IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the proposed Horizons One Plan – Chapter 3 Infrastructure, Energy and Waste

STATEMENT OF EVIDENCE OF ROBERT GRAHAM HUNTER

1. INTRODUCTION

Qualifications and Experience

1.1 My name is Robert Graham Hunter. I am the Manager – Environmental Strategy and Policy for Mighty River Power Limited ("Mighty River Power" or "the Company") and have held that position since 2006, having previously been in the role of Generation Resources Manager since 2003. My responsibilities include the lead role in the policy and planning area of Mighty River Power, as well as understanding and developing strategy for Mighty River Power in the broad field of the Resource Management Act. This role also involves providing advice to aid the understanding and implications of central government policy on the company, and developing international drivers for various initiatives impacting on operations.

1.2 I hold a Bachelors degree in Civil Engineering from the University of Auckland and a Post Graduate Diploma in Business Studies from the University of Waikato. I am a member of the Institute of Professional Engineers Inc, the New Zealand Water and Wastes Association and the Resource Management Law Association. I have also gained certification in the RMA: Making Good Decisions programme.

1.3 I have been involved in the energy industry for 5 years, with approximately 25 years experience in industry in New Zealand, the past 18 of these involved with environmental management and the Resource Management Act.

Purpose and Scope of Evidence

1.4 I refer to my previous evidence, presented at the Overall hearings on 2 July 2008. In that statement of evidence I set out the background to Mighty River Power as a company, its business focus and corporate values (section 2), community focus (section 3), and core business activities (section 4). I will not repeat that evidence for the purposes of this Chapter 3 hearing, but refer the Committee to it.

1.5 The purpose and scope of this statement of evidence is to expand in more detail on aspects of my previous submissions relating to:

(a) Electricity supply and demand;

(b) Climate change policy;

(c) Mighty River Power interests in the Horizons Region; and

(d) Transmission efficiency.

1.6 In discussing these issues I will:

(a) Explain the importance of electricity to the economy and society and factors leading to an increase in the demand for electricity;

(b) Outline the state of energy supply and demand in New Zealand;

(c) Discuss the influence of climate change policies on energy generation in New Zealand;

(d) Outline Mighty River Power's current and future energy generation interests in the Horizons Region; and

(e) Discuss the need for and benefits of energy generation activities in the Region.

1.7 I am authorised to give evidence on behalf of Mighty River Power.

2. ELECTRICITY SUPPLY AND DEMAND

2.1 Electricity is an essential commodity in a modern economy, often with no alternatives. New Zealand's economic and social wellbeing are inextricably dependent on a secure and cost effective electricity supply system.

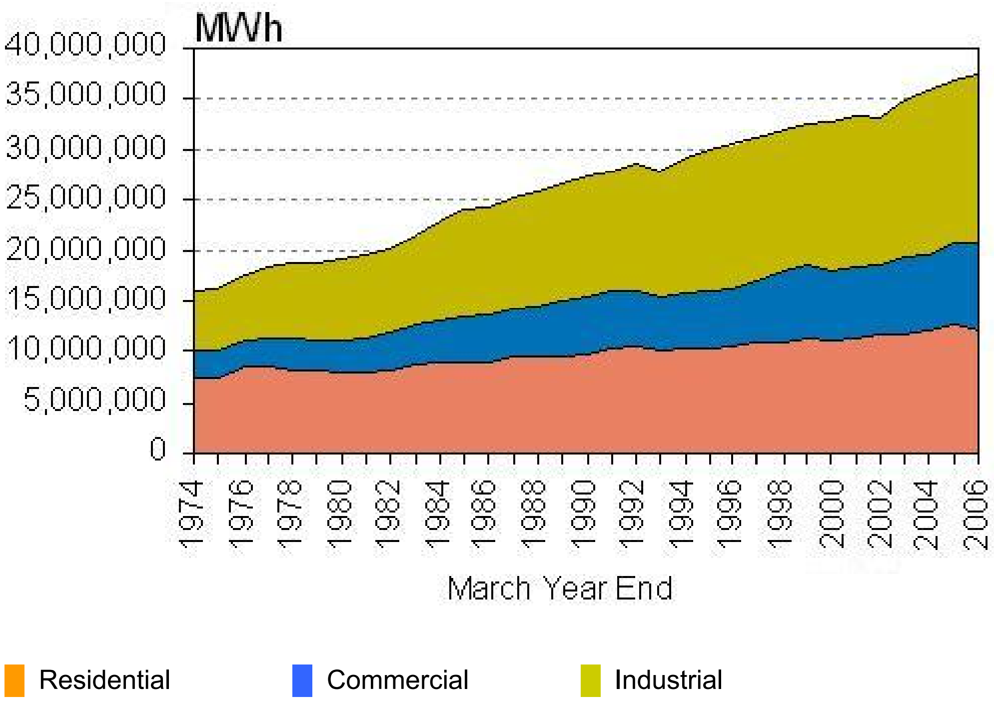
2.2 New Zealand's remote geographic situation means that it is important that the New Zealand electricity system is self reliant and that the means of electricity production must be diverse and stable.

