Chapter 3

Renewable Energy Integration in a Liberalised Electricity Markets: A New Zealand Case Study

Qing Yang
New Zealand Institute of Economic Research (NZIER)

August 2013

This chapter should be cited as
Yang, Q. (2013), 'Renewable Energy Integration in a Liberalised Electricity Markets: A New Zealand Case Study' in Kimura, S., H. Phoumin and B. Jacobs (eds.), *Energy Market Integration in East Asia: Renewable Energy and its Deployment into the Power System*, ERIA Research Project Report 2012-26, Jakarta: ERIA. pp.99-129.

CHAPTER 3

Renewable Energy Integration in a Liberalised Electricity Markets: A New Zealand Case Study

QING YANG
New Zealand Institute of Economic Research (NZIER)

In ASEAN and East Asian countries, renewable energy has become a mainstream option, driven by a tremendous growth in energy demand arising from rapid economic growth, concerns about energy security, abundance of renewable energy resources, improvements in renewable technologies, and efforts to limit pollution. This has presented both opportunities for economic growth and challenges to it. One challenge the ASEAN and East Asian countries face is the integration of renewable energy into national or regional electricity networks.

With the bulk (70%) of its current electricity generation from renewable resources, and targeting 90% by 2025, New Zealand's experience with renewable energy development may have some implications for the renewable energy development in ASEAN and East Asian countries.

While renewable energy accounts for the bulk of electricity generation, the variability and unpredictability of some renewable energy sources, together with the asymmetry of electricity generation and demand, mean that system integration is a significant issue. With the current expectations of high fuel prices and carbon emission charges, the use of renewable energy for electricity generation is likely to increase in the future, especially the contribution from wind energy.

To achieve the target of generating 90% of its electricity from renewable sources by 2025, and to ensure environmentally sustainable energy generation and ensure the stability and security of the electricity system. New Zealand has taken the following steps to promote the development of renewable energy, which may provide implications for ASEAN countries in their renewable energy development:

First, to encourage the development of renewable energy and to ensure environmentally friendly and sustainable economic development, the New Zealand government has published a long term energy development strategy, with a focus on renewable energy development and the adoption of environmentally sustainable energy technologies.

Secondly, recognizing the barriers to the deployment of Renewable Energy Sources (RES), the New Zealand Government has passed several regulations and laws to facilitate the development of renewable energy. For example, in 2008 parliament, passed the Climate Change Response (Emissions Trading) Amendment Act 2008, and the Electricity (Renewable Preference) Amendment Act 2008. To support the RES, the Emissions Trading Scheme has been passed into law and put *into effect since 2010, requiring electricity generators to take into account the carbon price in electricity pricing. This will allow renewable generators to gain competitive advantages over fossil-fuelled generators.*

In 2011, the New Zealand government released its National Policy Statement (NPS) on Renewable Electricity Generation under Section 32 of the Resource Management Act 1991 (MFE, 2011). This NPS has lifted the status of renewable electricity generation to that of national importance. This encourages local governments to incorporate renewable energy development into their policy statements and plans, and streamlines the consenting process for renewable energy projects.

The Energy Efficiency and Conservation Authority (EECA) has also provided small financial assistance for new renewable energy projects under its Energy Efficiency program. EEC also works with and provides support to renewable energy industries in New Zealand, such as providing seed funding for industry associations, supporting and encouraging the development of industrial standards, etc.

Thirdly, in New Zealand renewable energy development and integration have been mainly achieved through the functioning of a liberalised and vertically separated electricity market. Electricity is traded in the wholesale electricity market. An independent transmission grid gives the new renewable energy generators an access that is equal to that of incumbent generators. A competitive electricity wholesale market enables new renewable energy generators to compete with incumbent generators on a level playing field.

Due to the variable and unpredictable nature of some renewable energy, especially wind energy, New Zealand has also made a few operational adjustments in electricity market operation in order to facilitate renewable energy integration, and to ensure the stability of the electricity system at the same time. These operational adjustments include initiatives to improve forecasting methodology, establish back up mechanisms, more flexible "gate closure" time for wind generators, etc.

Fourthly, to deal with the timing difference between transmission investment and generation investment, in order to accommodate further renewable energy investment, the governing body of the electricity market, the Electricity Authority, and its predecessor the Electricity Commission, together with the system operator, have also taken proactive initiatives to facilitate transmission investment for further renewable energy investment and integration, such as identifying potential renewable energy resources and their location, the costs associated with each potential renewable project, and the transmission investment to support the development of renewable energy generation, which are then fed into the Electricity Authority and system operator's transmission investment planning and scheduling process, which then send signals to potential renewable generation investment.

Introduction

Renewable energy has experienced major global growth over the recent years, driven by factors including emission reduction, energy security, and economic growth (employment). In ASEAN and East Asian countries, renewable energy has become a mainstream option, driven by a tremendous growth in energy demand arising from rapid economic growth, concerns about energy security, an abundance of renewable energy resources, improvements in renewable technologies, and efforts to limit pollution. This has presented both opportunities for economic growth and challenges to it.

In New Zealand (NZ), renewable energy accounts for the bulk of electricity generation (77% in 2011). However, the variability and unpredictability of some renewable energy sources, together with the asymmetry of electricity generation and demand, mean that system integration is a significant issue.

With the current expectations of high fuel prices and carbon emission charges, the use of renewable energy for electricity generation is likely to increase in the future, especially the contribution from wind energy. The New Zealand Energy Strategy 2011-2021 (MED, 2011) set the target of generating 90% of electricity from renewable sources by 2025.

To achieve this target, the New Zealand government has taken steps to promote the development of renewable energy generation. In 2011, it released a National Policy Statement for Renewable Electricity Generation (MFE, 2011), lifting the status of renewable energy generation to that of national importance, with the objectives of encouraging investment in wind, geothermal, hydro, and tidal power, and accelerating the resource consenting process required for renewable energy development. It has also listed renewable energy development as a priority in its energy strategy.

With a large volume of renewable energy, especially wind energy, added to the system in the future, issues with system integration will become even more significant. These issues may require the adjustment of operational, market, and regulation mechanisms and policies, and new transmission investment to ensure the stable and efficient operation of the electricity market.

To ensure better integration of renewable energy into the electricity market, the previous Electricity Commission (replaced by the Electricity Authority in 2010) initiated the Transmission to Enable Renewables project to improve the understanding of the operational, market design, and regulatory issues associated with integrating renewable energy into the electricity market. The current Electricity Authority has also taken steps to better facilitate renewable energy integration.

There are some special characteristics inherent in New Zealand's electricity market. It has been liberalised and vertically separated as a result of market oriented economic reforms since the 1990s. The effective integration of renewable energy into the electricity system has been accomplished mainly through market mechanisms with only limited intervention from the government. The objectives of this study are to review New Zealand's experience with renewable energy integration, to examine policy challenges for renewable energy integration in New Zealand's liberalised electricity market, and to explore what East Asia Summit (EAS) countries can learn from New Zealand's experience.

This study will examine New Zealand's experience of promoting renewable energy generation and facilitating renewable energy integration, the current issues associated with renewable energy integration, and the way forward. We will draw some policy implications from New Zealand's experience for EAS countries to consider.

This report will be organised as follows: section 2 reviews the current electricity market in New Zealand and the New Zealand government's Energy Strategy; section 3 reviews renewable energy development in New Zealand and its challenges; section 4 reviews policy options, market design and operational adjustment in New Zealand to facilitate renewable energy integration; section 5 explores policy implications for ASEAN and East Asian countries.

1. The Current Electricity Market in New Zealand

1.1. History of Electricity Market in New Zealand

New Zealand consists primarily of two similar sized main islands: the North Island (NI) and the South Island (SI). The North Island has over 75% of the population and accounts for 73% of national gross domestic product (GDP), while the South Island has less than 25% of the population, and accounts for around for 27% of national GDP.

