Wellington Registry **ENV-WLG-2024-001**
Te Whanganui-a-Tara Rohe

In the Environment Court
I Mua I Te Kōti Taiao O Aotearoa

Under the Resource Management Act 1991

and in the matter of the direct referral of an application for resource consents by Meridian Energy Limited in respect of the proposed Mt Munro wind farm under section 87G of the Resource Management Act 1991 (**RMA**).

Meridian Energy Limited
Applicant

and

Tararua District Council, Masterton District Council, Manawatū-Whanganui Regional Council and Greater Wellington Regional Council (**Councils**)
Consent Authorities

and

s 274 Parties

Statement of Evidence of Jennifer M Purdie on behalf of Meridian Energy Limited

24 May 2024

ANDREW BEATSON
BARRISTER
RICHMOND CHAMBERS
TEL 021 223 9170 EMAIL ANDREW@BEATSON.CO.NZ

SOLICITORS ACTING: E TAFFS AND H TAPPER, MERIDIAN ENERGY LIMITED
287-293 DURHAM STREET NORTH, CHRISTCHURCH, 8013, NEW ZEALAND
TEL 021 676797 EMAIL ELLIE.TAFFS@MERIDIANENERGY.CO.NZ

INTRODUCTION

1. My name is Jennifer Margaret Purdie. I hold a PhD in climate forecasting. I am a full member of the NZ Meteorological Society, NZ Offshore Wind Working Group, and Flexforum (a group aiming to speed delivery of distributed energy flexibility in NZ).

2. I am employed by the University of Otago as a Senior Research Fellow. At the University I work in the Centre for Sustainability. I am currently Principal Investigator on a 3 year research project funded by the Deep South National Science Challenge (MBIE contract number C01X19011). The title of the project is Simulation of Climate Change Impacts on the New Zealand Energy System. This project explores the projected impact of climate change on wind and water systems in New Zealand over the next three decades, and the effect of these changes on New Zealand's electricity system out to 2050. This is undertaken in collaboration with the National Institute of Water and Atmosphere (**NIWA**) and University of Otago scientists, and uses a computer model which simulates the entire New Zealand electricity system, including generating plant, transmission, fuels, and electricity demand. This computer model is on licence to the University of Otago from its owner, Meridian Energy Limited (**Meridian**).

3. I am also sole director of a consulting company, ClimateWorks Ltd, which undertakes consulting work relating to climate and energy topics. In the past year I have undertaken consulting projects for government and industry bodies and associations.

4. Prior to this, I was employed by Meridian from 2007 to 2020 as Energy and Fuels Advisor, and have provided evidence in relation to climate change-related issues of relevance to appeals on the Proposed Southland Water and Land Plan, and to the reconsenting of the Waitaki hydro-electric power scheme.

5. I have 30 years' experience in New Zealand climate science and its application to water resources. I have published 9 peer reviewed papers on hydro-climatological forecasting and the impacts of climate change on renewable energy in New Zealand, and dozens of technical

reports. I have delivered about 20 papers on these subjects at national and international conferences.

6. Other previous relevant employment is as a climate scientist for Topoclimate South, a climate and soils research project in Southland, and as a contractor for Climate Management Ltd.

BACKGROUND TO THE PROJECT

7. In 2023 I was engaged by Meridian to provide a climate change assessment in relation to the proposed wind farm at Mt Munro in the Northern Wairarapa (the **Project**). I provided a final report in 2024 (the **Climate Change Impacts Report** or **my Report**), which was sent to the Councils in February 2024 ahead of the release of the s 87F report.[1] My Report explains the:

   (a) Projected climate change impacts on wind in the region; and

   (b) The importance of new renewable electricity projects to New Zealand's decarbonisation goals.

8. I confirm that I hold the same views and conclusions as expressed in my Report.

CODE OF CONDUCT

9. I confirm that I have read the 'Code of Conduct for Expert Witnesses' contained in the Environment Court Consolidated Practice Note 2023. I agree to comply with this Code of Conduct. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

[1] Available at www.horizons.govt.nz/HRC/Meridian-Energy-Limited/Mt%20Munro%20wind%20farm%20climate%20change%20report%20-%20Purdie%202023%20-%20V4.pdf

SCOPE OF EVIDENCE

10. I have been asked to provide evidence in relation to climate change impacts. My evidence summarises the findings of my Report, and also:

    (a) Respond to issues raised in submissions; and

    (b) Respond to the Councils' s 87F report.

METHODOLOGY

11. In forming my conclusions, I have considered the evidence of reports of the Intergovernmental Panel on Climate Change (**IPCC**), US Department of Energy, Boston Consulting Group, NIWA, the Ministry for the Environment (NZ), the Ministry of Business, Innovation, and Employment, the NZ Climate Change Commission, the Interim Climate Change Committee, Transpower New Zealand Limited, the Business Energy Council, Concept Consulting, the [Electricity] Market Development Advisory Group, and relevant scientific papers.

12. I have also drawn on met mast data from an exploratory met mast (anemometer), provided to me by Meridian. I have used wind speed projections provided by NIWA. These were daily wind speed projections and were downscaled by NIWA from Global Climate models, and are explained further in point 18, below.

Changing Wind Speeds in New Zealand

13. New Zealand has an excellent wind resource, as it is located perpendicular to the prevailing mid-latitude westerly wind belt, the "roaring forties". Faster wind speeds are found closer to mountain ranges and in some coastal areas.