Demand Forecast

2.3 The Electricity Commission's May 2007 National Demand Forecast predicts that New Zealand's demand for electricity will continue to grow for the foreseeable future. The growth in electricity demand is illustrated in Figure 1 for the period 1974 to 2006. Electricity Generation increased in 2007 to 42,374 GWh[1].The demand for electricity in New Zealand has grown on average by around 2.3% per annum since 1980 to its current level of around 40,000 GWh. In some years, demand growth has been around 1% while in others it has exceeded 3% to 4% and current forecasts range from 1.3% through to 2.5% per annum over the next 25 years.

[1] Ministry for Economic Development Data Electricity Generation, www.med.govt.nz

Figure 1 Electricity Consumption by Sector.



Source Ministry for Economic Development Energy Data Chart 2

http://www.med.govt.nz/templates/ContentTopicSummary____21417.aspx

Supply Options

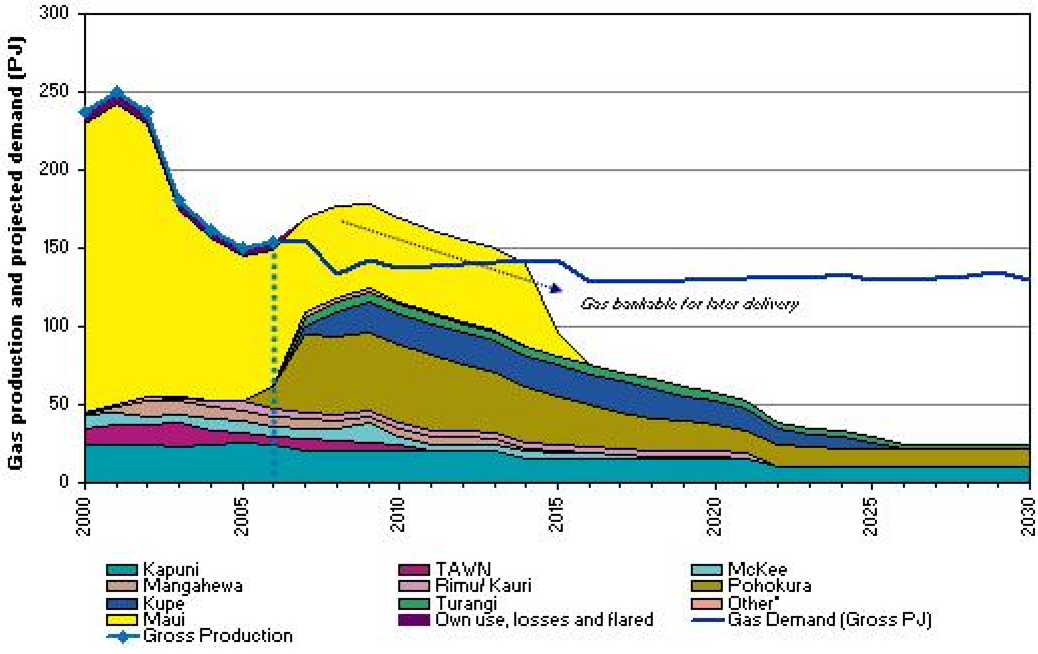
2.4 The attached Figure 2 shows the historical and forecast demand growth (the red line). Figure 2 shows the electricity generation supply provided by various fuel types. Figure 2 also identifies the hydro capacity by inflow in three broad classes, being “Hydro Wet”, “Hydro Normal” and “Hydro Dry”, to indicate generation capability when the hydro inflows are high, low or normal in any particular year, as a result of precipitation. This figure also provides an insight into the concerns being expressed in relation to the provision of sufficient generation capacity to meet this forecasted demand. The ongoing increases in generation capacity have clearly been able to meet historical demand in a way which has meant that under most scenarios there was not a shortfall caused by low inflows. This is evidenced by the demand line being generally within the band of “Hydro Dry” generation.

2.5 It should be noted that during the period of 2003 through to 2006 the demand was only able to be met by inflows being at least normal and there were years within that period when shortages were experienced as a result of lower than required inflows. Over the past 5 or so years then it has become evident that New Zealand has been relying on wet year rainfall to fuel hydro generation in order to maintain the electricity supply reliability we have all come to take for granted. This has left the nation, both socially and economically, at the mercy of the weather and forced to accept the long term risk on the stable provision of electricity to meet increasing demand. This situation arises when the ability to generate from the hydro systems around New Zealand is constrained by inflow conditions resulting in insufficient water being available. Under the "Hydro Dry" year scenario the electricity supply requirements to meet the demand are met by using non-hydro renewable and thermal generation capacity.

