TRANSPOWER

Whakamana i Te Mauri Hiko

Empowering our Energy Future

MARCH 2020

TRANSPOWER

Introducing Whakamana i te Mauri Hiko in a COVID-19 context

Over the last eight months, Transpower has been working on a refresh of its 2018 *Te Mauri Hiko – Energy Futures* paper, which set out how New Zealand's energy systems could lead the decarbonisation of New Zealand's economy.

Whakamana i te Mauri Hiko was completed in early March after a great deal of work with a range of stakeholders. *Whakamana i te Mauri Hiko* contributes to a growing consensus around New Zealand's opportunity to build a low carbon economy through our energy choices and examines the changes required to deliver it.

The release of this report has been well and truly overtaken by the rapid spread of the global pandemic COVID-19. Responding to this outbreak, while protecting the economy, is now quite rightly the single biggest concern for New Zealand.

So it may seem strange that we are choosing to release this report now and that COVID-19 is not mentioned in it. The fact it is not mentioned is evidence of how quickly this pandemic has started to impact our economy.

As an energy sector we must ensure we always deliver security of supply to our customers and the economy , particularly times such as these. At the same time, we must continue to focus on the long-term for the benefit of New Zealand.

Given the uncertainty and volatility in energy markets, and markets more generally, some of the numbers used in this report are now very difficult to predict with any confidence – such as the future oil price (which can impact relative prices for EVs) and near-term national electricity supply and demand. We have opted not to try.

We remain confident with the base case scenario upon which this report is anchored. The 'accelerated electrification' scenario estimates that electricity demand growth is relatively muted until 2025, beyond which most of New Zealand's electrification occurs, which we still believe is viable. The report makes the case that we must prepare for this future now - another reason I am sharing it with you now.

The scenario that examines the possibility of an exit of the Tiwai Point aluminium smelter can also be read as a proxy for possible energy supply and demand outcomes under conditions where the impacts of Covid-19 on energy supply and demand continue to be felt beyond 2020.

We appreciate there will be reduced appetite for this report from kiwis right now, outside of the broader energy and government sectors. Decarbonising our economy can count as a luxury when there is such an immediate threat to the economy and to public health.

However, we believe that once we have successfully navigated COVID-19 as a nation and begun to rebuild our economy, our attention will focus again on how we must mitigate the impacts of climate change on our world.

Our stakeholders and our customers expect us to manage the challenges of the short-term and the long-term on their behalf.

We offer this document in this spirit – in the commitment that when the time comes, we will be prepared and in the hope that rebuilding our economy will be undertaken hand-in-hand with the opportunity to begin decarbonising it.

Nga mihi nui

Alison Andrew Chief Executive

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APPENDIX to this report is available online at www.transpower.co.nz

All figures use rounding, so may vary slightly from expected sums.

NZ Story photo credits; Chris Sisarich – pages 57, 65, 71 and 73. ATEED page 24.

PART 1

Te Mauri Hiko

Energy Futures

Foreword

Tēnā koe

We in New Zealand face a unique opportunity to transform our country and economy through the choices we make around energy.

In June 2018, Transpower published *Te Mauri Hiko – Energy Futures* – a paper highlighting the opportunity that New Zealand has to decarbonise its economy.

Te Mauri Hiko highlighted that meeting New Zealand's international and domestic climate change commitments, and building a more sustainable future, are anchored in the ability to harness the power of renewable energy and to electrify the economy.

Nearly two years have passed since the original Te Mauri Hiko and the pace of social, political, scientific and environmental concern around climate change has continued to accelerate. At the same time, the rate of development and price reductions across a range of renewable energy technologies has continued to increase.

Over recent months New Zealand passed the Zero Carbon Act unopposed and established the Climate Change Commission. We have seen school children urging action on climate change and demonstrating how important this issue is across generations.

"We must combine our optimism with urgency."

We are seeing an accelerated shift away from fossil fuels in favour of renewable electricity, in the process heat space, as well as in the transport sector.

All these things combined give us cause for hope and optimism. There is tangible concern around the risks of climate change and more willingness to take action to cut emissions. It is now clear that affordably electrifying our economy must be a high priority in enabling New Zealand's decarbonisation.

Yet with this optimism must now come urgency, because at the same time as the opportunity to build a new, low carbon economy has never been clearer, we are not yet on track to realise it and there are many obstacles to be navigated.

Some five years after New Zealand signed up to the Paris Agreement little progress has been made against the commitment. Gross emissions continue to increase at the same time as we are experiencing accelerating signs of a warming climate. Unless there is now a major, coordinated intervention, we will not meet our commitments to reduce emissions, decarbonise the economy and will fail to do our bit to mitigate the risks of climate change.

This report is titled *Whakamana i te Mauri Hiko*: *empowering our energy future* for a reason: our focus must shift from talking about the opportunity to electrify the economy, to planning and taking the steps to drive the change required.

Whakamana i te Mauri Hiko refreshes the comprehensive modelling of New Zealand's energy sector and shows how we can effectively and affordably decarbonise it, principally through electrification. It reviews multiple scenarios and charts an updated course for how harnessing our renewable energy options can replace the burning of fossil fuels across generation, transport and process heat.

While some things have changed in the modelling, the thesis of the original Te Mauri Hiko remains intact – decarbonising our economy requires its electrification. Electrifying the economy can deliver gains across each part of the energy trilemma – delivering affordable, sustainable and reliable energy to power our lives and the economy. We must also be clear that electrification alone will not be enough. Emissions reductions and removals are required from right across the economy if we are to meet our Paris Agreement and 2050 climate change goals.

