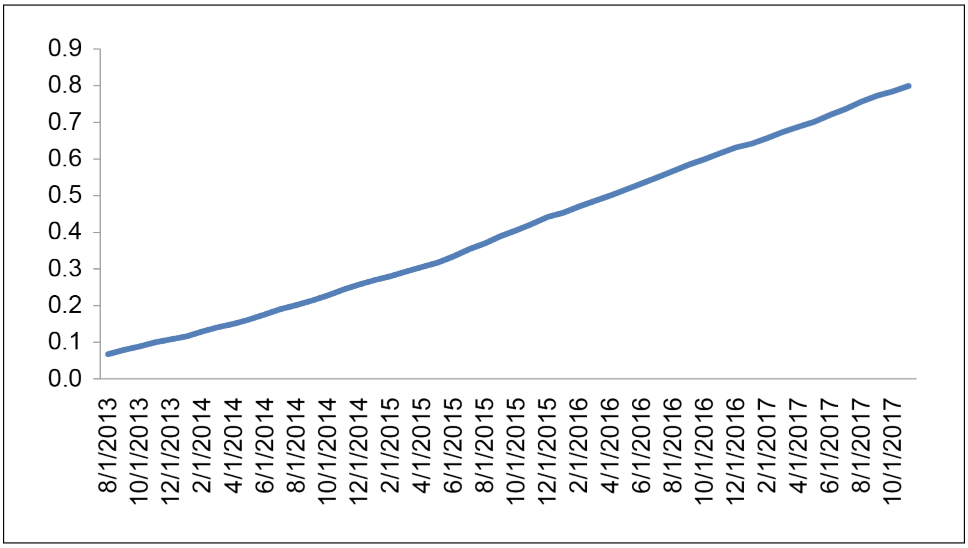
While in other jurisdictions feed-in-tariffs have been used as an alternative to GCMs for encouraging large-scale renewable deployment (Davies and Diaz-Rainey 2011), a number of countries have employed both policies, with GCMs being used for large-scale projects and FITs used to encourage DG. Australia is a case in point – although there are examples of FITs being used for larger projects in Australia (Buckman et al. 2014). FITs provide a subsidy or a premium for electricity

[8] De Gabriele et al. (2017) "Infographic: The National Energy Guarantee at glance" web page, The Conversation. Available from http://theconversation.com [cited 20 December 2017].

generated from renewables or DG. They have been shown to be highly effective, but their success is moderated by the tariff design and the stability of the policy (Dijkgraaf et al. 2017).

In Australia, the FIT schemes have been largely used to encourage rooftop PV deployment and have been designed at the state level (Byrnes et al. 2013). Since they have been state-level policies, there has been a great deal of variation in terms of design, and some incentive schemes have interacted with the RET scheme (see Burtt and Dargusch 2015). The schemes have clearly been a success, with 17% of Australian households having solar panels on their roofs, representing more than 1.76 million units across Australia (as at 1 November 2017).[9] This high deployment rate is evident in our data, both in terms of installed capacity and investment (see Figure 2 and Figure 5). This PV deployment has had considerable environmental benefits – along with the PV units, the tariffs have helped reduce Australia's emissions by just under 4% by 2020 (Burtt and Dargusch 2015).

Figure 8: Percentage of ICPs (Installation Control Points) with Solar Generation



Source: Compiled from Electricity Authority data.