2.6 I have produced Figure 2 to show the level of risk in the supply of electricity to meet demand based on the mix of generation capacity available in New Zealand at any time. In viewing the figure it can be seen that the assumption is that existing non-hydro, new geothermal and thermal plant as well as wind generation are all running and the risk identified in the supply of electricity is that of hydro uncertainty. The Figure clearly shows that there have been years when electricity supply would have been constrained if the inflows had been low. This is shown by the demand line falling below the "Hydro Wet" range and being within the "Hydro Normal" range telling us that in dry years there has been insufficient capacity available to meet demand.

2.7 Figure 2 also clearly shows that looking at the future predictions of demand growth and electricity generation capacity increases there is a likelihood that the situation could become more critical as future thermal generation drops off. The concerns in terms of ability to supply demand are as a result of the expected future reduction in thermal electricity generation as a result of the run down of domestic gas supplies. Given the current assumptions about the amount of electricity generation available this could result in years that will rely on high hydro inflows as a result of wetter than normal conditions to meet demand. Based on this data this situation might be expected to occur around 2012, subject to ongoing changes in the assessment of reserves. The expected reduction in the availability of gas supply for use in the generation of electricity is more clearly identified in Figure 3, which shows the assessments of reserves available for New Zealand.

Figure 3: Historical Net Production and Projected Gas Deliverable by Field (Gross PJ)



*Others include Kaimiro, Ngatoro and Radnor

Source Ministry for Economic Development website Gas Data July 2008 Chart 3

(http://www.med.govt.nz/templates/ContentTopicSummary____21218.aspx)

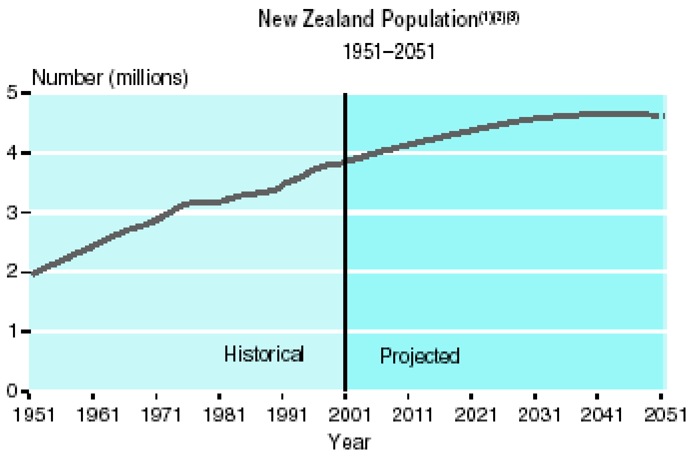
2.8 As we look into the future this shortfall is likely to get worse unless moves are made to provide for additional, probably renewable, generation capacity to be installed.

Factors in the Electricity Demand Growth

2.9 At the same time as New Zealand has been facing increasing demands for the provision of electricity supply the expectations have significantly increased in terms of the stability of the electricity supplied in terms of frequency and voltage. This expectation has occurred as a result of the dramatic increases in the use of digital technology in all facets of our lives and economy and the requirements this places on supply in order to avoid upsets. Maintenance of this stability is made much more possible in situations where the supply system is not working at maximum capacity as is the case in New Zealand at the current time.

2.10 Although there have been significant improvements in the efficiency of use of electricity in our economy the overall demand for electricity has increased as more technology has been introduced into all facets of our lives. This ranges from the increase in the average size of television set in our homes to the number of computers used by students involved in the education system at all levels to the significant increases in electricity use in industry and agriculture as the New Zealand economy continues to grow. As figure 4 illustrates the New Zealand population is projected to increase at a modest rate which will also contribute to increased demand. It must be recognised that in order for the economy to continue to grow and develop the demand for electricity will continue to increase and that any constraints imposed by lack of capacity in the ability for supply to meet the demand will result in economic uncertainty and slowing of growth.

Figure 4 New Zealand Population Growth - Historical and Projected



1. Figures from 1951–1998 are as at 31 December. Figures from 1999 onwards are as at 30 June.
2. From 1951–1990 the population is calculated using the de facto population. From 1991 onwards, the population is calculated using the usually resident population.
3. Projections based on New Zealand resident population at 30 June 1999, medium fertility and mortality, and a long-term, annual net migration gain of 5,000.