New Zealand's history of electrification began in the late 19th century, when local authorities and private entrepreneurs started to construct small generation facilities to serve local markets. The first substantial use of electricity was for lighting. Various shops and small factories generated their own electricity for this purpose, city councils either built their own small generation plants or purchased electricity from private generators to provide street lighting, lighting for public buildings, etc. The first major hydro electricity generation project, and one of the major electricity generation initiatives, came in 1886 at a gold mine in South Island.

In the early 1900s, the development of high voltage transmission provided the opportunity to develop large scale hydro electricity generation and electricity transmission over long distance. Increasingly, the central government was seen as the only entity with the necessary financial resources to enable the development of large electricity generation and transmission projects, and was granted the exclusive right to generate electricity using water power in 1903.

In the 1920s and 1930s, the Government started with the construction of a set of large state-owned hydroelectric plants on major rivers. These plants were linked by a transmission grid from which power was taken off by local government distribution and retail companies, the so called ESAs (Electrical Supply Authorities). After World War II, more power stations were built, including hydro powered, coal fired, gas fired, oil powered, and geothermal powered stations. Since the later 1980s and early 1990s, market oriented economic reform has significantly changed the electricity market in New Zealand.

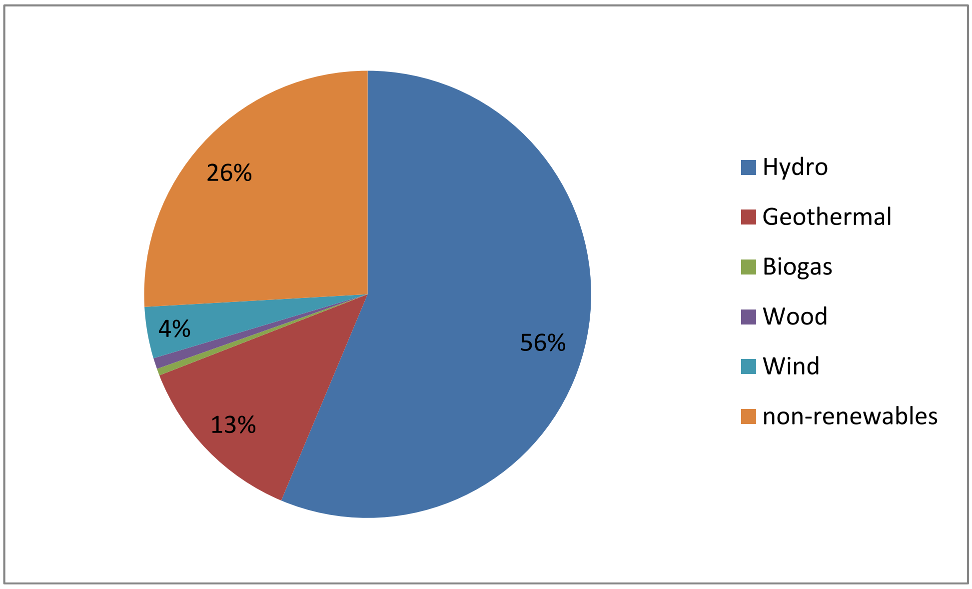
The majority of transmission lines, which established the national grid, were built by the government in the 1950s and 1960s. By 1965, the North and South Islands were linked by undersea High Voltage Direct Current (HVDC) cables across the Cook Strait.

1.2. Electricity Supply and Demand in New Zealand

In 2011, the installed capacity for electricity generation was 9751 megawatts (MW), generating 43,110 gigawatt hours (GWH) of electricity. Renewable energy sources have provided the bulk of electricity, making New Zealand one of the lowest carbon dioxide emitting countries in terms of electricity generation. In 2010, a total of 74% of electricity generation came from renewable resources (see

Figure 1), with 56% from hydro, 13% from geothermal, 4% from wind, and another 1% from other forms of renewable energy sources, such as biogas, wood, etc.

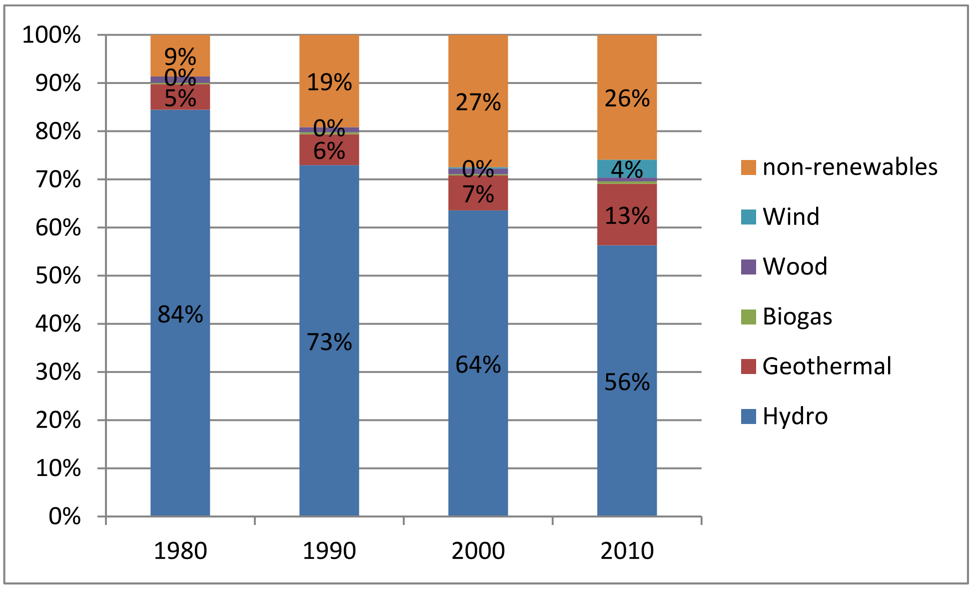
Figure 1: Share of Electricity Generation by Fuel Types in 2010



Source: NZIER calculation based on New Zealand Data File 2012 (MBIE, 2012).

However, the share of electricity generated from renewable sources has trended down over time, dropping from over 90% in 1980 (see Figure 2). The share of electricity generated from hydro sources has decreased from around 85% in 1980 to 56% in 2010. Contrasting to this, the shares of electricity generated from geothermal and wind sources have increased. The share of electricity generated from geothermal resources has increased from 5.3% in 1980 to 12.8% in 2010. While in 2000, the share of electricity generated from wind energy was still negligible (0.3%), by 2010, this share had increased to around 4%.

Figure 2: Share of Electricity Generation by Fuel Types in 1980, 1990, 2000, and 2010



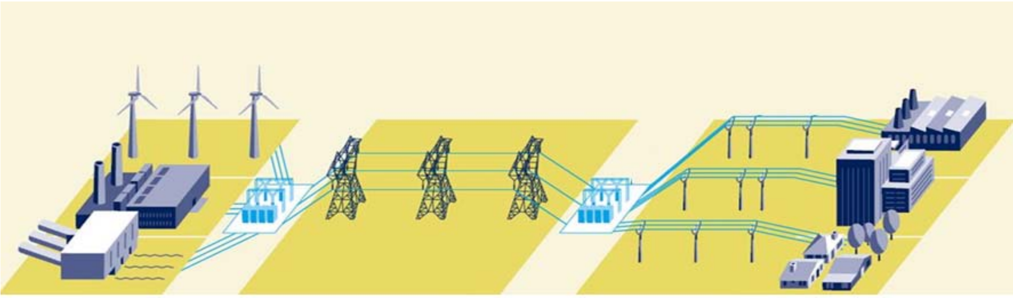
Source: NZIER calculation based on MED's New Zealand Energy Data File 2012 (MBIE, 2012).