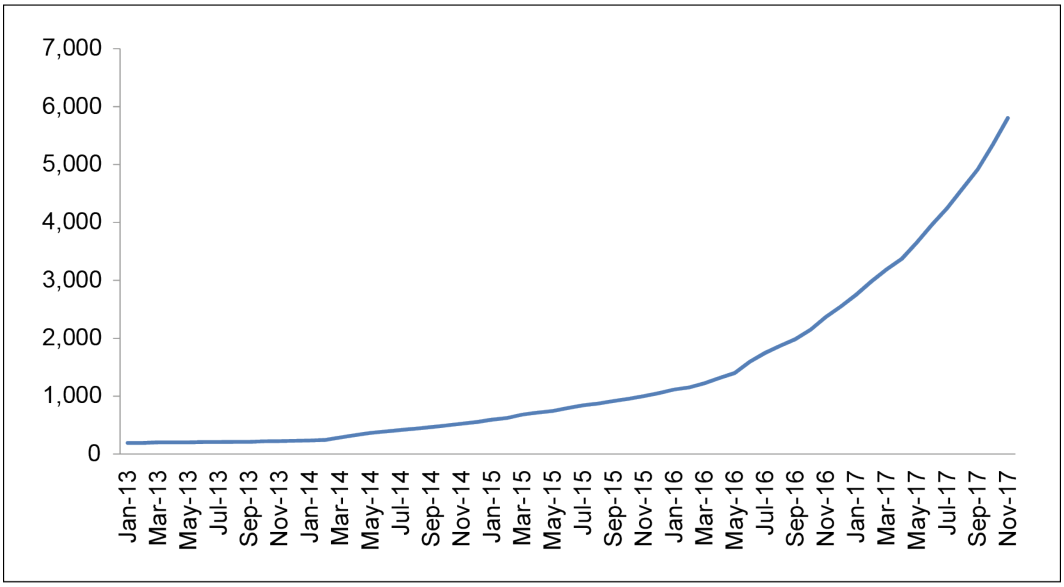
In contrast to Australia, New Zealand has no direct incentives for DG. It has been argued that an implicit subsidy for DG was in place until recently, as retailers agreed to buy excess solar power back from consumers at the same rate that the customer purchased electricity from retailers, typically at least 16 c/kWh. However, from 2014 large retailers have all lowered their solar buy-back rates to match wholesale rates, and these are as low as 3.5c/kWh depending on the time of year. The removal of retail buy-back rates is also encouraged by the Electricity Authority (EA 2015), which argues that it is uneconomic to install solar power at home if it cannot be built, owned, and operated for a total cost that is less than the cost of connecting new, large-scale renewable generation to the grid, for example, large wind farms and geothermal stations. This approach contrasts dramatically with the approach to distributed power in Europe and Australia, where DG is often supported with generous FITs. Despite an arguably hostile regulatory environment toward DG, solar installations have been growing and now represent just under 1% of ICPs (installation control points – broadly

[9] DoEE (nd), *op. cit.*

representing metering points) (see Figure 8). This is well below the 14% seen in Australia, highlighting the difference that support schemes can make.

Finally, despite the absence of meaningful incentives, the uptake of electric vehicles (EVs) in New Zealand is showing rapid growth (see Figure 9). EVs represent an opportunity for the electricity industry to trigger some demand growth (see discussion about low demand growth in Section 4.1).

Figure 9: Registered Electric Vehicles in New Zealand



Source: Compiled from Ministry of Transport data.

4.6 Green Investment Bank and Other Funding Mechanisms

Australia has been one of a handful of countries to establish a dedicated green investment bank – the UK is another. It established the Clean Energy Finance Corporation (CEFC) in 2012, and by 2017 CEFC has made commitments of more than $4.3 billion for projects worth over $11 billion.[10] Its investment ranges from building energy-efficient homes for low-income families, to helping to finance wind and solar projects. In addition, the Australian Renewable Energy Agency (ARENA), also established in 2012, has more of a research and development focus and has been involved in co-funding innovative projects.

In New Zealand, the new government intends to "stimulate up to $1 billion of new investment in low carbon industries by 2020, kick-started by a Government-backed Green Investment Fund of $100 million" (NZLP and GPANZ 2017, p. 3).

[10] DoEE (nd), *op. cit.*

5. CONCLUSION

It is clear from the preceding analysis that neither New Zealand nor Australia has met its respective potential with respect to growing renewable energy, and a major factor in this is the absence of strong and consistent incentives to engender green energy financing. Neither country can be considered an exemplar in terms of its response to the increasingly important issue of energy transition in response to climate change.

New Zealand, on the face of it, looks impressive with a generating mix of over 80% renewables, but this is largely the legacy of state interventionism in decades past and masks high per capita greenhouse gas emission due to intensive agricultural systems (see Section 3.1 and Section 4.2). Much more could be done to incentivize distributed generation and the electrification of transport.

Australia still has a system dominated by coal, and although it has had more policies in place to incentivize renewables, their effect has been muted due to political instability and fragmentation (federal and state policies), and most of all because of a lack of commitment to energy transition across all parties and regulators. Importantly, this, at best, mixed success of the two countries provides valuable lessons for other jurisdictions wishing to mobilize investment in renewables. These lessons include the following:

- *Lesson 1: Policy stability is needed, otherwise market confidence and ultimately investment erodes.* This was evident in both jurisdictions, with policy changes in the NZ ETS in New Zealand and changes in terms of carbon pricing and the RET in Australia contributing to a volatile investment pattern in both countries (see Figures 5 and 6).
- *Lesson 2: Political and regulatory acceptance of the need for energy transition is as important as policy stability*. The analysis in Section 3.1 showed that the volatility in investment flows in Australia was not particularly high relative to some other developed countries. Rather, our *energy-transition-intensity measure* (Table 3) suggests that both Australia and New Zealand have lower levels of green energy investment relative to GDP per capita than many other developed countries. This is reflective of a lack of commitment to energy transition and climate action by political parties (notably National in New Zealand and until recently the Liberals in Australia) and regulators (see Sections 3, 4.1, and 4.2).
- *Lesson 3: Conventional efficiency-focused, oligopolistic, liberalized electricity markets may not be ideally suited for rapid energy transformation.* The introduction of electricity markets in New Zealand in 1996 initially led to the construction of smaller plants and an increased use of thermal generating units. Incumbents and regulators in both Australia and New Zealand are fearful of a "death spiral" induced by distributed generation (DG) and low prices from intermittent renewables leading to stranded (uneconomic) thermal plants. Similar concerns were voiced in Europe over a decade ago. They represent opposition to change, yet politicians and regulators (largely through EU policies), with their eye firmly on the public interest, pressed ahead. This imposed real costs and risks on energy utilities (Tulloch et al. 2017) but has contributed to decarbonization and innovation in the sector, without a ballooning of electricity costs. The need for an electricity market and industry reform is highlighted by the Turnbull administration's assertion in its "National Energy Guarantee" that the National Electricity Market (NEM) is "no longer fit for purpose."

- *Lesson 4: Even fragmented, varied, and state-defined FIT schemes have fostered green investment and a rising share of solar power in Australia.* The success of these policies is evident in terms of installed capacity (Figure 2), investment flows (Figure 5) and environmental benefits (see Section 4.5).

From the preceding discussion it is clear that electricity industry and markets reform is a critical issue for meaningful energy transition. Electricity markets remain too concentrated, and technologies such as smart meters, DG and EVs offer the possibility that electricity markets can be transformed from oligopolistic linear supply chain models to a more network-type infrastructure, more akin to perfect competition (with lots of suppliers and consumers and an increased focus in energy services). This will involve opening markets to greater competition from DG and will require market innovations such as storage markets or capacity markets. Europe is moving in this direction. The alternative is to have much greater state intervention and potentially even the rolling back of markets – unsurprisingly, this option is even more unpalatable to existing oligopolistic electricity markets/industry.

The Australian energy crisis, the Paris Agreement and the associated impetus of the Turnbull and Ardern administrations suggest that green energy investment is set to increase in Australia and New Zealand in the coming years. The success of their strategies will, we suspect, largely rest on the degree to which they are willing to tackle substantive electricity market/industry reforms.

REFERENCES

ACCC (2017) Retail Electricity Pricing Retail Inquiry: Preliminary report, Australian Competition and Consumer Commission, Canberra, 22 September.

Battaglini, A, Lilliestam, J, Haas, A, Patt, A, (2009) Development of SuperSmart Grids for a more efficient utilisation of electricity from renewable sources. *Journal of Cleaner Production*, 17, 911–918.

Biggs, C (2016) A resource-based view of opportunities to transform Australia's electricity sector. *Journal of Cleaner Production*, 123, 203–217.

Buckman, G, Sibley, J, Bourne, R (2014) The large-scale solar feed-in tariff reverse auction in the Australian Capital Territory, Australia. *Energy Policy*, 72, 14–22.

Burtt, D, Dargusch, P (2015) The cost-effectiveness of household photovoltaic systems in reducing greenhouse gas emissions in Australia: Linking subsidies with emission reductions. *Applied Energy*, 148, 439–448.

Byrnes, L, Brown, C, Foster, J, Wagner, LD (2013) Australian renewable energy policy: Barriers and challenges. *Renewable Energy*, 60, 711–721.

Cheung, G, Davies, PJ (2017) In the transformation of energy systems: what is holding Australia back? *Energy Policy*, 109, 96–108.

Clear Environment (2017) National GreenPower accreditation program: Annual compliance audit for 1 January 2016 to 31 December 2016. A Report for the National GreenPower Steering Group Prepared by Clear Environment Pty Ltd, 16 July.

Crowley, K (2017) Up and down with climate politics 2013–2016: The repeal of carbon pricing in Australia. *Wiley Interdisciplinary Reviews: Climate Change*, 8(3), e458.

Davies, SW, Diaz-Rainey, I (2011) The patterns of induced diffusion: Evidence from the international diffusion of wind energy. *Technological Forecasting and Social Change*, 78(7), 1227–1241.

Diaz-Rainey, I, Ashton, JK (2008) Stuck between a ROC and a hard place? Barriers to the take up of green energy in the UK. *Energy Policy*, 36(8), 3053–3061.

———. (2011) Profiling potential green electricity tariff adopters: green consumerism as an environmental policy tool? *Business Strategy and the Environment*, 20(7), 456–470.