Source: Statistics New Zealand

2.11 Historically New Zealand has relied heavily on hydro electricity and since the 1980's Maui gas fired generation. However, with the depletion of the Maui gas fields and an increasing demand for energy, New Zealand has become increasingly reliant on what are varying rainfalls to sustain hydro generation. It is difficult to envisage future large scale hydro projects being developed in New Zealand given difficulties in gaining public acceptance and expected costs.

Renewable Energy Generation Targets

2.12 The issues of climate change and its impact on the New Zealand economy will be discussed later in the evidence but one of the matters arising from the response to climate change is relevant to this discussion and that is the matter of the target introduced by the New Zealand Energy Strategy and the New Zealand Energy Efficiency and Conservation Strategy of 90% renewable electricity generation by 2025. The current level of electricity generation from renewable sources in an "average year" is of the order of 70% of the supply and the current demand for electricity is of the order of 40,000 GWh annually. Tables 1 – 3 show the projections for annual demand growth of 1.5%, 2% and 2.5% respectively and it can be seen that by 2025 the demand will have grown to between 52,000 GWh and 62,000 GWh. Viewed in isolation this in an increase in demand of between 12,000 and 22,000 GWh and many commentators are expressing a view, which I agree with, that this growth can be met by construction and commissioning of renewable electricity generation facilities.

2.13 <u>Table 1</u> Electricity Supply Projection base on Growth in Electricity Demand at 1.5% per annum

Year	Demand 1.5%	Renewable %	Renewable	Thermal	Thermal Cap
2007	40000	70.0	28000	12000	12000
2008	40600	71.1	28871	11729	12180
2009	41209	72.2	29761	11448	12363
2010	41827	73.3	30672	11155	12548
2011	42455	74.4	31603	10851	12736
2012	43091	75.6	32556	10536	12927
2013	43738	76.7	33529	10208	13121
2014	44394	77.8	34525	9869	13318
2015	45060	78.9	35543	9517	13518
2016	45736	80.0	36584	9152	13721
2017	46422	81.1	37648	8774	13926
2018	47118	82.2	38736	8382	14135
2019	47825	83.3	39848	7977	14347
2020	48542	84.4	40984	7558	14563
2021	49270	85.5	42146	7124	14781
2022	50009	86.7	43333	6676	15003
2023	50759	87.8	44546	6213	15228
2024	51521	88.9	45787	5734	15456
2025	52294	90.0	47054	5240	15688

<u>Table 2</u> Electricity Supply Projection base on Growth in Electricity Demand at 2.0 % per annum

Year	Demand 2%	Renewable %	Renewable	Thermal	Thermal Cap
2007	40000	70.0	28000	12000	12000
2008	40800	71.1	29013	11787	12240
2009	41616	72.2	30055	11561	12485
2010	42448	73.3	31127	11321	12734
2011	43297	74.4	32230	11067	12989
2012	44163	75.6	33365	10798	13249
2013	45046	76.7	34533	10514	13514
2014	45947	77.8	35733	10214	13784
2015	46866	78.9	36968	9898	14060
2016	47804	80.0	38238	9566	14341
2017	48760	81.1	39544	9216	14628
2018	49735	82.2	40887	8848	14920
2019	50730	83.3	42268	8462	15219
2020	51744	84.4	43688	8057	15523
2021	52779	85.5	45147	7632	15834
2022	53835	86.7	46648	7187	16150
2023	54911	87.8	48190	6721	16473
2024	56010	88.9	49776	6234	16803
2025	57130	90.0	51405	5724	17139

<u>Table 3</u> Electricity Supply Projection base on Growth in Electricity Demand at 2.5% per annum.

Year	Demand 2.5%	Renewable %	Renewable	Thermal	Thermal Cap
2007	40000	70.0	28000	12000	12000
2008	41000	71.1	29155	11845	12300
2009	42025	72.2	30350	11675	12608
2010	43076	73.3	31587	11488	12923
2011	44153	74.4	32867	11285	13246
2012	45256	75.6	34191	11065	13577
2013	46388	76.7	35561	10827	13916
2014	47547	77.8	36978	10570	14264
2015	48736	78.9	38443	10293	14621
2016	49955	80.0	39959	9996	14986
2017	51203	81.1	41526	9677	15361
2018	52483	82.2	43147	9337	15745
2019	53796	83.3	44822	8973	16139
2020	55140	84.4	46555	8585	16542
2021	56519	85.5	48346	8173	16956
2022	57932	86.7	50198	7734	17380
2023	59380	87.8	52112	7268	17814
2024	60865	88.9	54090	6774	18259
2025	62386	90.0	56135	6251	18716

2.14 However the future picture is altered significantly if the requirement is to meet the target of 90% renewable electricity generation by the 2025 date. To achieve this, the amount of renewable electricity generation required to *displace* current thermal generation in an average year would be between 19,000 and 28,000 GWh, as identified in Tables 1 to 3. This target will require a significantly greater level of commitment by the whole economy to achieve.