14. However, it is now "unequivocal"[2] that there is relatively rapid change in our climate as a result of human activities, and that this changing climate will have an impact on the rainfall, temperatures, and wind speeds we have experienced in the past.

[2] IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Switzerland, pp.1-34, doi: 10.59327/IPCC/AR6-9789291691647.001

15. For the past few decades, globally, wind speeds have slowed over land almost everywhere, at the rate of approximately 2% per decade[3]. In New Zealand, reductions in wind speeds since 1970 have been estimated at approximately 0.5 ms^{-1} per decade in the South Island, and approximately 0.2 ms^{-1} in the North Island[4].

Mt Munro Past Wind

16. Winds in the lower North Island are strongly modified by the topography, including the Tararua ranges, which lie perpendicular to the prevailing westerlies. An exploratory 80 m wind mast has been in place at the Mt Munro wind farm site for the past fifteen years. Data from this site show that wind is predominantly from the north-west (see Figure 1), with a smaller amount from the south. It is a windy site, with much of the wind in the higher wind speed bracket. Average annual wind speed at the site is 9.5 ms^{-1} at 40m. The data collected at the site puts this site at Class 1, making it amongst the best sites in the world for wind generation (determined by wind speed, strong gusts, and turbulence). Highest wind speeds at the site are in spring, and lowest wind speeds are in early autumn and winter.

[3] McVicar et al 2012: Global Review and synthesis of trends in observed terrestrial near surface wind speeds. In journal of Hydrology 416-417, 182-205. doi:10.1016/j.jhydrol.2011.10.024

[4] Pirooz et al 2019: Effects of climate change on New Zealand design wind speeds. Paper presented at the Australian and New Zealand Disaster and Emergency Management Conference Gold Coast, Queensland, Australia 12-13 June 2019. In National Emergency Response, pg 14-20

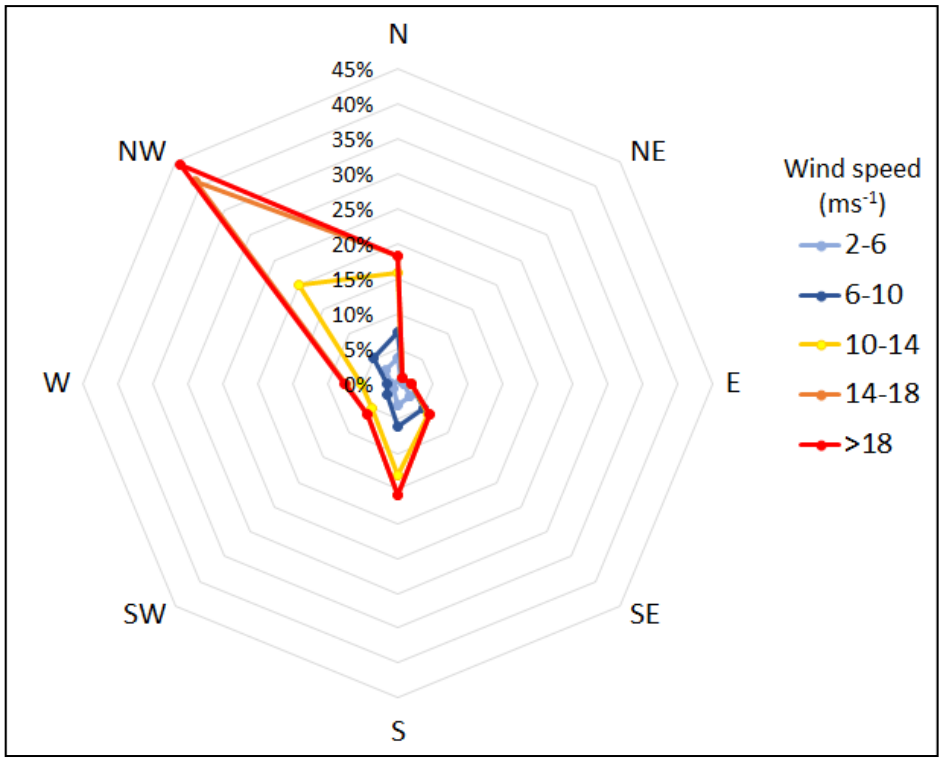

Figure 1: Wind rose for Mt Munro wind farm exploratory mast wind speed and direction data (daily averages), 40m height, 2013–23. Colours are different daily average wind speed bands in ms^{-1}. Percent lines are the % of time wind of that speed comes from that direction.

Projected Future Wind Speeds in New Zealand

17. Future global projections of wind speeds are for increases in wind speeds in some places, and decreases in others. Future wind projections are available for New Zealand from NIWA's downscaling of Global Circulation Model outputs. Projections for future New Zealand wind speeds are generally for an increase in wind speeds in the South Island and lower North Island in coming decades, and a decrease in wind speeds in the north of the North Island.

18. To estimate the impact of climate change on New Zealand, NIWA uses ocean-atmosphere state projections out to 2100 from six Global Climate Models (GCMs) (as part of the Global Coupled Model

Intercomparison Project Phase 5 (CMIP5)[5] (and, in the near future, from CMIP phase 6[6]).