During the period between 1976 and 2010, electricity generation grew at an average of 2.1% per annum. This was largely fuelled by the growth in generation from non-renewable sources, with an average growth rate of 2.9% annually, and renewable sources other than hydro, such as geothermal, with an annual growth rate of 4.3%. The growth of generation from wind energy is even more significant. In 1990, there was no electricity generated from wind; by 2011, electricity generated from wind had reached nearly 2000GWH.

1.3. The Electricity Market in New Zealand

Traditionally, the electricity sector in New Zealand was organised as a vertically integrated state monopoly. Since the 1990s, the sector in New Zealand has experienced significant changes due to market oriented reform and restructuring initiated in the 1990s. The reform is still going on with the recent partial privatisation of a state owned electricity generation company, and another planned in the near future. As a result of this reform and restructuring, the current New Zealand electricity market is split into the following areas: regulation, generation, wholesale, retail, transmission, and distribution.

Figure 3: The Four Main Components of the Electricity Industry in New Zealand



Generation Transmission Distribution Retailing

Source: Ministry of Business, Innovation & Employment.

1.3.1. Generation

Electricity in New Zealand is largely generated from hydro, gas, coal, and geothermal resources, of which hydro accounts for more than 50% of the electricity generated. Electricity is produced at generation stations and supplied at high voltage to the national grid at grid injection points (GIPs). There are around 40 major electricity generation stations connected to the grid.

There are currently five major generation companies: Contact Energy, Genesis, Meridian, Mighty River Power and TrustPower. These five companies generate more than 93% of New Zealand's electricity; the biggest three supply 74%. These five generators are also electricity retailers; they are the so called "gentailers".

1.3.2. Retail Market

Electricity is supplied to residential and small commercial and industrial customers through electricity retailers. Retailers purchase electricity from the electricity wholesale market. The electricity purchased may come from a retailer's own generation arm (gentailer) or another generator that has supplied into the wholesale market.

Currently, there are five major retailers. All of them are vertically integrated gentailers, and they are all major generators too. These five companies account for 96% of the electricity purchased from the wholesale market, while the remaining 4%

is purchased by a number of small retailers. Electricity retailers pay distribution companies for distribution and transmission services.

1.3.3. Wholesale Market

The wholesale market is the place where the electricity supplied by generators meets the demand from retailers. All electricity generated is traded through the central pool, with the exception of small generating stations of less than 10MW. Bilateral and other hedge arrangements are possible, but function as separate financial contracts.

The market operation is managed by several service providers under agreements with the Electricity Authority. The physical operation of the market is managed by Transpower in its role as System Operator. NZX is contracted as Reconciliation Manager, reconciling all metered quantities, Pricing Manager, determining the final prices at each node, and Clearing and Settlement Manager, paying generators for their generation at the market clearing price and invoicing all retailers for their off-take. The wholesale market operates every day on a continuous basis in 30-minute trading periods; there are thus 48 trading periods per day. Generators submit generation offers to the system operator, indicating for each period how much electricity the generator is willing to supply, and at what price. Likewise, electricity purchasers must submit bids to the system operator, indicating the amount of electricity they intend to purchase.

Once all offers and bids have been received and finalised for a particular trading period, the system operator issues actual dispatch instructions to each generator on how much electricity it is required to generate and/or other required actions.

For each trading period, the pricing manager determines the single price to be paid to the generators for all electricity supplied. This price is determined by the price of the marginal generation required to meet demand for a given trading period.

1.3.4. Transmission

The electricity transmission system connects generators to the local distribution networks, who transmit high voltage electricity from GIPs at generation stations to grid exit points (GXPs). At GXPs, transformer substations reduce the electricity voltage for distribution through local distribution networks to end-users.

The New Zealand transmission network consists of two subsystems, one in the North Island and one in the South Island. The two subsystems are connected by a high voltage direct current (HVDC) link. This makes possible the export of electricity from the South Island, where 60% of the electricity is generated, to the North Island, where the demands for electricity are predominantly located.

Transpower, a state-owned enterprise (SOE), owns, operates and maintains the transmission network. As owner it provides the infrastructure for electric power transmission that allows consumers to have access to generation from a wide range of sources, and enables competition in the wholesale electricity market. As system operator, under contract with the Electricity Authority, it manages the real-time operation of the network and the physical operation of the New Zealand electricity market.

1.3.5. Distribution

The electricity distribution network distributes electricity from the transmission system to the end-users. There are 28 electricity lines businesses in New Zealand. They range in size from around 5,000 electrical connections to nearly 500,000 connections. Other entities also provide electricity distribution services as part of their normal activities. Included among these are airports, ports, and large shopping mall operators. The electricity distribution networks are considered to be natural monopolies, and are subjected to performance based incentive regulation.

1.3.6. Regulatory Framework

The electricity industry is covered by a set of generic and specific legislation (including regulations), including

- Electricity Industry Act 2010 (the Act)
- Commerce Act 1986;
- Electricity Industry Participation Code 2010
- Electricity Industry (Enforcement) Regulations 2010 (Regulations)
- National Policy Statement on renewable electricity generation.

The regulatory bodies include the Electricity Authority (previously the Electricity Commission), the Ministry of Business, Innovation, and Employment (MBIE), and the Commerce Commission.

MBIE is responsible for developing and implementing policies and legislation for the electricity sector, and for monitoring the performance of the Electricity Authority and the Commerce Commission. The Commerce Commission implements and monitors the price and quality regulation of distribution and transmission businesses.

The Electricity Authority is responsible for giving effect to government policies, and is required to make and administer the electricity industry participation code, and to monitor compliance with the electricity industry act, electricity industry regulations, and the industry participation code. It is also responsible for the operation of the electricity market. It contracts Transpower as system operator for the day-to-day operation of the electricity system. It also contracts NZX as reconciliation manager, pricing manager, and clearing and settlement manager.

1.4. Issues in the Electricity Market

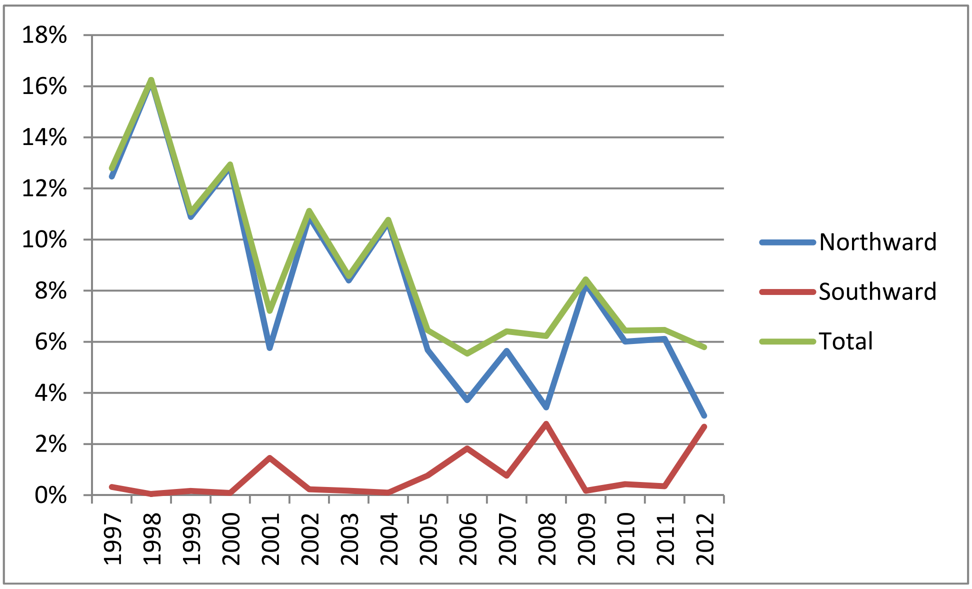
The issues in the electricity market revolve around the two main challenges facing New Zealand: security of electricity supply and climate change.