2.15 The Government has moved to discourage new thermal base-load generation (unless required for security of supply) for the next 10 years, as a means of encouraging the development of renewable electricity generation projects. This means that New Zealand will have to look to develop its hydro, geothermal, biomass, wind, solar, wave and tidal energy resources. It is also proposed to introduce an emissions trading scheme that will favour the use of renewable energy resources. Opportunities for such development need to be maximised in the national interest.

Thermal Generation Required for Security of Supply

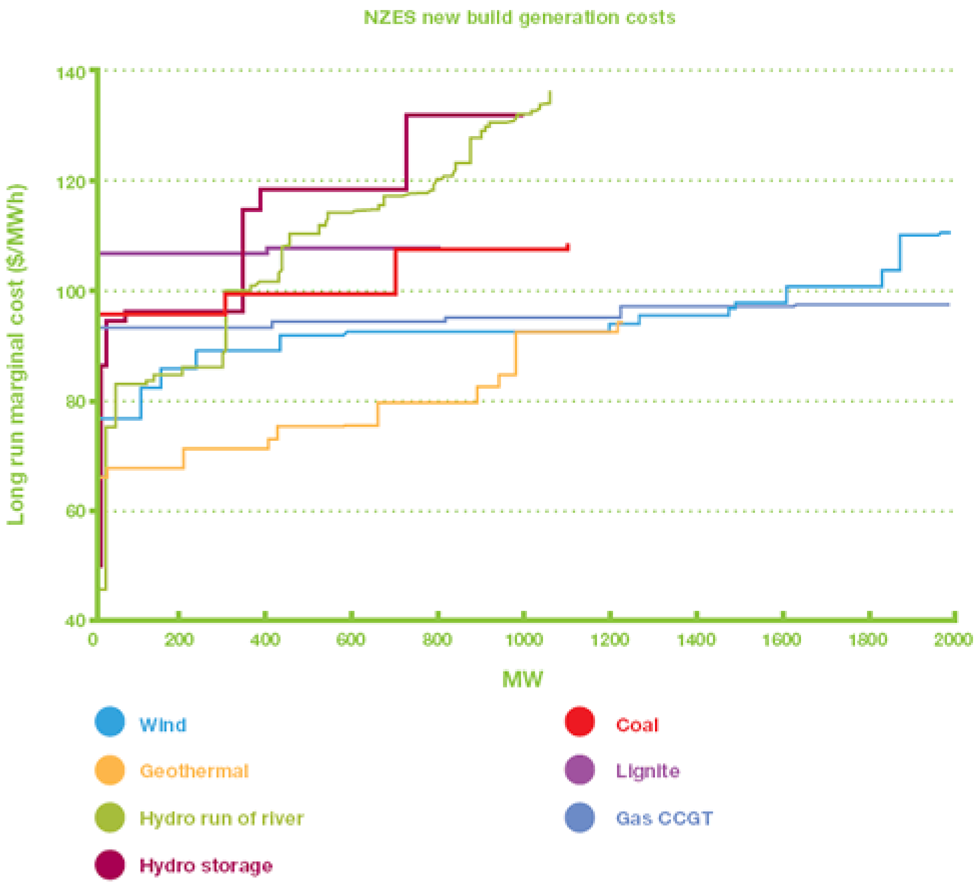
2.16 We now need to consider this future scenario set alongside the understanding we have from the consideration of Figure 2 in this evidence and realise that security of supply cannot be maintained by development of renewable electricity generation capacity alone. If we needed any further proof of that late last year the summer/autumn dry period of early 2008 has brought home the need for thermal plant capacity to be available for the instances when the risks of low inflows of hydro water become too much and the economy cannot continue to function normally by relying on the installed renewable generation capacity. Currently the capacity in New Zealand for generation from thermal plants is of the order of 30% of capacity, and for the sake of this scenario this is an appropriate level to maintain. In aiming to maintain this security of supply the level of thermal generation capacity required by 2025 will be between 16,000 and 19,000 GWh compared to the currently level of capacity of some 12,000 GWh. This means that along with the significant amounts of renewable electricity generation required to be installed there is also an increase in the thermal capacity of the order of 50% required in order to maintain the security of supply into the future.

Levels of Diversified Generation Required

2.17 Against the backdrop of increasing demand and diminishing supply, it is critical that existing energy infrastructure is maximised and opportunities to increase and diversify New Zealand's generation capacity, and in particular renewable generation capacity, are fostered.