19. The global models have a resolution of approximately 100–300km, and sea surface temperatures and pressures from these are downscaled initially with the HadRM3P regional atmosphere model (resolution ~27km[7]), and then further statistically downscaled to a 5km grid over the whole of NZ. This process produces projections of such variables as rainfall, temperature, and wind speeds out to 2100, to enable the closer examination of the regional impacts of climate change in New Zealand.[8]

20. The IPCC uses four Representative Concentration Pathways (RCPs) to represent the impact on the climate from low, moderate, moderate–high, and high emissions pathways. These RCPs are denoted RCP 2.6, 4.5, 6.0, and 8.5 and represent the change in radiation reaching the earth by 2100, (expressed in watts per square metre; Wm^{-2}) which will be caused by the emissions scenario they represent. The latest IPCC report[9] uses a different nomenclature for future pathways, that of "Shared Socioeconomic Pathways", or SSPs. Whereas RCPs describe the amount of greenhouse gases in the atmosphere and the resulting likely warming, SSPs describe the socioeconomic pathways that would lead to those RCPs. As current NIWA downscaling uses RCPs, those are reported on here.

21. Regional atmospheric circulation changes are likely to result in increased wind speeds in the South Island, and reduced wind speeds in the North Island, generally.

[5] IPCC 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2013; p. 1535.

[6] NIWA 2024: Updated national climate projections for Aotearoa New Zealand https://niwa.co.nz/climate/research-projects/updated-national-climate-projections-for-aotearoa-new-zealand

[7] Ackerley et al 2012 Regional climate modelling in New Zealand: Comparison to gridded and satellite observations. Weather Clim. 2012, 32, 3–22.

[8] MfE 2018: Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition. Wellington: Ministry for the Environment. https://environment.govt.nz/assets/Publications/Files/Climate-changeprojections-2nd-edition-final.pdf

[9] IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001

Mt Munro Future Wind Projections

22. Annual changes to wind speeds by 2050 at the Mt Munro site are expected to be only +0.3% (low emissions) to +1.5% (high emissions), with the most likely scenario (mid-range emissions, RCP4.5) being an increase of +1.3% in wind speeds. The highest and lowest wind speeds are expected to increase at the same rate as the mid-range speeds. This small increase is not expected to significantly alter wind generation at the site, or result in damage to turbines.

23. Projections for the proposed Mt Munro wind farm site show increases to winter wind speeds in the future (1–3% for low to high emissions scenarios by mid-century), with mid-range (most likely) emission resulting in a 1–2% increase in wind speeds in winter by mid-century. Summer wind speeds are expected to decrease slightly (0–2% for low to high emissions), with mid-range emissions expected to result in a 0.5–1% decrease in wind speeds by mid-century.

24. The impact of these changes can be seen on average Mt Munro wind speeds for different emissions scenarios by mid-century in Figure 2.

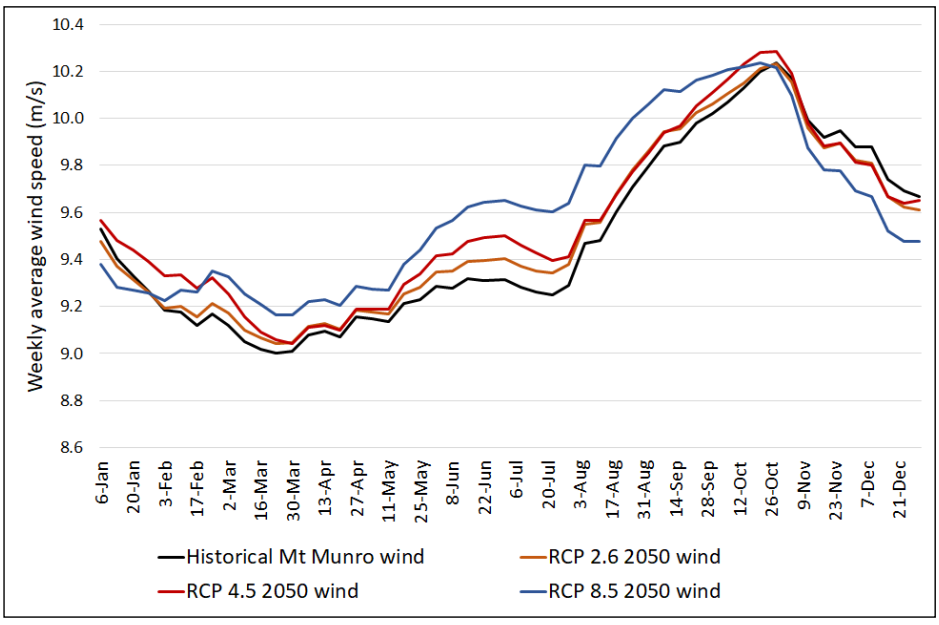

Figure 2: Mt Munro average weekly wind speed 2013–23, and average weekly wind speed adjusted for 2050 future projected wind speed under three different emissions scenarios: RCP 2.6, RCP 4.5, RCP 8.5.

25. Changes to wind speeds are expected to be fairly consistent across the distribution of wind speeds, with the highest, extreme wind speeds expected to increase by approximately 0.8% by mid-century, and the lowest wind speeds expected to increase by 1–1.5% by mid-century. These changes are small, and are not expected to increase time above cutoff speed significantly, or incur major damage to turbines, relative to today's conditions.

THE GLOBAL AND NATIONAL ENERGY TRANSITION

Global Agreements on Emissions Reduction

26. The IPCC is the United Nations body which assesses existing published science on climate change and is the internationally accepted authority on climate change.