The first issue is the geographical asymmetry of electricity generation and demand between New Zealand's South Island and North Island. The North Island has over three times the population of the South Island (3.39 million vs 1.04 million). Consequently, the North Island has a substantially larger energy demand. In 2011, around 37.1% of the total electricity generated was consumed in the South Island, while 62.9% was consumed in the North Island. Before the 1980s the South Island used to account for 60% of the electricity generated in New Zealand, while the North Island accounted for 40%. This imbalance has been shifting due to investments in geothermal and gas-fuelled electricity generation. However, this imbalance still exists three decades later although to a lesser degree. In 2011 generation from South Island has reduced to 40.9% of national electricity generation, while the contribution from the North Island has increased to 59.1% from a mixture of mainly hydroelectric, natural gas and geothermal generation, plus smaller amounts of coal and wind generation.

The imbalance has been managed through the wholesale electricity market and with substantial transmission between the two islands through an undersea high voltage direct current (HVDC) cable. This transfer is typically from the South Island to the North Island. While in the late 1990s, electricity transmitted from the South Island to the North Island accounted for more than 10% of the total electricity demanded, this figure has dropped to around 5 or 6% since 2005 (see Figure 4).

This results in the HVDC system being a critical facility for electricity security and availability. For example, on 16 June 2006 the HVDC experienced an unplanned outage just before the evening peak period on one of the coldest days of the year. With four North Island power stations out for service and an outage of another power station's (Tauranga's) ripple load control equipment, even with a reserve (Whirinaki) power station being called upon, the North Island experienced electricity shortages and Transpower subsequently declared a nationwide Grid Emergency.

Figure 4: Electricity Transmission between the North Island and the South Island (% of Total Electricity Demanded)

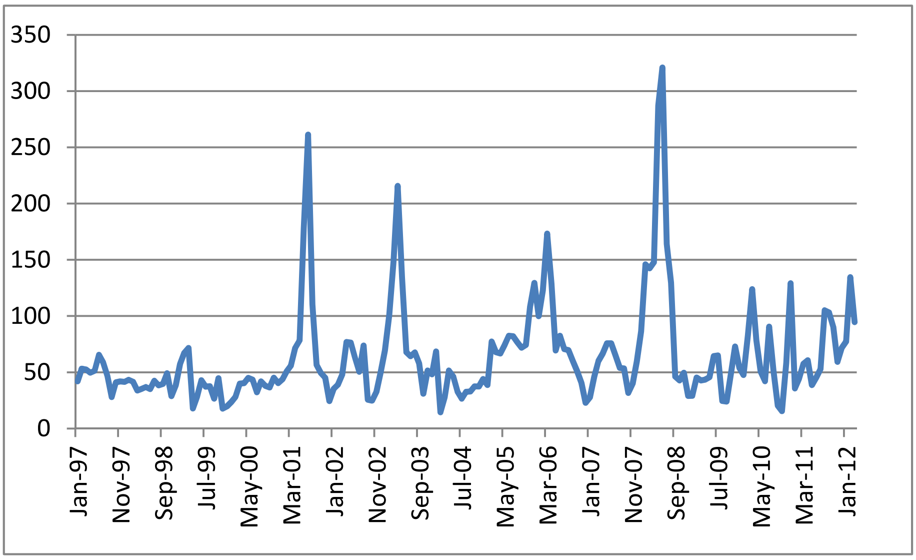


Source: NZIER Calculation based on Electricity Authority's Centralised Dataset.

The second issue is the low volume storage system in New Zealand, which makes the electricity market subject to supply shortfalls in the event of dry seasons. The storage system only has a storage capacity of 34 days' supply at peak winter demand. Therefore, the system is prone to supply shortfalls in the event of dry seasons. In a dry season the shortfalls have to be met by high cost fossil-fuelled reserve electricity generators. This can lead to high wholesale electricity prices which we saw in 1992, 2001, 2003, 2006, and 2008 (See Figure 5).

In the event of supply shortfall, generators also have incentives to hold back generation to raise the wholesale price even higher. In 2008, following the high price spike, there were indeed allegations of generators abusing market power and complaints about high wholesale and retail prices, which led to the Commerce Commission's investigation into the ability of and incentives for the four largest electricity suppliers in New Zealand to exercise unilateral market power and to quantify the market power rents in the wholesale market that have resulted from the exercise of such unilateral market power.

Figure 5: Consumption Weighted Average Wholesale price ($/MWH), Jan 1997-Mar 2012



Source: NZIER calculation based on Electricity Authority's Centralised Dataset.

The third issue concerns ensuring that New Zealand has sufficient generation capacity to meet growth in energy demand in the future, another aspect of the security of electricity supply. It arises from the increasing demand for electricity, high forecasted fossil fuel prices, and New Zealand's commitment to reduce greenhouse gas emissions.

The recent Energy Outlook 2011 (MBIE, 2012) projects that electricity demand will grow by an average of 1% to 1.5% per annum over the period to 2030. There is some evidence to suggest that, in the shorter term, increases in demand may be higher than these figures. Analysis of grid exit point data from 1999 to 2005 indicates that electricity demand is currently increasing in the range of 2 to 2.5% per annum on average.

In order to meet increasing demand for electricity, according to MBIE’s New Zealand Energy Outlook’s projection, electricity generation needs to grow at 1.5% annually until 2025. This would mean that 10800GWH of additional generation will be needed by 2025. If the demand for electricity continues to grow at 1.5%, an extra 35000GWH of electricity would be needed by 2050.

For the period up to 2025, it is projected that prices for gas and coal will increase significantly (30% and 90%). As demand for electricity generation grows, together with the adoption of the Emissions Trading Scheme (ETS), forecast rises in the price of fossil fuels, the decline of gas supply from the Maui gas field, and a possible international cap and trade agreement on carbon, the costs of continuing reliance on fossil-fuel-fired generation to meet peak demand will escalate. New Zealand has also made commitments to reduce greenhouse gas emissions and for environmentally sustainable development.

All these factors mean that New Zealand needs to put more emphasis on renewable energy generation and to undertake the transition to renewable energy sources to ensure that it has the capacity to accommodate the growth in demand and to compensate for the likely decline in the availability of natural gas from local gas fields.

1.5. The New Zealand Energy Strategy

To meet these challenges, in 2007 the then Labour Government put forward the New Zealand Energy Strategy (NZES) to 2050 (MED, 2007). Through NZES, New Zealand has put renewable and environmentally friendly energy development at the centre of its long term energy development strategy. It has also declared that New Zealand should achieve the target of having 90% of its electricity generated from renewable sources by 2025.

The vision of the 2007 NZES was for New Zealand to have “A reliable and resilient system delivering New Zealand sustainable, low emissions energy services, through:

- Providing clear direction on the future of New Zealand’s energy system

- Utilising markets and focused regulation to securely deliver energy services at competitive prices
- Reducing greenhouse gas emissions, including through an Emissions Trading Scheme
- Maximising the contribution of cost-effective energy efficiency and conservation of energy
- Maximising the contribution of cost-effective renewable energy resources while safeguarding our environment
- Promoting early adoption of environmentally sustainable energy technologies
- Supporting consumers through the transition (MED, 2007, p.15).

In the 2007 NZES, the government also declared that 90% of New Zealand's electricity should be generated from renewable sources by 2025. This strategy was however put on hold in 2008 after the new National-led Government took office.