2.18 It is essential that every opportunity is taken to enable appropriate development of renewable generation capacity and this must continue to be kept in mind as the development of the Horizons One Plan continues. Figure 5 in this evidence is from the New Zealand Energy Strategy and shows the range of costs associated with the provision of new electricity capacity. When installing any generation plant it is important to understand that the capacity of the plant in Mega Watts (MW) is only a measure of the instantaneous output potential of the plant and the critical measure is the longer term generation capacity of the plant as a supplier into the market to meet the annual demand. This output is measured in GWh and is influenced by the type of plant and availability of fuel. The 'capacity factor' is a measure of comparing these two variables.

2.19 Figure 5 Typical Costs for New Electricity Generation by Fuel Type.



"Source New Zealand Energy Strategy to 2050 – Powering Our Future Towards a sustainable low emissions energy system" October 2007, New Zealand Government, Ministry of Economic Development, Figure 5.7 (updated August 2007)

2.20 In New Zealand the plant capacity factors are in the order of 36 – 47% for wind generation, 55 – 60% for hydro and 90 – 95% for geothermal generation. By converting the MW output of a plant and including the capacity factor we can arrive at an estimate of the total amount of annual generation likely. If we consider a base of 1000MW installed capacity the output for a wind plant is of the order of 3000 GWh annually with hydro at 4800 GWh and geothermal generation at about 8300 GWh. By comparison a theoretical 1000 MW plant running at capacity would have an output of 8760 GWh annually.

2.21 If these factors where applied to all of the renewable electricity generation shown in Figure 5 almost all of it would be required to be installed in order to meet the 90% renewable generation target by 2025, as identified in Tables 1 to

3. In summary, any realistic assessment as to whether renewable electricity supply will meet future demand must take into account capacity factors. Any further skewing of the scenario by limiting the amount of wind generation within the Horizons Region would increase even further the scale of the challenge faced by New Zealand in order to achieve the target.

2.22 The security of supply issue also has a regional dimension. The Horizons Region is a net importer of electricity, with a demand for 1584 GWh and a supply of 766 GWh in 2007. Generation activities within the Region have the opportunity to provide more secure energy options for regional needs, and so should be encouraged.

3. CLIMATE CHANGE POLICY

3.1 New Zealand has made an international commitment[2] to reduce greenhouse gas emissions to 1990 levels during the initial Kyoto Protocol commitment period (2008 to 2012). This has significant implications for New Zealand, noting that on current predictions, New Zealand faces adverse economic impacts during the first commitment period of approximately $0.5 to $1.2 billion[3].

3.2 To comply with its obligations under the Kyoto Protocol, New Zealand must look to reduce its emissions of greenhouse gases in all sectors of the economy including the current reliance on thermal generation by developing its renewable energy resources.

3.3 The New Zealand Energy Strategy sets a target of 90% of the country's energy being supplied by renewable energy generation by 2025. Government policy is that it is "*in New Zealand's longer-term economic and environmental interests to meet increases in [electricity] demand through an economic mix of renewable energy sources…*". The Government expects to achieve this outcome through:[4]

> *"Maximising the contribution of cost-effective renewable energy resources while safeguarding our environment."*
>
> *"Aggressively pursuing existing and new renewable-based electricity generation."*

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[2] In 1997, New Zealand signed the Kyoto Protocol on greenhouse gas emissions. The Protocol has now been ratified

[3] http://www.climatechange.govt.nz/about/kyoto-provision.html

[4] New Zealand Energy Strategy, pages 15, 36.

3.4 As has become evident during the current hydro fuel (water) shortage the provision of sufficient thermal generation in order to maintain the security of supply is key to success in the plans to generate a higher proportion of New Zealand's electricity from renewable sources. This means that in abnormal years such as this demand can be met from thermal generation which is not normally needed to make up the shortfall.

3.5 The challenge ahead of us all becomes more difficult is we pause now to consider the world beyond the current Kyoto commitment period ending in 2012. New Zealand has a target in this first period to reduce its Greenhouse Gas (GHG) emissions to the level of 1990 emissions by 2012, and currently emission rates are at about 1990 levels plus 30%. However the Annex 1 countries, along with those of the G8 are now beginning to discuss reductions of the order of 50% below 1990 emission levels by 2050, and 40% reductions from current levels by 2020. These are not agreed targets but are an indication of the debates currently being held internationally which will inform our domestic policy in the future. The outcome of these current debates will, in all likelihood, result in a strengthening of the requirements for renewable electricity generation in the future.

4. MIGHTY RIVER POWER IN THE HORIZONS REGION

4.1 Mighty River Power's Waikato hydro system relies, to some extent, on water that is diverted from the Horizons Region as part of the Tongariro Power Scheme. Mighty River Power wishes to ensure that the importance of this diversion is recognised and provided for in relevant planning instruments.

4.2 There may also be other hydro generation opportunities within or connected to the Region that can be developed in the future. For these reasons the Company has an interest in ensuring that renewable energy issues and water allocation questions within the Region are addressed in a way that preserves existing hydro generation potential and does not unduly restrict new development.