27. The most significant climate agreement ever signed is the Paris agreement, signed at the "Conference of the Parties" to the United Nations Framework Convention on Climate Change, in 2015. 195 parties have signed the agreement, including almost every country in the world. All but three of these parties have also ratified the agreement. The Paris Agreement's goal is to keep the increase in global average temperature to "well below 2°C" above pre-industrial levels, and preferably below 1.5°C". It requires all parties to define their own "nationally determined contributions" (NDCs) to reduce national greenhouse gas emissions, to report on these efforts, and to continue to increase their contributions in the years ahead.

New Zealand Climate Change Legislation and Targets

28. NZ has signed and ratified the Paris Agreement, and is now committed to reducing our net greenhouse gas emissions to 50% below our gross 2005 levels by 2030.

29. The Climate Change Response (Zero Carbon) Amendment Act 2019 (the **Zero Carbon Act**) came into force July 2019 and commits New Zealand to achieving net zero greenhouse gas emissions by 2050.

30. The Interim Climate Change Committee (ICCC) was set up in 2018 to advise the NZ government on how to deal with climate change. Their

report[10] "Accelerated Electrification" advocated for significant electrification of transport and industrial heat as a primary means to significantly reduce GHG emissions from these sources.

31. The ICCC was replaced by the independent Climate Change Commission (CCC) under the Zero Carbon Act. The Climate Change Commission's purpose is to provide independent, evidence-based advice to government on climate issues. Its first advice to government was in May 2021 and was a report[11] advising on the first of three emissions budgets.

32. The NZ government then produced its Emissions Reduction Plan[12] in June 2022, which lays out emissions reduction targets, and plans to meet those targets. Targets include that long-lived greenhouse gases will be net zero by 2050, and that biogenic methane emissions will be 24–47% below 2017 levels by 2050.

33. The Emissions Reduction Plan talks of the importance of using "our highly renewable electricity system to further electrify industry and transport", and the plan aims to phase out fossil fuels while "massively ramping up renewables in transport, electricity generation and industry".

34. Plans to meet those targets include a target to generate 100% renewable electricity by 2030 (in an "average hydrological year"), phasing out coal boilers, and supporting electric vehicle uptake. A ban on offshore oil and gas exploration is about to be reversed. The last government also committed to planting 1 billion trees by 2028, as a carbon sink (carbon storage)[13].

35. New Zealand is a member of the Powering Past Coal Alliance (PPCA), which is dedicated to phasing out coal power plants in OECD countries by 2030 and globally before 2050. The New Zealand Emissions

[10] ICCC 2019: Accelerated electrification – evidence, analysis, and recommendations, 30th April 2019, 120pp. https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/ICCC-accelerated-electrification-report.pdf

[11] CCC 2021: Ināia tonu nei: a low emissions future for Aotearoa – advice to the New Zealand Government on its first three emissions budgets and direction for its emissions reduction plan 2022-2025, 418pp. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa.pdf

[12] MfE 2022 Aotearoa New Zealand's first emissions reduction plan | Ministry for the Environment

[13] One billion trees planting programme | NZ Government (mpi.govt.nz)

Trading Scheme (NZ ETS) is the key tool for reducing emissions and meeting New Zealand's emission reduction targets[14]. The NZ ETS requires all sectors of New Zealand's economy to report on their emissions and (apart from the current exception for biological emissions from agriculture) to purchase and surrender emissions units to the Government for those emissions. Just over half of New Zealand's greenhouse gas emissions are covered by NZ ETS surrender obligations.

36. The NZ price of carbon rose from NZ$17 per tonne CO_2 in early 2017 to $85 per tonne in February 2022, but has sat between $60 and $75 per tonne since mid-2023[15].

37. An amendment to the Resource Management Act 1991 (**RMA**) in 2004 now requires persons exercising functions and powers under that Act to have particular regard to the effects of climate change and the benefits to be derived from the use and development of renewable energy in achieving the purpose of the RMA[16]. Sections of the RMA which prevented decision-makers having regard to the effects of activities on climate change ceased to have effect in 2023.

New Zealand's Current and Future Electricity Systems

38. New Zealand's electricity system is currently 84% renewable (average of last 5 years). Generation in 2022 (most recent data available) was primarily from hydro generation (58%), with lesser amounts from geothermal (18%), coal (4%) and gas (12%), wind (6%), and solar and biomass (<1%) (see Figure 3).

[14] New Zealand Emissions Trading Scheme | Ministry for the Environment

[15] CommTrade: https://www.commtrade.co.nz/

[16] Resource Management (Energy and Climate Change) Amendment Act 2004 No 2, Public Act 3 Purpose – New Zealand Legislation