In 2011, the National-led Government put forward another energy strategy, New Zealand Energy Strategy -Developing Our Energy Potential for the period between 2011 and 2021 (MBIE, 2011), replacing the New Zealand Energy Strategy to 2050 (MBIE, 2007) released in 2007. The new strategy has however retained the renewable energy target for electricity generation proposed in the 2007 NZES that 90% of electricity generation be from renewable sources by 2025.

As described in the new strategy document, the goal of the government is "for New Zealand to make the most of its abundant energy potential, for the benefit of all New Zealanders" (MBIE, 2011, p.4), and the Government proposed to achieve this goal through the "environmentally responsible development and efficient use of the country's diverse energy resources, so that:

- The economy grows, powered by secure, competitively priced energy and increasing energy exports
- The environment is recognised for its importance to our New Zealand way of life." (MBIE, 2011, p. 4)

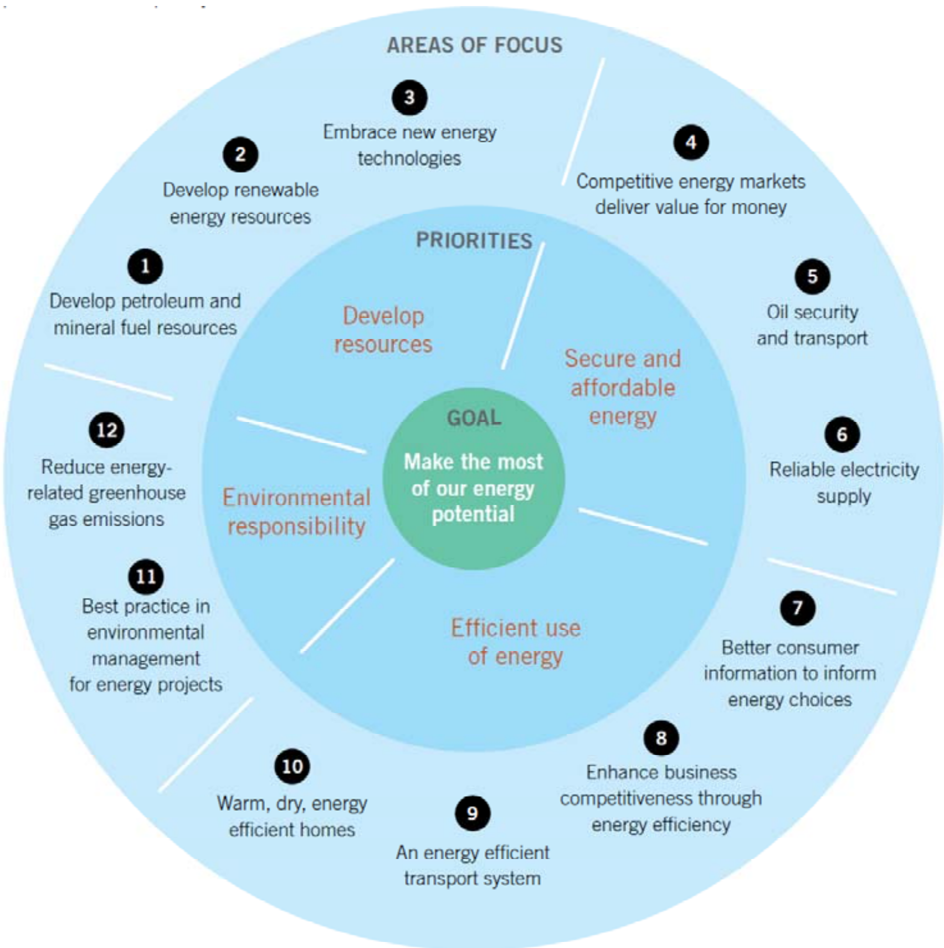
To put the goals into action, the 2011 NZES has further identified four strategy priorities to achieve this goal, including:

- Diverse resource development
- secure and affordable energy

- efficient use of energy
- environmental responsibility.

For each strategy priority, the government has identified a few areas of focus (see details in Figure 6).

Figure 6: New Zealand Energy Strategy, 2011-2021.



Source: New Zealand Energy Strategy, Developing our Energy Potential, 2011-2021.

One noticeable difference between the two versions of the NZES is that the 2007 NZES focused on building a “reliable and resilient energy system” (MED, 2007, p.15) , while the 2011 NZES focused on the benefits of building such a system: “the economy grows” and the “environment is recognised for its importance to our New Zealand way of life” (MBIE, 2011, p. 4). However, there are some common themes underlying the two versions of NZES; developing renewable energy for the security of energy supply is one of them.

2. Renewable Energy Development

This section focuses on the current use of renewable energy in New Zealand and its capacity for future development. While hydro power already accounts for more than half of electricity generation, its capacity to grow in the future is limited. The growth of renewable energy will mainly come from wind energy. However, because of its inherent characteristics, there are several barriers to its development.

2.1. Renewable Energy Capacity and Potential

Renewable energy already provides 75% of electricity generated in New Zealand, but there is still potential for further growth, especially in wind energy (see Table 1).

Table 1: Renewable Energy Capacity and Potential (MW)

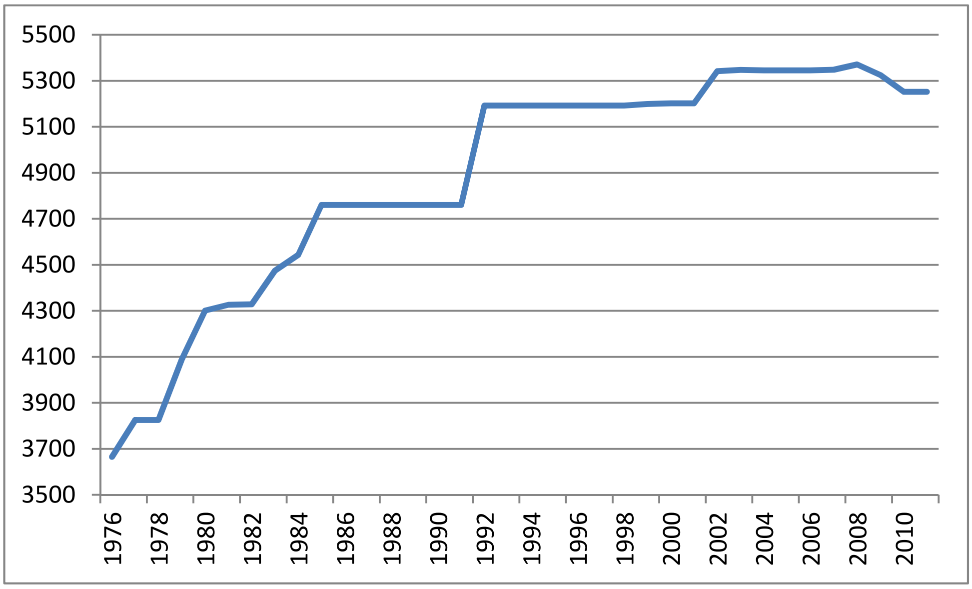
	Hydro	Geothermal	Wind
Operational generation capacity	5252	730	610
Potential capacity	1295	1100	4100
2025 capacity	6500	1500	2000

Source: Draft report on transmission to enable renewables (Energy Authority, 2008).

Hydro power is the main source of renewable energy in New Zealand, accounting for 56% of total electricity generated in 2010. Although its contribution to total electricity dropped from nearly 90% in 1980, the actual generation capacity has increased nearly 1,000MW over the 30 year period. However, capacity has remained static since 1990 (See Figure 7). According to the most recent study commissioned by the previous Electricity Commission (reference), there is still 1295MW of hydro capacity to exploit.

But this capacity will be significantly constrained by physical, environmental, and cost factors. Most of the potential hydro capacity identified is located in the South Island, but the increased demand is mainly located in the North Island. The development of this capacity would subject the security of the system more to the reliability of the undersea HVDC cable.

