FUELING THE FUTURE OF NEW ZEALAND'S ELECTRICITY

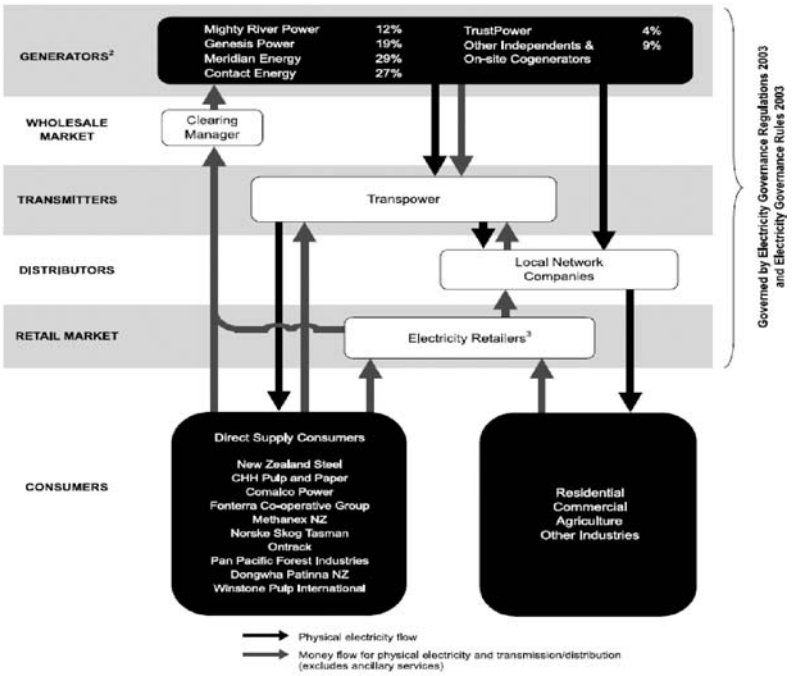
Eileen Mazzochette

Introduction

As in many countries throughout the world, New Zealand's government is focused on promoting sustainable energy generation and consumption. The benefits to this are clear. Use of renewable resources will prevent depletion of a resource, decrease dependence on other countries for energy, and reduce the country's carbon footprint. The government plans to promote sustainable energy usage within various industries by cutting down on the consumption of fossil fuels. In 2007 the New Zealand Ministry of Economic Development published a report called *New Zealand Energy Strategy to 2050*. The report focuses on the government's role in the energy industry and sets specific goals for the next 40 years. The topics discussed include the generation of electricity, carbon emissions, and energy for transport. The report sets a specific goal of generating 90 percent of the electricity in New Zealand from renewable resources by 2025, an increase from the current level of 70 percent. If New Zealand can achieve this, the country will set a precedent for sustainability for the rest of the world.

Renewable electricity generation is beneficial for New Zealand for several reasons. While natural gas is an abundant resource for New Zealand, it must import 90 percent of the oil it consumes each year. (World Factbook Online) Reducing dependence on foreign oil will allow the price of electricity to remain reasonably independent of foreign affairs and less vulnerable to fluctuation. New Zealand is geographically located extremely far away from most other countries. Because of this isolation, transport costs of oil are higher in New Zealand than in most other countries. Use of renewable resources decreases the amount of carbon emissions sent into the atmosphere, limiting further contribution to global climate change. New Zealand currently has a surprisingly large carbon footprint because a significant portion of its economy is dependent on agriculture. The waste produced by the sheep and cattle industries is a significant contributor to the release of carbon dioxide into the atmosphere. Use of renewable

Figure 1. Structure of Electricity Sector



Source: Ministry of Economic Development, June 2007.

resources will decrease at least that portion of the carbon footprint resulting from electricity generation. Most importantly, however, renewable generation is an example of sustainable development. Sustainable development is development that considers not only the immediate impacts of new projects on the environment, the economy, and society, but also what the project means for future generations. Use of renewable resources will not only meet the needs of New Zealand right now, but will also be a means of providing sufficient electricity for generations to come.