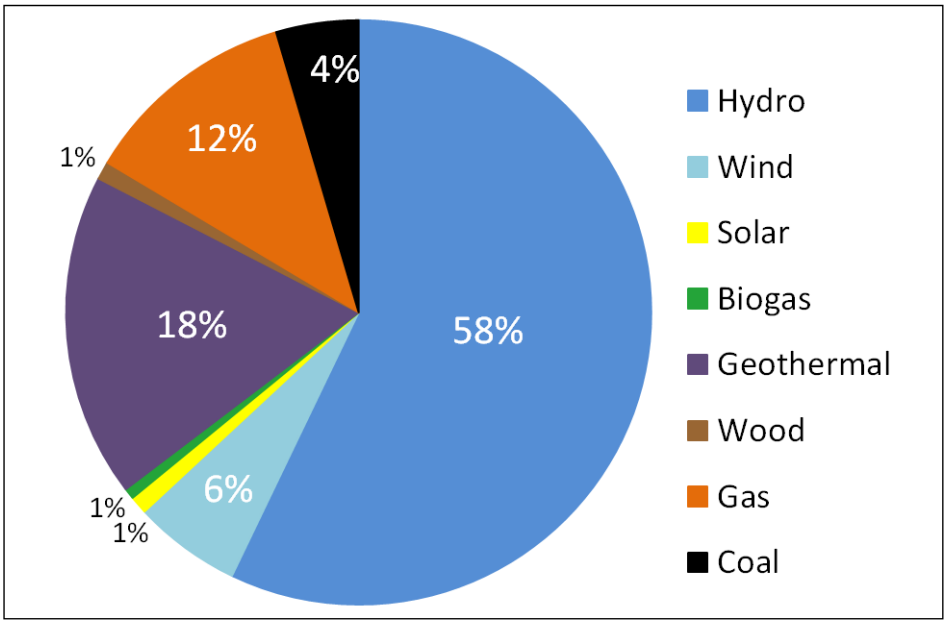

Figure 3: Current annual (2022) electricity generation by type, New Zealand[17]

39. The contribution of different types of generation to the electricity system is set to be transformed in coming decades, as old thermal plant is displaced by new renewable generation, and new generation plant to supply increasing demand is predominantly renewable.

Impact of Decarbonisation on Electricity Demand

40. New Zealand's decarbonisation strategy, to meet Paris Agreement and Zero Carbon Act goals, includes accelerated electrification, particularly of transport and industry. This electrification is projected to approximately double electricity demand by 2050, resulting in the need for significant new generation infrastructure[18].

41. The Climate Change Commission estimates that all new light vehicles entering New Zealand's vehicle fleet will be electric by 2035, and Concept Consulting[19] estimates that by 2040 ~40% of New Zealand's overall vehicle fleet will be electric. There will also be significant electrification of process heat and other industrial processes.

[17] MBIE 2023: Electricity Statistics. https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/

[18] Boston Consulting Group 2022 The future is electric – a decarbonisation roadmap for New Zealand's Electricity Sector. 206pp. https://www.bcg.com/publications/2022/climate-change-in-new-zealand

[19] Concept consulting 2018: Driving change - Issues and options to maximise the opportunities from large-scale electric vehicle uptake in New Zealand, Mar 2018. https://www.concept.co.nz/uploads/1/2/8/3/128396759/ev_study_v1.0.pdf

Transpower (2020)[20] estimates that, due to the decarbonisation imperative, an ever-increasing portion of our energy use will come from electricity. It estimates that electricity as a proportion of total delivered energy demand will increase from 25% today to 58% by 2050. This increase in electricity demand will require significant new build of generation capacity.

42. As well as electrification, other factors influencing electricity demand over the next few decades include the prospect of new, energy intensive industry in New Zealand. For example, a large green hydrogen plant is planned for Southland[21], potentially requiring 600MW of electricity, and several data centres (20–100MW each) are likely to be built in New Zealand in coming years[22]. Tiwai Point Aluminium smelter is exploring remaining open, beyond their current closure date the end of December 2024[23]. One new large industry, such as those mentioned, would result in the need for another 6–7 wind or solar farms that can produce the equivalent generation capacity of the proposed Mt Munro wind farm.

43. The New Zealand electricity industry will therefore have three main tasks in the near future:

- Firstly, existing fossil fuel electricity generation plant (coal, gas, diesel) will have to be replaced by renewable generation as it retires (likely by 2035).
- Secondly, significant new generation will be required for a) the mass electrification of transport and industrial heat, and b) the electricity requirements of any new industry.
- And thirdly, retiring renewable plant nearing end of life will require replacement. This is difficult to quantify, as many renewable generators are likely to just have key components replaced and

[20] Transpower 2020: Whakamana i te Mauri Hiko-Empowering our Energy Future, Mar 2020, 89pp.www.transpower.co.nz/about-us/our-strategy/whakamana-i-te-mauri-hiko-empowering-our-energy-future.

[21] Stuff, 2023: Partner confidence high for Southern Green Hydrogen. Newspaper article. https://www.stuff.co.nz/southland-times/news/132145485/partner-confidence-high-for-southern-green-hydrogen

[22] Driver 2022: Aotearoa, land of the digital cloud. North and South magazine, July 2022 edition, pg44. https://northandsouth.co.nz/2022/06/12/data-farming-data-grid-new-zealand/

[23] Newsroom 2023: Tiwai smelter sees path to remain open. https://www.newsroom.co.nz/tiwai-smelter-sees-path-to-remain-until-2039

keep generating, but it could equal approximately 1–5 TWh of plant over the next 30 years.

44. There will be large increases in electricity demand resulting from the three drivers mentioned above. Estimates of demand increases vary depending on the assumptions included in various models, but all result in large increases from today's ~43TWh national annual electricity demand. Estimates of total New Zealand electricity demand range from 70TWh[9] to 80–100TWh[24] by 2050. The Climate Change Commission[9] estimates that 1 TWh of new electricity generation will be needed every year from 2026 to 2035, and will increase after that.