4.3 An important feature of the Waikato Hydro System is the storage role of Lake Taupo which represents 13% of New Zealand's maximum national hydro storage capacity when assessed against the hypothetical situation of all of the storage lakes being at full storage. The majority of the balance of storage is provided by the South Island hydro lakes. Continued availability of inflows to Lake Taupo are therefore critical to the security of supply scenarios that I have outlined above.

4.4 The Horizons Region also contains other energy resources with significant potential to benefit New Zealand's energy supply. The quality of the wind resource on the Tararua and Puketoi Ranges is virtually unparalleled both in New Zealand and internationally.

4.5 Mighty River Power has entered into commercial arrangements with the Palmerston North City Council to develop a wind farm on the Tararua Ranges in the Turitea Reserve, and is currently monitoring the wind resource on the site. If the project goes ahead it will not only have benefits in terms of electricity generation and security, but revenue generated will assist the Council to implement its own environmental aspirations for the Turitea Reserve.

4.6 As Mr Nash will outline the Company is exploring further wind energy developments in the Region. He will identify the considerable wind resource in the Region. Wind energy generation can only be undertaken efficiently in locations where the wind is strong and reliable. The development of wind energy resources helps decrease New Zealand's dependence on hydro generation, and the vagaries of rainfalls and lake levels.

4.7 EECA's Renewable Energy Assessment for the Manawatu-Wanganui Region identifies a wide range of other renewable energy technologies that are or may become feasible power generation options, including: solar energy collection; hydro; biomass using a variety of fuels; geothermal; and a range of emerging marine generation methods utilising wave, tide and current energy. As market conditions change or technologies improve a wider range of these options may be worthwhile pursuing within the Region.

4.8 Energy generation activities within the Horizons Region benefit not just New Zealand generally, but the Region in particular. Economic benefits flow from the construction, maintenance and employment associated with the energy industry, as well as the resulting increase in regional generation and reduction in imported electricity. This has benefits in the efficiency of transmission of electricity as well as improved security of supply for the region.

4.9 Mighty River Power views the Horizons Region as the most important Region in the country in terms of the significant potential and opportunity for the development of renewable energy projects. In coming to this view recognition has been given to the issue of transmission of electricity, which I will now discuss.

5. TRANSMISSION EFFICIENCY

5.1 The larger 'load centres' in New Zealand exist in the upper North Island, especially in the Auckland region. Electricity supply in New Zealand generally flows from south to north, because in the South Island, hydro electricity supply typically exceeds demand.[5] Greater transmission distances result in greater energy losses. The renewable energy resources in the Manawatu-Wanganui region have an advantage in that they are reasonably proximate to the northern load centres, and to the national transmission grid.

5.2 Therefore, electricity generation in the Horizons Region, closer to demand, would reduce transmission losses that occur when electricity generation is transported from generation locations that are more remote from demand, saving supply that would otherwise be wasted. A proportion of this would be renewable hydro supply from the South Island, especially at times of peak demand when incremental losses can be particularly high.

5.3 Along with provision of generation in amounts to satisfy the demand requirements of consumers in terms of availability, stability and security it is key that provision is made for sufficient transmission infrastructure to be put in place to allow the electricity supply system to work as required. A strong transmission system is key to a renewables future. We are seeing ongoing issues develop with transmission from provision of infrastructure, maintenance and upgrading of the existing infrastructure, constraints developing in the transmission network and issues of reverse sensitivity. The development of the One Plan provides a timely opportunity to allow for this transmission infrastructure in the region in order to provide for the current needs of the industry and also to meet the future requirements of transmission as the demand for electricity continues to increase. Without making such provision transmission infrastructure, which is essential to electricity supply, will continue to be an unnecessary point of tension in the community.

6. IMPLICATIONS

6.1 Opportunities such as the process to develop the One Plan which we are currently engaged in cannot be overlooked in order to make the appropriate provision for renewable energy development and use.

6.2 Renewable energy has a number of potential benefits that should be given recognition in the Horizons One Plan. Mr Peterson will explain how this can be achieved. Some of the key benefits of new electricity generation from renewable energy sources are:

(a) A positive contribution to addressing the effects of climate change through low emissions of greenhouse gases;

(b) the ability for New Zealand to satisfy current and future electricity demand and thereby enhancing the reliability and security of electricity supply;

(c) utilisation of sustainable sources of energy for the long term benefit of the economy, people and communities; and

(d) enhanced storage of energy for hydro electricity generation.

7. CONCLUSIONS

7.1 For the reasons set out in my evidence electricity is an essential commodity in a modern economy. People and communities expect a reliable electricity supply to match demand so that economic and domestic activities can continue to function. It is therefore entirely appropriate in my opinion that Horizons has recognised electricity generation as essential infrastructure in the One Plan.