Diaz-Rainey, I, Han, X, Sise, G, Aitken, S (2018) Electricity futures and stock market response to electricity sector material disclosures, mimeo (University of Otago).

Diaz-Rainey, I, Tulloch, D (2016) Carbon pricing in New Zealand's Emissions Trading Scheme, USAEE/IAEE Working Paper No. 16-255, Available at SSRN.

Diaz-Rainey, I, Tzavara, D (2012) Financing the decarbonized energy system through green electricity tariffs: A diffusion model of an induced consumer environmental market. *Technological Forecasting and Social Change*, 79(9), 1693–1704.

Dijkgraaf, E, van Dorp, TP, Maasland, E (2018) On the effectiveness of feed-in tariffs in the development of solar photovoltaics. *The Energy Journal*, 39(1), 81–99.

EA (2015) Implications of evolving technologies for pricing of distribution services, Consultation Paper, Electricity Authority, Wellington, 3 November.

Elliston, B, Diesendorf, M, MacGill, I (2012) Simulations of scenarios with 100% renewable electricity in the Australian National Electricity Market. *Energy Policy*, 45, 606-613.

Elliston, B, Macgill, I, Diesendorf, M (2013) Least cost 100% renewable electricity scenarios in the Australian National Electricity Market. *Energy Policy*, 59, 270–282.

Hobman, E. V., Frederiks, E. R. (2014) Barriers to green electricity subscription in Australia: Love the environment, love renewable energy… but why should I pay more? *Energy Research & Social Science*, 3, 78–88.

Jamieson RE, Brasell MR, Wakelin W (2005) Projects to reduce greenhouse gas emissions in New Zealand, Working Paper. Available at ResearchGate.

Jotzo, F (2012) Australia's carbon price. *Nature Climate Change,* 2, 475–476.

Kerr, S, Ormsby, J (2016) The New Zealand Emissions Trading Scheme de-link from Kyoto: impacts on banking and prices. Motu Working Paper, 16–13.

Ma, C, Burton, M (2016) Warm glow from green power: Evidence from Australian electricity consumers. *Journal of Environmental Economics and Management*, 78, 106–120.

Mason, IG, Page, SC, Williamson, AG (2010) A 100% renewable electricity generation system for New Zealand utilising hydro, wind, geothermal and biomass resources. *Energy Policy*, 38(8), 3973–3984.

Mason, IG, Page, SC, Williamson, AG (2013) Security of supply, energy spillage control and peaking options within a 100% renewable electricity system for New Zealand. *Energy Policy*, 60, 324–333.

Mercury (2017) Mercury NZ Annual Report 2016–17, August 2017.

Nelson, T (2015) Australian climate change policy–where to from here? *Economic Papers*, 34(4), 257–272.

MBIE (2017) Energy in New Zealand, 2016 calendar year edition, Ministry of Business Innovation and Employment, Wellington.

MfE (2011) National policy statement for renewable electricity generation, Ministry for the Environment, Wellington.

MoED (2007) New Zealand Energy Strategy to 2050: Powering our future–Towards a sustainable low emissions energy system, Ministry of Economic Development Wellington, Available from: http://www.mcguinnessinstitute.org.

Nelson, T, Nelson, J, Ariyaratnam, J, Camroux, S (2013) An analysis of Australia's large scale renewable energy target: Restoring market confidence. *Energy Policy*, 62, 386–400.

Newbery, DM (2018) What future(s) for liberalized electricity markets: Efficient, equitable or innovative? *The Energy Journal,* 39(1), 1–27.

NZLP and GPANZ (2017) Confidence and supply agreement between the New Zealand Labour Party and the Green Party of Aotearoa New Zealand.

Reilly, H (2008) Connecting the country: New Zealand's National Grid 1886-2007, Steel Roberts Publishers, Wellington, 2008.

Simpson, G, Clifton, J (2014) Picking winners and policy uncertainty: Stakeholder perceptions of Australia's Renewable Energy Target. *Renewable Energy*, 67, 128–135.

Simshauser, P (2014) From first place to last: The National electricity market's policy-induced ‘energy market death spiral’. *Australian Economic Review*, 47(4), 540–562.

Tulloch, DJ, Diaz-Rainey, I, Premachandra, IM (2017) The impact of liberalization and environmental policy on the financial returns of European energy utilities. *The Energy Journal*, 38(2), 77–106.

Verbong, GPJ, Geels, FW (2010) Exploring sustainability transitions in the electricity sector with socio-technical pathways. *Technological Forecasting and Social Change*, 77, 1214–1221.

Vithayasrichareon, P, Riesz, J, MacGill, IF (2015) Using renewables to hedge against future electricity industry uncertainties—An Australian case study. *Energy Policy*, 76, 43–56.