45. Most of this demand increase is from the electrification of the transport and industrial heat sectors (see Figure 4). Increases to base demand (due to growing population and productivity) are expected to be offset by increases in efficiency, particularly in the NZ housing stock, keeping this increase small. Base demand from increases in population and productivity is expected to rise at <1% per year, totalling a 14% increase by 2050[20]. In Transpower's modelling[20], vehicle electrification is expected to increase electricity demand by 38% by 2050, and process heat is expected to increase it by 16% which, with base increases, may result in a total increase in electricity demand of 68% by 2050 (to 70TWh).

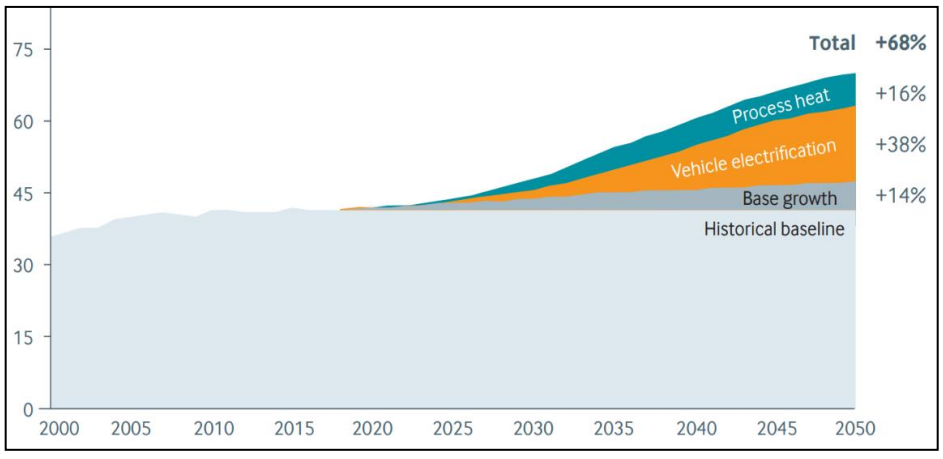

Figure 4: Electricity demand projection out to 2050, showing different drivers behind generation growth[20]

[24] Business Energy Council 2019: New Zealand Energy Scenarios TIMES-NZ 2.0, https://times.bec.org.nz/

46. New Zealand's electricity infrastructure will have to grow by approximately one to two wind or solar farms a year (the size of Mt Munro wind farm) for the next 30 years to cater for this increased demand.

New Generation Capacity Build

47. The lion's share of new generation build is projected to be wind generation, and to a lesser extent solar generation. Hydro generation capacity is not expected to increase much in the next few decades, due to the significant regulatory and policy barriers in building new large hydro schemes, as well as the difficulty in getting public acceptance for flooding land to create hydro storage lakes. Some new geothermal generation will be built, but will be limited by the small number of new sites with geothermal resource which are available for development. A projection of the potential future generation mix can be seen in Figure 5[25].

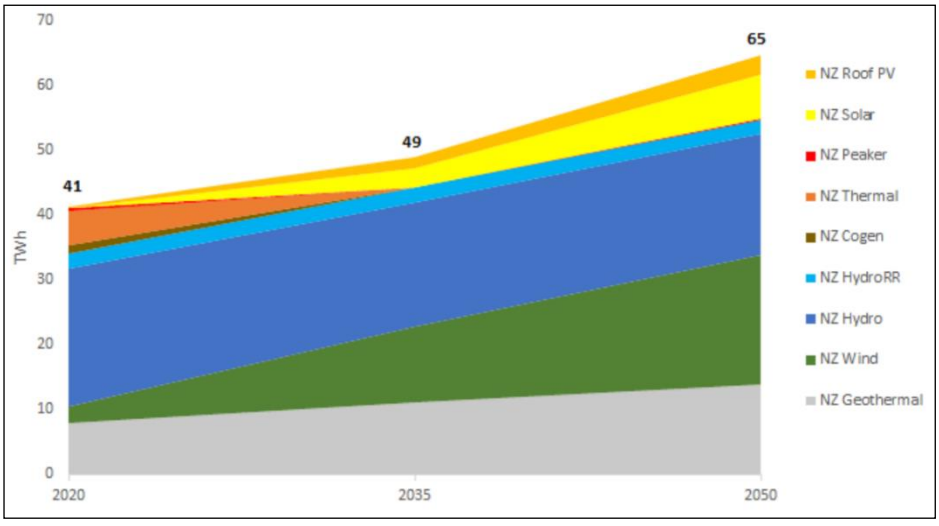

Figure 5: Projected sources of NZ electricity generation out to 2050[23].

48. In this scenario, almost half (47%) of total electricity supply comes from intermittent sources (wind and solar) by 2050. Wind generation grows by approximately 20TWh, which implies the need for an additional 66 wind farms the size of the proposed Mt Munro wind farm by 2050, or 2 new wind farms a year.

[25] MDAG 2022: Market Development Advisory Group – Price discovery under 100% renewable electricity supply – issues discussion paper, 2nd February 2022. https://www.ea.govt.nz/projects/all/pricing-in-a-renewables-based-electricity-system/consultation/price-discovery-under-100-renewable-electricity-supply/

49. Mt Munro wind farm will have a capacity of 86MW, with an estimated output of ~300GWh per year (0.3TWh/yr). This is enough to supply ~42,000 households, and is a small but significant contribution to New Zealand's required capacity increase. MBIE's Electricity Demand and Generation Scenarios (2019)[26] have several scenarios of new generation build out to 2050, each with different assumptions in their modelling. Most of their scenarios estimate 4,000MW of new wind farm capacity will be needed by 2050, which is equivalent to 44 wind farms the size of the proposed Mt Munro wind farm. With less than one wind farm a year being built in New Zealand over the last 20 years, there is some urgency around the need to build new wind farms.