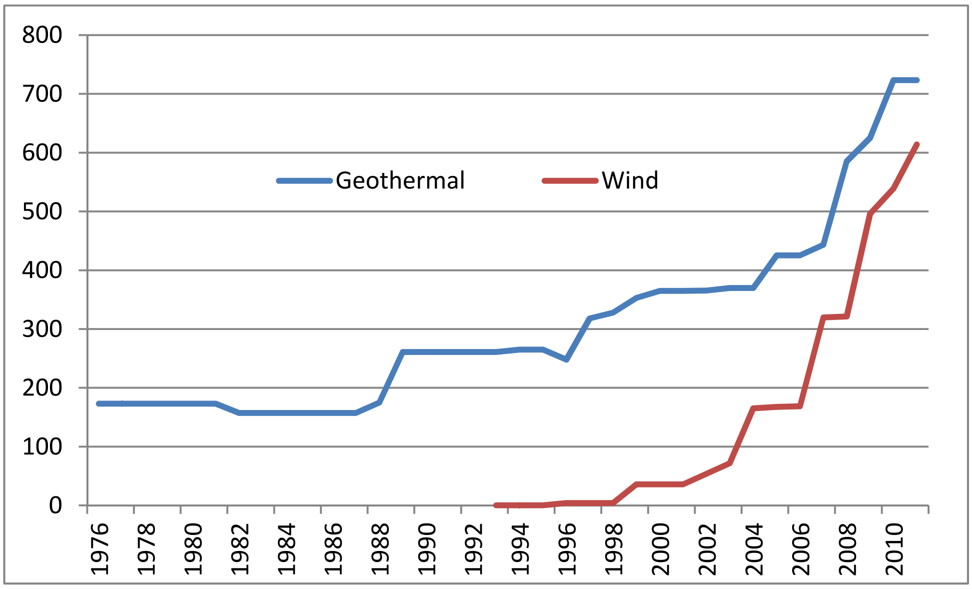
Figure 7: Operational Hydro Electricity Generation Capacity (MW)



Source: New Zealand Energy Data File 2012 (MBIE, 2012).

Geothermal and wind energy together currently account for 17% of electricity generated, with operational capacities of 700MW and 600MW installed in 2010 respectively. Both have increased significantly over the past two decades (see Figure 8).

Figure 8: Operational Geothermal and Wind Electricity Generation Capacity (MW)



Source: New Zealand Energy Data File 2012 (MBIE, 2012).

Both geothermal and wind energy still have big growth potential. A recent assessment of geothermal capacity suggested that a net increase of 1100MW could be added to the system, taking into account various constraints; by 2025, the capacity of geothermal could reach up to 1500MW, a net increase of 770MW. Wind energy could have an even bigger potential. Research for the Electricity Commission has suggested that more than 4000MW electricity generation capacity from wind energy could be added to the system in the future. By 2025, the installed wind energy capacity could reach up to 2000MW, contributing around 20% of the total electricity generated without causing major problems to the system.

As we have seen from Table 1, only around 12% of potential wind energy capacity is utilised currently; even by 2025, there will still be more than 50% of wind energy capacity available for exploitation. To meet the increasing demand for electricity, wind energy has actually been identified as a priority source of new energy.

2.2. Issues with Renewable Energy Development

Most of the renewable energy sources are normally located in remote and (often) conservation areas, away from the existing transmission grid and away from demand.

Consequently, new renewable generation projects tend to have high set up costs and high connection costs, and face a higher uncertainty of the availability of sufficient transmission capacity.

Renewable energy production, especially wind energy, solar energy, and tidal energy, has high variability and cannot be predicted with great accuracy. This requires improving forecasting methodology, establishing back up mechanisms, and changes in market design and operational practices to ensure the security of supply and stability of the system.

There are a few issues associated with furthering renewable energy development. **First, environmental considerations** have been a major issue. In New Zealand, energy project proposals are managed in consent terms through the Resource Management Act 1991 (RMA). Under the RMA, the consenting authority must have regard to the follows:

- The effects (actual or potential) on the environment
- The provisions of any relevant national coastal or regional policy statement and plan, proposed or operative
- Any other matter the consenting authority considered relevant.
-

While for a proposed renewable energy project the effects on the environment are mainly local, the benefits are generally national. It is a difficult task for a local consenting authority to balance the local effects with the national benefits. Environmental concerns have led to the process of seeking resource consent being long and expensive. Typical environmental concerns include: the visual impacts of renewable energy projects on the landscape, the impacts of road and other infrastructure construction on site ecology, the noise from wind turbines, disruption to the local economy, etc.

Recently these environmental concerns led to the withdrawal of the Project Hayes wind farm proposal in the South Island, with projected capacity up to 630MW making it potentially the largest wind energy project to date planned for New Zealand. Project Hayes was developed by Meridian Energy from 2006 to 2012. Meridian lodged applications for resource consents with the Central Otago District Council and with the Otago Regional Council between July and October 2006. Resource consents were granted in 2007. However, the project was opposed by a group of prominent individuals, and the decision was appealed to the Environment Court. In November 2009, the Environment Court declined the consents. Meridian appealed the Environment Court's decision to the High Court, which allowed Meridian's appeal, and sent the case back to the Environment Court. The High Court's decision was appealed to the Court of Appeal in August 2010. As of February 2011, no dates had been set for the next round of court hearings. In January 2012, Meridian announced it had withdrawn the applications for resource consent. The whole process cost Meridian Energy around $8.9million.

Second, system integration cost issues. Most renewable energy generation is located away from demand and away from the existing transmission grid. Consequently, the costs of setting up the generation capacity and connecting to the existing transmission grid are high. Compared to gas fuelled electricity generation, the main form of fossil-fuelled electricity generation, the capital cost per MW capacity for wind, hydro and geothermal generation are at least two times higher. While the connection costs for fossil-fuelled electricity generation are typically NZ$ 1 million, the average connection costs for wind energy projects are NZ$76.85 million per project.

Table 2: Average Costs for New Generation Projects by Energy Yypes (NZ$/MW)

	Variable O&M $/MWh	**Fixed O&M, $/kW**	**LRMC $/MWh (exclude CO2 price)**	**Capital cost (Million $/MW)**	**Connection cost (Million $)**
Coal	12.96	67.19	164.41	5.27	1.00
Diesel	10.59	15.30	664.31	1.91	1.00
Gas	6.24	22.57	175.47	1.53	1.00
Geo	0.00	100.43	91.20	5.89	5.90
Hydro	0.72	7.13	132.54	4.98	19.40
Wind	2.87	58.23	128.29	3.52	76.85 (?)

Source: Variable Fixed O&M, LRMC, and Capital cost are based on MBIE's electricity generation cost model 2011, see http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/new-zealands-energy-outlook/interactive-electricity-generation-cost-model-2010; Connection cost is based on "Transmission to Enable Renewables Project: Transmission Network Reinforcement Inputs for GEM" (System Study Groups, 2008)

Renewable energies are volatile and cannot be predicted with great accuracy. This is particularly true of wind energy. With a target of having 20% of electricity generated from wind by 2030, the high volatility and unpredictability of wind energy will create potential errors in the scheduling and dispatch process, and consequently have impacts on the stability and security of the security of this system. This in turn increases the levels of capacity margins and operating reserves that are required to be available to system operators in order to ensure the demand and supply of electricity are constantly balanced. As a result, there are costs associated with a higher level of capacity margin and higher operating reserves. A study commissioned by Meridian (Meridian, 2008) has estimated the additional costs under the scenarios of having 5%, 10%, and 20% wind penetration in 2010, 2020, and 2030. The estimated additional costs are listed in Table 3. As the wind penetration increases, the addition costs increase.