The government recognizes that this goal is ambitious, but it remains determined and optimistic. As the report *New Zealand Energy Strategy to 2050* states:

> The government is introducing a target for 90 percent of electricity being generated from renewable sources by 2025. This is a challenging target but, given our wealth of natural energy resources, is considered achievable without imposing significant additional costs on the electricity sector. (Ministry of Economic Development, October 2007, p. 22)

The government recognizes that it must both increase investment in generation from renewable resources and reduce current use of fossil fuels to be successful. (Ministry of Economic Development, October 2007, p. 22) However, it is important that government funds be apportioned strategically for research and development and for new projects in industry. There must be support from the electricity industry itself, as well as from the public. Kiwis must also be constantly looking abroad for advances in technology. If all of this is done well and efficiently, New Zealand will be able to achieve the goal of generating 90 percent of its electricity from renewable resources.

In this article, I first describe and evaluate the current structure of New Zealand's electricity generation industry and demonstrate the country's ability to meet its goal. Then I identify several weaknesses in the current structure that can be addressed by the government and industry. Finally, I conclude with a set of suggestions that may help the Kiwis to succeed.

Current Electricity Industry Structure

The structure of the electricity industry has several levels as highlighted in Figure 1. The first is the generation of electricity. There are five

Table 1
Electricity Capacity by Company, Year Ending March 2005

		General Capacity (MW)						
	Market Share	Total	Hydro	Gas/Coal/ Oil	Geothermal	Cogeneration	Wind	Other
Meridian Energy	29%	2539	2448	0	0	0	91	0
Contact Energy	26%	2293	752	1137	360	44	0	0
Genesis Power	18%	1602	502	1040	0	54	6	0
Mighty Rover Power	14%	1260	1090	12	33	125	0	0
Trust Power	6%	491	423	0	0	0	68	0
Other	8%	689	130	164	72	159	1	0
Total	100%	8874	5345	2353	465	382	166	164
Percentage of Total Generation			60.2%	26.5%	5.2%	4.3%	1.9%	1.8%

Source: International Energy Agency.

main electricity-generating power companies in New Zealand that operate about 40 generating stations throughout the country. (Electricity Commission, *Industry*) Three of them, Meridian Energy, Genesis Power, and Mighty River Power, are state-owned. Contact Energy and TrustPower are privatized companies. After generation, electricity moves to the transmission grid. TransPower is a state-owned transmission company that operates the national grid system. The high voltage utility lines owned by TransPower run from power plants to substations throughout the country as well as to a few direct supply consumers. The substations are owned by 28 distribution companies that make up the third structure level. These companies manage local power networks and deliver electricity to consumers. Some of these companies are Vector, Powerco, Unison, and Orion. These companies are, as the Ministry of Economic Development describes them, a combination of public listings, shareholder co-operatives, community trusts, and local body ownership, with most line companies being owned by trusts. (Ministry of Economic Development, "Distribution") Retailers comprise another group of companies separate from those that own the infrastructure that moves electricity from the power plant to a home or business. These companies manage the flow of money between consumers and generators. New Zealand has a reliable supply of electricity due to a well-established infrastructure and a competitive market. A good framework gives New Zealand a good base from which to start as it works toward achieving its goal of generating ninety percent of its electricity from renewable resources.

Kudos for Kiwis: What They Are Doing Right

New Zealand already generates a significant amount of its electricity from renewable resources, approximately 70 percent in 2005. In that same year, just over 60 percent of total electricity generation was from hydro power alone, as highlighted in Table 1. By 2025 the demand for electricity is expected to grow by as much as 30 percent. (International Energy Agency) In

order to meet this anticipated growth, about 175 megawatts (MW) of new generation, presumably using renewable resources in light of New Zealand's ultimate goal, must be created each year. (Duynhoven)

Not only do both the government and industry support this goal, but it is apparent that the public is also enthusiastic. In a survey conducted by the Energy Efficiency and Conservation Association in May 2008, the responses of Kiwis reflected an overwhelming concern for the use of renewable resources. Ninety-one percent of the respondents said that they believed energy sources in New Zealand will have either "some" or a "significant" impact on future generations. Ninety-four percent said that renewable energy is something on which New Zealand needs to focus in the future. The public does not seem to mind the presence of power plants generating electricity from renewable resources in their neighborhood, either. Over 70 percent of survey respondents were willing to have wind farms within sight of their homes as long as they were beneficial for the environment. Furthermore, more than 65 percent would not object to geothermal or tidal or wave power generators in their neighborhood. ("Public Perceptions . . .") Kiwis are apparently willing to help their country reach this goal.