7.2 I support the changes to the One Plan recommended by Mr Peterson to give greater recognition of the important role that electricity plays in society and policy support for renewable energy use and development in the Horizons Region.

7.3 It is appropriate to recognise the benefits of renewable energy and the contribution that generation of electricity from renewable energy can make to address the effects of climate change. To provide for a secure and reliable supply of electricity into the future, development of generation from diverse sources of energy is required.

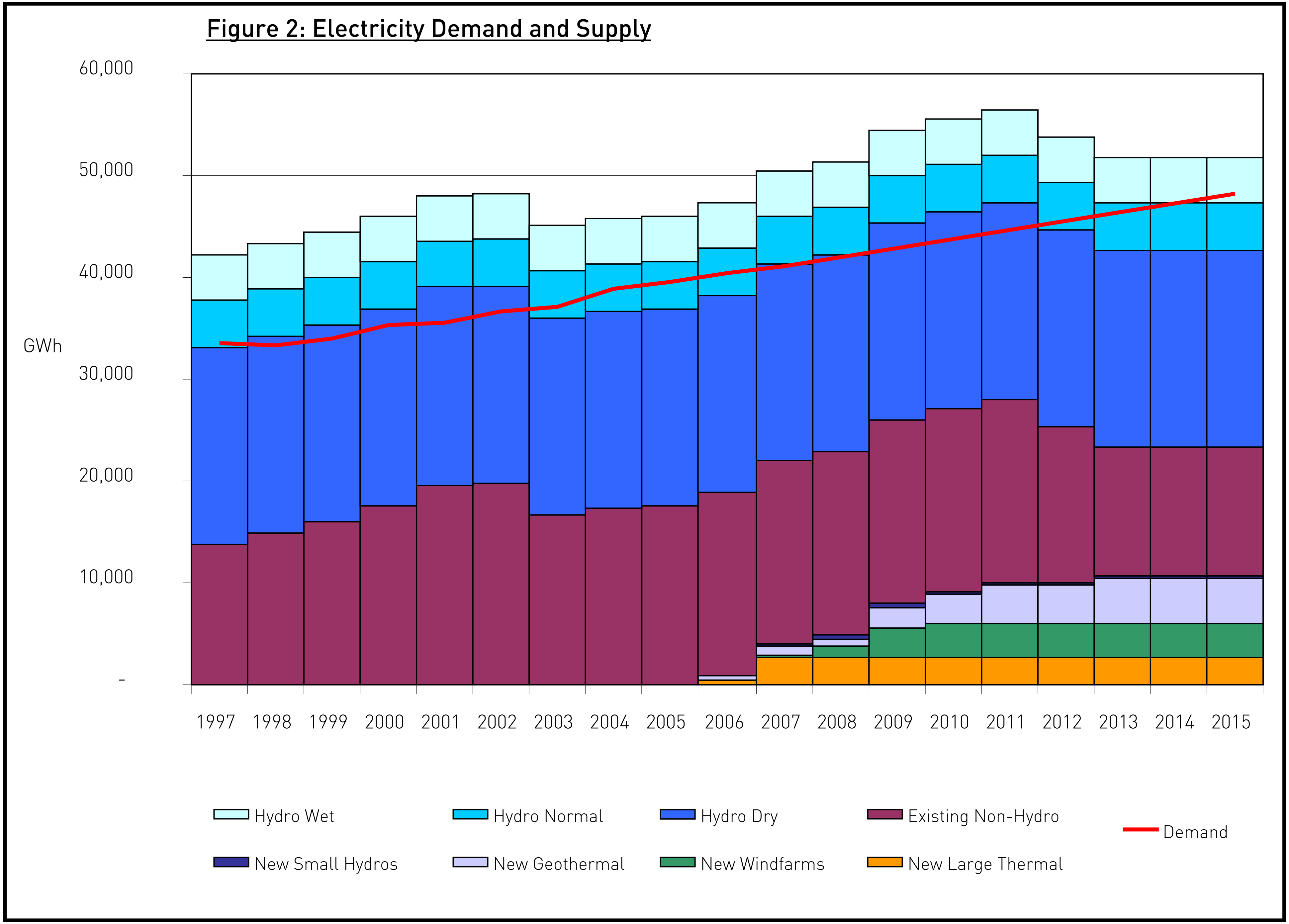
Figure 2: Electricity Demand and Supply
60,000
50,000
40,000
GWh
30,000
20,000
10,000
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1997
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2014
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Hydro Wet
Hydro Normal
Hydro Dry
Existing Non-Hydro
Demand
New Small Hydros
New Geothermal
New Windfarms
New Large Thermal