Table 3: Additional System Costs (NZ$/MWh) in Wind Generation Integration

	2010 (5% of wind penetration)	**2020 (10% of wind penetration)**	**2030 (20% of wind penetration)**
Installed wind capacity (MW)	634	2066	3412
Capacity cost	2.4-3.6	3.6-5.5	6.3-9.5
Reserve cost	0.19	0.76	2.42

Source: The system impacts and costs of integrating wind power in New Zealand (Meridian, 2008).

The high variability and unpredictability of wind energy also requires operational and market design changes, such as investment in forecasting, to have more accurate forecasts and to have more reserve and curtail mechanisms, etc. All these entail costs, which raises the question of who should pay for the costs associated.

Third, incentives to invest. Another key issue concerning renewable generation investment is the incentives to investment. There are several factors that discourage investments in renewable generation, especially investment by smaller investors.

There are big differences in timing between generation investment and transmission capacity development. Transpower needs to have a lead time of eight years for the provision of a new transmission line, while wind generation investment can be developed rather quickly, taking as little as 12 months from the granting of consents to full operation. It is unlikely that new small entrants would be able to endure eight years of negotiation and waiting.

New Zealand is characterised by vertical integration between generation and retail. Five major electricity generators are also major retailers ("gentailers"). Both the generation and retailing markets are highly concentrated. These five gentailers have 91% of electricity generation capacity and cater for 97% of the total demand. One consequence of this is that existing gentailers are hedged on both generation and retail sides against the high volatility in the electricity market. Small non-vertically integrated generators, who find it hard to get such hedging contracts, have to face the full consequences of wholesale price volatility.

All these factors create barriers to entry for small non-vertically integrated generators, reflected in the fact that 99% of all existing wind capacity is owned by only three gentailers.

Fourth, New Zealand also lacks policy instruments to induce investments. In many countries a variety of policy instruments have been applied to encourage investment in renewable energy generation. The two main forms of such policy instruments are: the feed-in tariff, and the renewable portfolio standard.

A feed-in tariff requires energy generators to be paid a specified price for their output from renewable energy. The goal of feed-in tariffs is to offer cost-based compensation to renewable energy producers, providing the price certainty and long-term contracts that help finance renewable energy investments.

A renewable portfolio standard (RPS) requires electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. Certified renewable energy generators earn certificates for every unit of electricity they produce and can sell these along with their electricity to supply companies. There are also other forms of policy instruments, such as capital subsidies and tax credits, etc.

In New Zealand there are no direct policy instruments to encourage renewable energy developments. However, there are indeed small financial grants available under the energy efficiency programs of the Energy Efficiency and Conservation

Authority (EECA). Furthermore, the Emissions Trading Scheme (ETS) when put in place may create incentives for investment in renewable energy.

3. Government Policies and Market Designs to Facilitate Renewable Energy Integration

The issues around renewable energy development have been attended to in New Zealand through government policy initiatives, market design improvements, and special operational arrangements in the electricity market. These policies are still at their early stage of implementation, and it is still too early to assess their impacts, given the long term nature of electricity generation. However, they do provide incentives for and facilitate the development of renewable energy.

3.1. Government Policy Initiatives to Encourage the Development of Renewable Energy Sources

To encourage renewable energy development, to ensure future energy supply security, to reduce greenhouse gas emissions and to maintain environmentally sustainable development, the government has listed developing renewable energy resource as one of its strategic priorities under the New Zealand Energy Strategy (NZES).

To achieve a 90% renewable energy target, Parliament passed in 2008 the Climate Change Response (Emissions Trading) Amendment Act 2008, and the Electricity (Renewable Preference) Amendment Act 2008. While the former requires the electricity generators to effectively price the cost of carbon into the price of electricity from July 2010, the latter effectively imposes a 10 year ban on the construction of new baseload fossil-fuelled electricity generation with capacity over 10MW except where an exemption is appropriate (for example, to ensure security of supply) from 2010.

To deal with the environmental barriers to renewable energy development, in 2011 the New Zealand government released its National Policy Statement (NPS) on Renewable Electricity Generation under the Section 32 of the Resource Management Act 1991 (Ministry of Environment, 2011). This NPS has lifted the status of renewable electricity generation to that of national importance. The objectives of the NPS are to recognise the significance of renewable electricity generation to the wellbeing of New Zealand, to incorporate provisions for renewable energy generation activities into regional policy statements and regional and district plans, to drive a consistent and streamlined consenting process for renewable energy generation projects, and to encourage investment in wind, geothermal, hydro, and tidal power so as to achieve New Zealand's renewable energy target. The NPS has proposed eight policies to achieve these objectives.

In regard to policy instruments, the Emissions Trading Scheme has been passed into law and put into effect since 2010, requiring electricity generators to take into account the carbon price in electricity pricing. This will allow renewable generators to gain competitive advantages over fossil-fuelled generators. The Energy Efficiency and Conservation Authority (EECA) has also provided small financial assistance for new renewable energy projects under its Energy Efficiency program. EEC also works with and provides support for renewable energy industries in New Zealand, such as providing seed funding for industry associations, supporting and encouraging the development of industrial standards, etc.

3.2. The Current Market Design to Facilitate the Integration of Renewables

The integration of renewable generation into the system is through the functioning of the market, with electricity governance rules and related arrangements neither penalising nor favouring wind generation relative to its true system costs.

Under the current regulatory framework, transmission services are provided independently. As a result, new renewable energy generators have equal access to the transmission network as do incumbent generators. On the other hand, Transpower, as system operator, is obliged to make transmission assets accessible to grid users, giving no preferential rights to existing grid users.

Electricity is traded in the wholesale electricity market. Electricity from new renewable energy generators is traded the same way as electricity generated from incumbent generators, and is dispatched on the basis of the prices they bid into the wholesale market at the relevant point of injection.

The connection of generation to the grid is either through the so called "connection" or "deep connection" assets, lines that are solely used to connect generators to the grid, or through transmission assets, lines that are part of the interconnected grid. Connection and deep connection assets are commissioned as a result of bilateral negotiation between Transpower and the generator requiring the relevant assets. While the generators pay for the services of "deep connection" assets, grid off-take customers pay for the service of transmission assets. The charge for the services of transmission assets are governed by transmission pricing methodology.

Due to its high volatility and unpredictability, the connecting of renewable energy, especially wind energy, to the grid would increase the systems' demand for additional capacity and additional reserve capacity to ensure electricity supply security and the stability of the electricity system. Consequent high prices for such capacity would send a strong signal for investment.

Introducing new or potential generation investment could reach the limits of the connecting transmission grid and increase the demand for upgrades of, or new investment in, transmission capacity to relieve the constraint. A constrained transmission grid would also make additional new generation investment less attractive. Similarly, transmission investment and potential future transmission investment will also have significant impacts on the economic analysis of generation investments.

Upgrades of, and new investment in, transmission capacity are typically conducted by Transpower with the approval of the Electricity Authority. The Electricity Authority uses the Grid Investment Test (GIT) to establish whether investment in additional transmission capacity is necessary. If a generator saw a significant benefit in a transmission investment that did not pass GIT, it could negotiate with Transpower and contract them to make the investment with costs met by the generator.

3.3. Transmission Investment to Accommodate further Renewable Energy Integration

To deal with the timing difference between transmission investment and generation investment, the previous Electricity Commission initiated the ‘Transmission to Enable Renewables Project, (TERP) in order to facilitate the coordination of renewable energy generation and transmission investment.

This project has investigated the potential renewable energy resources in New Zealand, including hydro, geothermal, wind, and marine energy, and has provided an up-to-date “map” of renewable resources location and potential scale, which are then factored into Transpower’s planning process.