Implementing Alternative Technologies

Since a large portion of the electricity in New Zealand is already generated from hydro power, Kiwis are looking for other technologies to employ. New Zealand is conveniently located in the "Roaring Forties," the area of the earth between the latitudes of 40° and 50° in the Southern Hemisphere that was nicknamed by sailors of the nineteenth century because of the prevailing western winds. ("Roaring Forties") These famous winds blow right across the width of both islands along the whole length of New Zealand, making electricity generation from wind a viable possibility. As of the end of 2006, there were eight functioning wind farms in New Zealand. (Ministry of Economic Development, June 2007) The first wind project in New Zealand was the Wellington wind turbine constructed in 1993 and is owned by Meridian Energy. It is capable of generating only 225 kW during peak winds, which is trivial compared to the hundreds of megawatts that can be generated at a hydro power plant; but on average this is enough to power about 80 homes in the area. (Meridian Energy, "Wellington Wind Turbine") This project led the way for larger wind farms such as the Te Apiti Wind Farm, which opened in 2004 and is rated at 90 MW. This is the first wind farm to connect to the national power grid, and it is capable of powering approximately 45,000 homes on average. (Meridian Energy, "Te Apiti Wind Farm") By the middle of 2007, approximately 322 MW of electricity was being generated on wind farms in New Zealand, which was a 100 percent increase from the previous year. (Ministry of Economic Development, June 2007) While only about two percent of New Zealand's electricity now comes from wind generation, it is a promising source.

There are no generation sites from tidal or wave resources currently in place in New Zealand; but Crest Energy, a small generation company, is investing funds for the development of generation sites utilizing these types of resources. The company is proposing a system that would involve about 200 turbines anchored to the seafloor of the mouth of the Kaipara Harbor near Auckland. It is predicted that these turbines could produce 200 MW of electricity and would be sufficient to supply power to about 250,000 homes on average. (Jones) One of the major benefits of using the tides is that they are predictable and reliable, unlike wind and hydro resources. The turbines will be spinning at full speed more frequently, allowing the site to power more homes than other types of generation such as wind and water. Since the turbines are sunk below the surface of the water, there are no aesthetic issues to battle. This project and others like it in the future have the potential for creating a truly reliable and sustainable resource for electricity generation.

Demand Side Efforts

One way to make the transition to an increase in renewable resources easier is to decrease current demand for electricity and accordingly relieve high levels of stress on the grid. A decrease in demand would allow companies to focus on making other changes to move forward with renewable generation instead

of struggling to meet immediate electricity needs. To this end, the major electricity generation companies in New Zealand have set up programs to encourage consumers to cut back on the amount of electricity they use. On their websites the companies offer tips on the most efficient operation of major users of electricity such as appliances and lighting, and they inform consumers about how much money they could be saving. Companies have also become creative by starting other programs. For example, Genesis Energy has a program called "Brownie Points" in which customers earn points that can be redeemed for rewards. Customers can earn points by, e.g., receiving and paying their bills online. (Genesis Energy, "Brownie Points") Companies are also providing various services to help Kiwis reduce their electricity bills. Genesis Energy, for example, provides various types of insulation services — from wrapping a hot water heater to insulating an entire house. (Genesis Energy, "Smart Savers") Contact Energy will perform audits for businesses by sending out a professional to evaluate energy usage. This allows businesses to figure out where they can cut back on electricity usage and ultimately reduce their costs. Contact Energy also has hosted a competition in which customers were asked to submit creative ideas for energy savings. Prizes included money as well as other items such as a snowboard. (Contact Energy) All of these programs help to inform consumers about electricity savings and keep them aware of the issues surrounding electricity generation. If consumers are able to reduce their demand for electricity, it will take pressure off companies to expand their generation capacity at a high rate. Focusing on meeting immediate high-demand levels can divert attention from the ultimate goal of reliable, efficient, renewable generation sites.