50. Since the MBIE EDGS scenarios were published in 2019, there has been a proliferation of proposals to build new solar generation in New Zealand, as the Levelised Cost of Energy (LCOE) for solar generation has plummeted in recent years. Nonetheless, wind is still estimated to be predominant in new renewable energy capacity builds in New Zealand in the next couple of decades[23]. Solar and wind generation are the cheapest forms of electricity generation available, and significant capacity of these generation forms is expected to be built.

Intermittency and Firming

51. The movement of an electricity system towards 100% renewable necessitates the building of renewable generation that is inherently intermittent in its output, as it varies with the weather and time of day and year. No electricity can be generated from these sources when the wind stops blowing or the sun stops shining. Historically, thermal generation, such as coal or gas, has been turned on or off when the hydro lakes are dry or there is little wind generation. In a 100% renewable system, an alternative to this firm dispatchable thermal plant is needed. Potential solutions to firming intermittency include hydro storage, pumped storage, grid scale batteries, or demand response (reduction in usage by electricity consumers at times of shortage of supply). A diversity of generation types and geographical locations assist in firming up intermittency, to ensure generation by some plant

[26] MBIE 2019: Electricity demand and generation scenarios: Scenario and results summary, 40pp. https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-modelling/electricity-demand-and-generation-scenarios/

when other plant is not generating. Another potential solution is overbuild, where more capacity is built than is needed, so that there will be some plant generating at any given time. If overbuild is needed to counter renewable intermittency, then new capacity volumes may be much higher than currently estimated.

RESPONSE TO ISSUES IN SUBMISSIONS

52. I have reviewed the submissions on the Application which raise climate change related issues, and have provided a short response or comment on these below.

53. One submitter has stated that wind turbines are "not a renewable resource", as they cannot be built without the use of fossil fuels.[27] The inference is that the use of fossil fuels in the construction and operation of a wind farm creates GHG emissions, which cause climate change.

54. It is true that the construction and operation of a windfarm results in GHG emissions. However, there is significant evidence in the peer-reviewed literature which supports the conclusion that life cycle carbon emissions from wind farm construction, operation, and decommissioning in New Zealand are significantly net negative. That is, their existence results in far lower net emissions for New Zealand than if they had not been there.

55. There is also significant evidence globally that the emissions produced by the construction and maintenance of a wind farm are far smaller than the emissions offset by its existence, and so the construction of a windfarm will result in a net reduction of GHG emissions overall.

56. Emissions are deferred in two ways. Firstly, in the offsetting of thermal electricity generation. The US Department of Energy (**USDE**)[28] quotes a peer reviewed study that states that wind energy produces around 11 grams of CO_2 per kilowatt-hour[29] of electricity generated over its lifetime (from construction to decommissioning). A summary of 11 peer

[27] Submission 46 (Ms Rebecca Braddick-Tohiariki)

[28] US Dept Energy 2024: How wind can help us breathe easier https://www.energy.gov/eere/wind/articles/how-wind-can-help-us-breathe-easier

[29] Dolan, Stacey, and Heath, Garvin 2012 Life Cycle Greenhouse Gas Emissions of Utility-Scale Wind Power – a systematic review and harmonisation. J. of Industrial Ecology. doi.org/10.1111/j.1530-9290.2012.00464.x

reviewed studies[30] published between 2012 and 2019 put this figure at between 5 g and 26 g CO_2-equivalent/kWh.[31] This can be compared with 980 g CO_2/kWh for coal powered electricity generation and roughly 465 g CO_2/kWh for natural gas powered electricity generation. The USDE article states that shifting electricity production away from fossil generation sources to renewable sources has a significant impact on lowering CO_2 emissions from the power sector.

57. Secondly, construction of new electricity generation in New Zealand is facilitating the decarbonisation of the transport and industrial heat sectors by their electrification, thereby drastically reducing emissions from these sectors. Based on New Zealand's Emissions Reduction Plan[11], MfE projects that NZ's gross GHG emissions will have reduced by 30% by 2050, and reductions in the transport and energy sectors make up almost all of this.[32] These reductions are enabled by the construction of renewable electricity generation, such as the proposed Mt Munro windfarm.

58. Several submitters support the application on the basis that there is a need for more renewable energy to provide energy security and help NZ reach its target of 100% renewable energy.[33] I agree with these submitters.

59. The submission from the New Zealand Wind Energy Association (**NZWEA**) notes that more renewable generation is needed by 2050 for NZ to meet its climate change commitments, and the project will assist New Zealand to reach forecast demand increases.[34] NZWEA makes the point that, with an expected capacity of 90 MW, Mt Munro would represent 41% of the capacity needed to be built in 2025. This submission also highlights the benefits of onshore wind energy.

[30] Yale Climate Connections 2021 What's the carbon footprint of a wind turbine? https://yaleclimateconnections.org/2021/06/whats-the-carbon-footprint-of-a-wind-turbine/

[31] 5, 12, 26, 9, 6, 5, 11, 8, 8, 10, 9 g CO_2-equivalent/kWh respectively.

[32] CCC 2021: Ināia tonu nei: a low emissions future for Aotearoa – advice to the New Zealand Government. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa.pdf, Figure 7.5, page 105

[33] Submissions 2, 12, 59, and 52.