As a result, substantial renewable energy resources have been identified. It is estimated that geothermal capacity could be 3600MW, and that wind capacity could be even more significant, reaching up to 41000MW.

In addition to identifying potential renewable resources, TERP has also investigated the costs associated with each potential renewable project, including capital costs, operating costs, system costs, (such as connection costs), and the additional capacity and reserve costs.

To investigate the possible transmission investments, for which Transpower could apply for approval to support the development of renewable energy generation, the previous Electricity Commission in 2007 commissioned research to look into different options for the transmission investment required to support the integration of renewable generation, and the costs (grid connection cost and cost of upgrade) associated with each option.

These options were then fed into the Generation Expansion Model (GEM). The GEM helps to define how much of the identified renewable resource is economically rational to develop, how much transmission investment is justified and where the investment should be located, and the form of investment (deep connection or inter-connection). It also helps determine the optimal transmission and generation investment sequence.

The results from these exercises are then fed into the Electricity Authority and Transpower’s transmission investment planning and scheduling process, which then send signals to potential renewable generation investment.

3.4. Operational Arrangements

To facilitate renewable energy integration and to ensure the stability of the electricity system at the same time, New Zealand has also made some operational adjustments in electricity market operation.

While New Zealand is adept at managing hydro and geothermal generation, managing wind energy is still a challenge. The previous Electricity Commission had actually initiated a Wind Integration Project (WIP) to look into the different operational options to facilitate wind energy integration. The operational arrangements mentioned below only apply to wind energy.

The variable and unpredictable nature of wind energy requires improvements in forecasting methodology in order to improve forecast accuracy. Currently, New Zealand has a decentralised wind forecast system. Each wind generator is responsible for its own wind generation forecast over the schedule period, which is then required to feed into market schedules. At the same time, non-wind generators and big consumers may also have incentives to forecast more accurate wind generation, especially when wind energy penetration increases. The system operator, Transpower, can prepare its own forecasts of wind generation. The Electricity Authority further provides incentives for wind generators to provide more accurate wind generation forecasts by publishing a quarterly wind forecast accuracy monitoring report.

Wind generators are allowed a more flexible gate closure time. All generators are required to submit an offer 71 trading periods before the relevant trading period. All generators can revise or cancel offers at least 2 hours before the trading period in respect of which the offer is made. However, for wind generators, while they can only revise the offer price at least 2 hours before the trading period, they can revise the offer quantity within the 2 hour period immediately before the trading period. Wind generators can also cancel offers in writing 30 minutes before the trading period. Having a more flexible gate closure time could help wind generators better manage wind uncertainty. To deal with the flexibility of gate closure time for wind generators, the system needs to have sufficient reserve and curtail capacity to respond to the subsequent variations in energy supplied.

Wind energy is also treated as “must run” in the wholesale spot market, and can only bid at $0.00/WW and $0.01/MW. This ensures that wind generation could be dispatched if the market price is higher than $0.01/MW. However, this does not guarantee that the wind generation will be dispatched, especially during the time when the dispatch price could be negative at some nodes. Even when the dispatch price is high, it is not guaranteed that wind generation will be profitable, because the dispatch price might be lower than the wind generator’s marginal cost.

Currently, wind generation only accounts for around 4% of total electricity generation, so these operational arrangements in regard to wind generation are still special cases. With the increase of wind penetration in the next 10 to 20 years, operational arrangements for wind generators would still need to be adjusted.

4. Policy Implications for ASEAN and East Asian Countries

We understand that, in ASEAN and East Asian countries, renewable energy has become a mainstream option, driven by a tremendous growth in energy demand arising from rapid economic growth, concerns about energy security, abundance of renewable energy resources, improvements in renewable technologies, and efforts to limit pollution. This has presented both opportunities for economic growth and challenges to it. One challenge the ASEAN and East Asian countries face is the integration of renewable energy into national or regional electricity networks.

With the bulk (70%) of its current electricity generation from renewable resources, and targeting 90% by 2025, New Zealand’s experience with renewable energy development may have some implications for the renewable energy development in ASEAN and East Asian countries.

The main lessons from New Zealand include the following:

First, to encourage the development of renewable energy development and to ensure environmental friendly and sustainable economic development, the New Zealand government has put out a long term energy development strategy, with a focus on renewable energy development and adoption of environmentally sustainable energy technologies.

Second, Recognising the barriers of the deployment of RES, the New Zealand has passed several to facilitate the development of renewable energy development. For example, the parliament, in 2008, passed the Climate Change Response (Emissions Trading) Amendment Act 2008, and the Electricity (Renewable Preference) Amendment Act 2008. To support the RES, the Emissions Trading Scheme has been passed into law and put into effect since 2010, requiring electricity generators to take into account the carbon price in electricity pricing. This will allow renewable generators to gain competitive advantages over fossil-fuelled generators.

In 2011, the New Zealand government released its National Policy Statement (NPS) on Renewable Electricity Generation under the Section 32 of the Resource Management Act 1991 (Ministry for Environment, 2011). This NPS has lifted the status of renewable electricity generation to that of national importance. This encourages the local governments to incorporate renewable energy development into their policy statements and plans, and streamlines the consenting process for renewable energy projects.

The Energy Efficiency and Conservation Authority (EECA) has also provided small financial assistance for new renewable energy projects under its Energy Efficiency program. EEC also works with and provides support to renewable energy industries in New Zealand, such as providing seed funding for industry associations, supporting and encouraging the development of industrial standards, etc.

Third, in New Zealand renewable energy development and integration have been mainly through the functioning of a liberalised and vertically separated electricity market. Electricity is traded in the wholesale electricity market. An independent transmission grid gives the new renewable energy generators an access that is equal to that of incumbent generators. A competitive electricity wholesale market enables new renewable energy generators to compete with incumbent generators on a level playing ground.

Due to the variable and unpredictable nature of the renewable energy, especially wind energy, New Zealand has also made a few operational adjustments in electricity market operation in order to facilitate renewable energy integration and to ensure the stability of the electricity system at the same time. These operational adjustment include initiatives to improve forecasting methodology, establishing back up mechanisms, more flexible "gate closure" time for wind generator, etc.

Fourth, to deal with the timing difference between transmission investment and generation investment in order to accommodate further renewable energy investment. The governing body of the electricity market, the Electricity Authority and its predecessor the Electricity Commission, together with the system operator, have also made proactive initiatives to facilitate transmission investment for further renewable energy investment and integration, such as identifying potential renewable energy resources and their location, the costs associated with each potential renewable project, and the transmission investment to support the development of renewable energy generation, which are then fed into Electricity Authority and system operator's transmission investment planning and scheduling process, which then send signals to potential renewable generation invest

References

Electricity Authority (2008), ‘Draft report on transmission to enable renewables’.

Meridian (2008), ‘The system impacts and costs of integrating wind power in New Zealand’.

Ministry for Environment (2011), ‘National Policy Statement for Renewable Electricity Generation’.

Ministry of Business Innovation and Employment (2012), ‘New Zealand Energy File Data’.

Ministry of Business Innovation and Employment (2011), ‘New Zealand Energy Outlook 2011’.

Ministry of Economic Development (2007), ‘New Zealand Energy Strategy to 2050, Powering Our Future, Towards a sustainable low emissions energy system’.

Shen, D. and Q. G. Yang (2012), ‘Electricity Market Regulatory Reform and Competition – Case Study of the New Zealand Electricity Market’, in Wu, Y., X. Shi and F. Kimura (eds.) *Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies*, ERIA Research Project Report 2011-17. Jakarta: ERIA, pp.103-139.

System Study Groups (2008), ‘Transmission to Enable Renewables Project: Transmission Network Reinforcement Inputs for GEM’.