Many companies are beginning to use advanced metering infrastructure. Also known as SmartMeters, these new meters are intended to replace the standard meters currently installed in buildings. They will record the exact usage of electricity in the building, providing the company with a precise, real-time measurement. Thus, billings will no longer be based on estimates of use. The information will also be sent electronically, eliminating the need for the company to send someone to read the meter each month. In the future, these meters will also be able to tell Kiwi consumers exactly how much electricity they are using and when they are using it. (Meridian Energy, "Smart Meters") Likewise, power company access to this data will allow them to understand when the most power is being consumed and who is using it. Power companies can use this information to adjust their production accordingly. Recently the Electricity Commission, the government organization that regulates the electricity industry, published a policy on the integration and use of these meters allowing companies to employ them but not to discriminate by charging different prices for different users. (Electricity Commission, May 2008, p. 8) The Electricity Commission is encouraging the use of these meters, which will benefit both producers and consumers.

Exploring New Possibilities

Even as changes are made in the industry, New Zealand must be constantly looking for new technologies to employ. The Ministry of Research, Science and Technology is the government organization responsible for allocating funds for research and development. Currently about 2.4 percent of all New Zealand research and development funds are dedicated to energy research. (Ministry of Research, Science and Technology, 2006, p. 26) The sources of funds are the government, academia, and the private sector. In the ministry's agenda published in July 2008, its intentions for allocating funds to meet the renewable energy goal are made clear. The ministry intends to "accelerate research, science and technology in the realm of renewable energy technologies . . . [while] integrating these into the national energy system." (Ministry of Research, Science and Technology, 2008, p. 43) This increased investment in renewable resource research will help New Zealand reach its goal.

The ministry fully recognizes that it cannot fund all the needed research in order to achieve the country's goal. New Zealand needs to strike a balance between using technology developed by the rest of the world and developing what it needs on its own. Other countries like the United States can invest more funds dedicated to energy research, but the research

focuses on a variety of resources, only some of which coincide with New Zealand's needs. New Zealand recognizes that it should not duplicate efforts in developing technologies that are already being developed abroad, but should rather be poised to apply new technologies to its own existing infrastructure. (Ministry of Research, Science and Technology, 2006, p. 18) Adjusting technologies developed abroad to meet the unique features of New Zealand is the ministry's biggest challenge.

Areas for Improvement

While New Zealand has taken great steps toward meeting its 90 percent goal, there are still many issues that must be considered when constructing new power plants and modifying existing infrastructure. The location of future plants, the overdependence on one resource, and the new role of generation from fossil fuels will have significant impacts on the ability of Kiwis to achieve their goal.

Location of Generation Sites versus Location of Demand

One of the benefits of using fossil fuels is that the location of power plants is not crucial to the generation of power. In the case of most renewable resources, however, the location of the plant is crucial. This is particularly true with wind and water resources. Power plants generating electricity from these resources must be constructed in locations that will allow them to be most effective.

Because of the concentration of New Zealand's population, most electricity is consumed in and around Auckland. The rest of the population is sparsely distributed across the country and in a few other larger cities such as Wellington and Christchurch. The South Island of New Zealand is host to most of the hydro power plants in the country and, as a result, a significant portion of the country's power generation. Since so much electricity is generated on the South Island, most of it must be transported across the South Island, across the Cook Strait via a high-voltage DC line, and then across the length of the North Island to reach Auckland. The mountainous geography of the country makes this infrastructure hard to construct and costly to maintain. Developing generation capacity far from the demand further increases the need for transmission infrastructure. Instead, large projects should be concentrated in areas of high demand on the North Island with small, localized projects distributed throughout the country.

Resource Fluctuation

The New Zealand government has also emphasized the need for a reliable supply of electricity in its grid. Unfortunately, the availability of some renewable resources is subject to fluctuation. An industry with heavy reliance on a single resource will not succeed in meeting the country's goal of reliability. Consequences of this have already been seen in the hydro and wind sectors of the industry.