[34] Submission 52

60. Mr Sutherland makes the point that increasing renewable electricity generation is the "only option" for New Zealand.[35] Again, I agree with this submission.

SECTION 87F REPORT

61. I have read the section 87F report prepared for this matter, and the technical report prepared by Deborah Ryan and attached as Appendix 2 to the 87F Report. I note that Ms Ryan concurs with the conclusions and recommendations in my Report, and agrees with my statements around the importance of new renewable electricity projects to New Zealand's decarbonisation goals.

62. Ms Ryan notes at paragraph 45 of her report that there is little precedent for considering life cycle assessment of GHG emissions from a project under the RMA, as GHG emission effects of an activity on climate change have only been able to be considered since 30 November 2022. However, she considers that a high-level assessment (at least) of the potential positive and negative impacts on GHG emissions associated with the project life cycle stages would be useful, to identify whether a more detailed assessment is warranted.

63. Despite the acknowledged lack of precedent, Ms Ryan gives two examples of recent wind farm projects and how they dealt with "GHG matters". The first (Waiuku Wind Farm, Dec 2023) does not quantify GHG emissions associated with the project, but just mentions that transport emissions will be minor due to the proximity of the project to a port. The second (Te Rere Hau wind farm, Nov 2022) gives a life cycle carbon emissions assessment which covers construction, operation, and recycling of the wind farm and its components. This assessment concluded that 3.7 grams of CO_2e were emitted per kWh of electricity generated, compared to a baseline of average emissions by the grid as a whole (calculated in 2020) of 145 grams of CO_2e per kWh. This figure (3.7g) can be compared favourably with the summary of 11 global peer reviewed studies[36] mentioned in paragraph 56, above, which put this figure at between 5 g and 26 g CO_2-equivalent/kWh. Another global

[35] Submission 59

[36] Yale Climate Connections 2021 What's the carbon footprint of a wind turbine? https://yaleclimateconnections.org/2021/06/whats-the-carbon-footprint-of-a-wind-turbine/

review study[37] found life cycle carbon assessments for wind farms to be between 3 and 45 grams of CO_2e per kWh, and two New Zealand studies put that figure at 3 g[38] and 16 g[39], respectively.

64. Walmsley (2017)[40] undertook this analysis for all existing wind farms in New Zealand at the time, and found that their lifecycle carbon emissions were between 5 and 30 g CO_2e/kWh. This extensive list of New Zealand and International wind farm greenhouse gas emission assessments all fall within a narrow envelope (3 to 45 g CO_2e/kWh), which sits well below the LCA impact of coal generation plant (980 g CO_2e/kWh) and natural gas generation (465 g CO_2e/kWh), as previously mentioned. I also note in the evidence of Grant Telfar that a Life Cycle Assessment for the construction of Harapaki wind farm is underway, which will have significant parallels to likely emissions from the Mt Munro project, and that Meridian's Sustainability Management Plan for the Mt Munro project will address ways to reduce project emissions.

65. In my view lifecycle greenhouse gas emissions from wind farm construction and operation both internationally and in New Zealand are well documented, and life cycle emissions for Mt Munro wind farm are very unlikely to fall outside the above documented range of emissions (3 to 45 g CO_2e/kWh).

CONCLUSIONS

66. New Zealand has a good wind resource, and over most of New Zealand (except the north of the North Island), wind speeds are expected to increase over time due to anthropogenic climate change.

67. The proposed Mt Munro wind farm site has a good wind resource, based on 15 years of local measurements by an exploratory mast. In

[37] Dolan, S. L., & Heath, G. A. (2012). Life Cycle Greenhouse Gas Emissions of Utility-Scale Wind Power. Journal of Industrial Ecology, 16, S136-S154. doi:10.1111/j.1530-9290.2012.00464.

[38] Rule, B. M., Worth, Z. J., & Boyle, C. A. (2009). Comparison of life cycle carbon dioxide emissions and embodied energy in four renewable electricity generation technologies in New Zealand. Environmental Science & Technology, 43(16), 6406-6413

[39] Madrigal, E. 2015 Assessment of the Life Cycle-based Environmental Impacts of New Zealand Electricity – Masters thesis, Massey University. https://mro.massey.ac.nz/items/0350ba6f-5e9f-496e-85ef-6bd2c96eac80

[40] Walmsley T., Walmsley M. R. W., Atkins M., & Matthews L. Energy Return on Energy and Carbon Emissions Investments for New Zealand Wind Energy Farms, University of Waikato, 2017.

future these wind speeds are projected to get slightly faster in winter, slightly slower in summer, and to increase by about 1.3% annually by 2050. This small increase is not expected to significantly alter wind generation at the site, or result in damage to turbines.

68. New Zealand's decarbonisation strategy includes accelerated electrification, particularly of transport and industry. This electrification is projected to potentially double electricity demand by 2050, resulting in the need for significant new generation infrastructure. Projections of electricity demand vary, but all project the need for between 1 and 2 wind farms a year to be built every year from now until 2050, at least. With less than one wind farm a year being built in New Zealand over the last 20 years, there is some urgency around the need to build new wind farms to meet New Zealand's decarbonisation goals.

69. There is significant evidence in the peer-reviewed literature supporting the conclusion that life cycle carbon emissions from wind farm construction, operation, and decommissioning in New Zealand are significantly net negative. That is, their existence results in far lower net emissions for New Zealand than if they had not been there.

Jennifer Purdie

24 May 2024