New Zealand relies heavily on hydroelectric power plants for its electricity, but further expansion of this resource could hinder its ability to maintain a reliable supply. In a dry year the ability to generate electricity from this resource is limited. During these years, prices can also increase dramatically. For a few months in 2000, prices were 300 percent higher than the year before due to a shortage of rainfall. (Taylor) According to Luiz Rangel, a member of the University of Auckland Research Centre, "If a dry period occurs, marginal costs (which include the opportunity cost of not saving water for future periods) can attain extremely high levels, sometimes even reaching system rationing levels." (Rangel) If too much is invested in hydro and not enough in other resources, then non-hydro power plants will not be able to compensate for the lack of electricity from this resource, causing possible electricity shortages and high prices throughout the country.

A similar problem exists for wind generation. A high concentration of wind turbines in one place could result in severe shortages in electricity if there is little-to-no wind at certain times. (Ancell) For instance, two large wind farms, Te Apiti and Tararua III located near Wellington, are close to each other so that their generation capabilities are linked. In December 2007 there was a wind shortage in the area, and as a result both plants went down within hours. (Ancell) Wind generation sites must be dispersed throughout the country so that such

problems are less likely to occur. Moreover, the rest of the grid must be able to quickly compensate for times when there is no wind.

Role of Generation from Fossil Fuels

The *New Zealand Energy Strategy to 2050* report only briefly mentions the role of generation from non-renewable resources in the future, stating that "existing fossil fuel generation will continue to be needed to provide back-up." (Ministry of Economic Development, October 2007, p. 68) Generation from fossil fuels must be available in New Zealand because of the risk that renewable resources may not be available at certain times. As the report says, non-renewable generation will need to assume a back-up role, but the transformation of plants from burning constantly to burning intermittently will require attention. Small increases in the amount of electricity generated by a plant already in operation are relatively inexpensive. However, turning on a power plant that is not currently in operation requires a lot of energy and, as a result, entails major costs. (Rangel) If a power plant using fossil fuels plays an intermittent back-up role, the start-up and shut-down costs that occur will have a significant impact on the price of electricity. This issue will be addressed again in the following section.

In summary, the New Zealand government has proposed an ambitious goal for the country in its *New Zealand Energy Strategy to 2050* report, but it has neglected to include many details on how it plans to achieve this goal. The document only makes general statements about passing legislation to facilitate development of new generation but gives few specifics. In the next section, some solutions to these problems are suggested.

Meeting the Goal

In 2006 the International Energy Agency (IEA), a group within the Organization for Economic Co-operation and Development (OECD), published a detailed evaluation of the New Zealand energy industry entitled *Energy Policies of IEA Countries: New Zealand 2006 Review*. In the report the IEA estimates that by 2025 total consumption of electricity in New Zealand will increase by approximately 30 percent. (International Energy Agency) Using the data provided by this publication shown previously in Table 1 and making some assumptions, one can make some rough estimates of needed generating capacity. By 2025 New Zealand must increase its generation to 11,536 MW. To meet this goal, 10,383 MW must be generated from renewable resources, and 1,154 MW must be generated from non-renewable resources. Achieving these numbers by 2025 will require a combination of changes within the current infrastructure, along with the construction of several new power plants and the implementation of new technologies.

Understanding the Numbers

The first step toward meeting the 90 percent goal is to understand the magnitude of what needs to be done in New Zealand. This involves calculating approximately how much new generation capacity must be added, as well as the amount of current generation capacity that must be modified in order to achieve the goal. One can make several rough calculations using the data in the IEA evaluation. The results of these calculations are shown in Table 2. There are two key results of the calculations that must be noted. First, ten percent of the total electricity needed in New Zealand by 2025 is only 1,154 MW, but currently 2,353 MW of electricity is generated from fossil fuels. Secondly, the figure in the bottom row of Table 2 is the total amount of electricity generation from renewable resources other than hydro that must be created to achieve the goal — approximately 4,000 MW. These calculations are based on several specific conditions that, if met, will help to alleviate the problems discussed in the previous section. The first condition is that there should be no more construction of hydroelectric power plants, which will decrease the relative dependence on hydro. A second condition is that generation from fossil fuels must be reduced by converting existing plants into back-up generation sites.

The New Zealand Energy Strategy to 2050 report identifies all planned generation projects as of 2006. If all of these projects are completed, New Zealand will have constructed almost 75 percent of its necessary electricity generation capacity from renewable resources other than

Table 2
Projections of Additional Generation Needed by 2025

Current Electricity Generating Capacity as of 2006	8,874 MW
Total Capacity Needed by 2025	11,536 MW
Capacity Needed from Renewable Resources	10,383 MW
Current Capacity from Hydro	5,345 MW
Capacity Needed from Renewables Other than Hydro	5,038 MW
Current Capacity from Renewables Other than Hydro	1,177 MW
Capacity Needed from Other Renewables	3,861 MW

Source: Calculated by the author using data from the International Energy Agency.

hydro specified, as in the last row of Table 2. It is also important to point out that current plans for generation sites only extend through 2012. (Ministry of Economic Development, October 2007, pp. 63–64) This is still thirteen years from the benchmark year of 2025.

How to Approach Development

When the Electricity Commission considers approving a request for the construction of new power plants, the following points must be considered. A high dependence on both wind and hydro resources has led to substantial problems in the past, as discussed previously. Therefore, a diverse selection of generation types is the ideal solution for this problem: if one resource for generation becomes unavailable, other resources will be able to compensate. Ultimately, then, efforts should be concentrated in developing generation from resources other than hydro and wind.

Also as previously discussed, the demand for electricity is high in a few urban areas such as Auckland, Wellington, and Christchurch, but is thinly dispersed across the many rural areas of the country. The solution to this is to implement small-scale generation facilities in the rural areas so that the need for new infrastructure is minimized. A major obstacle, however, is the inability of small-scale projects to compete with large, market-dominating plants. The demand side of the electricity industry is extremely price inelastic. This is due mainly to the fact that there are no close substitutes for electricity and that meters record usage over a month so that hour-to-hour price increases are not observed by the end user. This inelastic demand gives large power companies too much control over prices. The consumer has little ability to prevent companies from raising prices. (Rangel) The New Zealand government can help small-scale projects by helping to fund them and providing regulations that will allow small-scale generation to compete in the market.

While the government has engaged in much discussion about using renewable resources in New Zealand, it has said little about the restructuring of non-renewable generation. Since many of the renewable resources that New Zealand employs for electricity generation cannot be considered reliable, non-renewable resources can be used during times when renewable resources are not available. There must be more action taken on the part of the industry to address this issue. The first step, which should be taken by the Electricity Commission, is to perform a study of the role of generation from fossil fuels in New Zealand and to identify specific actions the industry can take to transition this part of the generation network into a back-up role. The industry must then respond to the study by implementing the actions that the Electricity Commission recommends.

Employing New Technology

The use of renewable resources and implementation of small scale generation will involve more than just creating new power plants. The future of electricity generation in developed countries generally is going to rely on the devel-

opment of "Smart Grid technology." To explain further, the current hierarchal system in most developed countries, including New Zealand, consists of central station generation sites creating a largely one-way flow of electricity from site to consumer. In the future, electricity will be generated at all levels — from large power stations to small-scale generation sites. Currently, there is not a ubiquitous solution for monitoring both the generation and consumption of electricity at any one site. In order for this new system to be effective, there must be a large, digital communication network, called a Smart Grid, which allows all the different parts of the system to interact seamlessly in real time. (Kunsman) The network nodes will be physical structures within the system, including buildings, generation sites, and distribution centers. The Smart Grid will be able to collect and transmit data describing both the generation and consumption of electricity at any node in the network, allowing for the implementation of small-scale generation. It will also enable the transmission grid to react quickly to power losses by automatically isolating problems, thereby creating a more reliable system. This technology is currently being developed in the United States and is particularly applicable to New Zealand since small-scale generation needs to be implemented in order to achieve its ultimate goal.

Conclusion: Can the Kiwis Do It?

The Kiwis have set an ambitious goal for themselves. The resources they need are available within the country, and they recognize that they have the potential to succeed. Still, there are well-recognized obstacles that the New Zealand government has recognized and is currently tackling.

The goal of generating 90 percent of New Zealand's electricity from renewable resources is one important step toward a greater goal of sustainability. New Zealand has the opportunity to show the rest of the world that it is possible to utilize local resources to achieve nearly complete independence from non-renewable resources for electricity generation purposes. Its precedent could influence other countries to do the same, thereby freeing the world from many of the problems that come from the use of fossil fuels.

REFERENCES

Ancell, Graeme. *Reviewing the Effects of Wind Generation — Three Years On*. New Zealand Wind Energy Association Conference 2008. Wellington, New Zealand. April 2008.

Contact Energy. "Helping You to Save Energy." Online. www.contactenergy.co.nz/web/view?page=/contentiw/pages/saveenergy/saveenergy&vert=se. Accessed September 8, 2008.

Duynhoven, Harry. "Leading the Way in Powering New Zealand." Speech to New Zealand Government. September 16, 2008.

Electricity Commission. *Advanced Metering Policy*. May 2008. Online. www.electricitycommission.govt.nz/pdfs/opdev/retail/ami/Advanced-metering-policy.pdf. Accessed October 5, 2008.

Electricity Commission. *Industry*. Online. www.electricitycommission.govt.nz/industry. Accessed September 8, 2008.

Genesis Energy. "Brownie Points." Online. www.genesisenergy.co.nz/genesis/your-home/brownie-points/en/brownie-points_home.cfm. Accessed January 14, 2009.

Genesis Energy. "Smart Savers." Online. www.genesisenergy.co.nz/genesis/your-home/smart-savers/en/smart-savers_home.cfm. Accessed January 14, 2009.

International Energy Agency. *Energy Policies of IEA Countries: New Zealand 2006 Review*. March 2006. Online. www.iea.org/textbase/nppdf/free/2006/newzealand2006.pdf. Accessed January 14, 2009.

Jones, Willie D. "Ocean Power Catches a Wave." IEEE Spectrum. Vol. 45, No. 7, July 2008, p. 14.

Kunsman, Stephen. September 24, 2008. *Making the "Intelligent Power Grid."* Lehigh University, Bethlehem, Pennsylvania.

Meridian Energy. "Smart Meters." Online. www.meridianenergy.co.nz/YourFarm/SmartMeters/. Accessed September 8, 2008.

Meridian Energy. "Te Apiti Wind Farm." Online. www.meridianenergy.co.nz/AboutUs/PowerStations. Accessed September 8, 2008.

Meridian Energy. "Wellington Wind Turbine." Online. www.meridianenergy.co.nz/AboutUs/PowerStations. Accessed September 8, 2008.

Ministry of Economic Development. "Distribution." Online. www.med.govt.nz/templates/Page____13497.aspx. Accessed September 8, 2008.

Ministry of Economic Development. *New Zealand Energy Data File*. Online. June 2007. www.med.govt.nz/upload/57976/000-200707.pdf. Accessed September 8, 2008.

Ministry of Economic Development. *New Zealand Energy Strategy to 2050*. Online. October 2007. www.med.govt.nz/upload/52164/nzes.pdf. Accessed August 12, 2008.

Ministry of Research, Science and Technology. *Government's Agenda for New Zealand Research, Science and Technology*. July 2008. www.morst.govt.nz/Documents/publications/policy/Governments-Agenda-for-RST.pdf. Accessed September 8, 2008.

Ministry of Research, Science and Technology. *Roadmaps for Science: Energy Research*. December 2006. www.morst.govt.nz/Util/GetFile.ashx?name=/Documents/work/roadmaps/MoRST-Energy-Research-Roadmap.pdf&path=/Documents/work/roadmaps/MoRST-Energy-Research-Roadmap.pdf&ufv=&action=. Accessed September 8, 2009.

"Public Perceptions of Renewable Energy." AC Nielson. Energy Efficiency and Conservation Authority. May 2008.

Rangel, Luiz Fernando. "Competition Policy and Regulation in Hydro-dominated Electricity Markets." Energy Policy. Vol. 36, Issue 4, 2008, pp. 1292–1302.

"Roaring Forties." Encyclopædia Britannica. Encyclopædia Britannica Online. http://search.eb.com/eb/article-505226. Accessed January 14, 2009.

Taylor, Chris. Remarks to Martindale Center Students, May 13, 2008. Auckland, New Zealand.

World Factbook Online — New Zealand. Online. www.cia.gov/library/publications/the-world-factbook/geos/nz.html. Accessed September 2008.