The energy scenarios modelled in *Whakamana i te Mauri Hiko* have become more aligned to what is now an emerging consensus on the role and required level of electrification in building a low carbon economy. The Productivity Commission, Ministry of Business, Innovation and Employment and New Zealand's Interim Climate Change Committee have all produced work that has a great deal in common with the key assumptions used in this document.

What's different in this report is our focus on what must now change for this vision and opportunity to be realised. We all face the risks of climate change together, as we do the opportunity to transform our economy with clean, renewable energy.

For this opportunity to be realised, action is required. From policy and regulatory regimes, to resource consenting processes, to the commitment of electricity generators, network companies, education and training institutions, Transpower and energy consumers across the economy – we all have a role to play.

While electrification can help deliver our decarbonisation commitments, we must also be clear that it cannot deliver these commitments on its own. We stand the best chance of meeting our climate change goals if every part of our economy contributes. And there is no time to waste.

The expected ramp up in electrification, and the build of new renewable electricity infrastructure is expected to start in earnest between 2025–2030. The level of investment in new renewable generation, grid connections and capacity, process heat installations, electric vehicle infrastructure and for the deployment of distributed renewables and storage, such as domestic scale photovoltaics and batteries, will represent a sustained level of infrastructure development on a scale that New Zealand has probably not seen before.

Already, we at Transpower are experiencing a significant increase in inquiries from generation developers wishing to build new renewable projects. We will welcome and support them to help ensure the delivery of our new energy future. We must ensure building renewable energy projects in New Zealand and then connecting to consumers is simple, streamlined and encouraged by our policy and regulatory regimes. Policy and regulatory changes are now required to ensure this happens in a timely, efficient and cost-effective way.

Whakamana i te Mauri Hiko tells us that we must start now if we are to be ready to deliver the unprecedented level of investment required from the middle of this decade onwards. We must all be ready – policy makers, regulators, consenting authorities, our workforce, the electricity industry and Transpower – to enable this to occur efficiently and effectively.

For our part, Transpower offers *Whakamana i te Mauri Hiko* as a contribution to the work that must be undertaken across the electricity supply and demand sectors. It seeks to highlight how we must work together to drive change and deliver a low carbon economy for New Zealand, and how we must combine our optimism with urgency. We will continue to take a whole-of-system, integrated view of the energy sector at the same time as focusing squarely on ensuring changes to enable rapid, easy connection of renewable energy projects to the grid and to ensure the main, interconnected grid can accommodate this supply and match it to enhanced demand flowing from electrification.

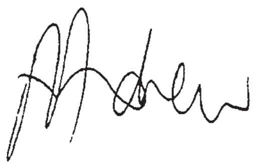
We also acknowledge that there are things Transpower needs to change, particularly in the way we work, the information we share, how we share it, and the speed with which we operate.

One of the most important steps we are already taking is in developing an Integrated System Plan – a long-term, integrated roadmap for the most efficient development of the energy sector consistent with an electrified, low carbon future.

Where external factors may impede Transpower's ability to connect new customers at the pace which is needed for decarbonisation, we must advocate for new approaches. That is one of the purposes of this document.

Alongside advocating for change where we need it, Transpower's commitment is to ensure New Zealand's grid is ready to connect and deliver a low carbon economy for New Zealand; an economy that benefits consumers, communities and our natural environment.

Ngā mihi nui,



Alison Andrew Chief Executive

About this report

The conversation around our energy future must now be continuous. It must also drive action. Technology, and our understanding of how our future is likely to unfold, is now moving at such a rate that we cannot sit still and rely on analysis undertaken last year or the year before.

> **"The Committee has identified accelerated electrification as a major opportunity to more rapidly reduce greenhouse gas emissions"**
>
> ICCC's Accelerated Electrification report, April 2019

We started updating 2018's original Te Mauri Hiko just a year after its release, by which time it was already in need of a refresh. Over that year we engaged with the electricity sector and a wide range of industry stakeholders. We consulted transmission operators in other parts of the world from whom we learned a great deal. As we shared our observations, we listened to different perspectives and experiences which we have taken on board and reflected in this document.

Whakamana i Te Mauri Hiko provides an update on assumptions and modelling with a much greater focus on Transpower's work programme to enable New Zealand's energy future. The report also focuses on a range of policy, regulatory and market changes that are barriers to, or enablers of, the electrification of the New Zealand economy.

In the separate appendix is the technical data that underpins the assumptions and recommendations in the report. We have included all of the modelling data, methodologies and assumptions in the interests of transparency and continued discussion and engagement with the sector and our stakeholders.

The electricity industry can be complicated. To help readers in connecting some measurements with tangible examples, one terawatt hour of electricity demand (1 TWh) is approximately the same amount of electricity as consumed by 150,000 average households in a year. Similarly, one megatonne of carbon dioxide equivalent (1 $MtCO_2$-e) equates to the annual emissions of roughly 400,000 typical petrol-powered cars.

One megawatt of capacity (1 MW) is roughly enough capacity to power the average demand of 1,000 houses. One megawatt hour (MWh) is enough electricity to power the average demand of 1,000 houses for an hour.

This report can be read in parallel with Transpower's submissions to government in February 2020 on amendments to the Resource Management Act and the Ministry of Business, Innovation and Employment (MBIE)'s consultation on Accelerating Renewable Energy and Energy Efficiency. Transpower's submissions contain more detailed and specific policy and regulatory recommendations.

The purpose of this report is to reiterate the Te Mauri Hiko vision and drive direction and urgency. It also seeks to continue the important dialogue amongst the diverse stakeholders who will collectively deliver a low carbon economy for New Zealand.

We're committed to keeping talking about the issues and opportunities raised in this report. If you'd like to engage with us on any element of this report, please contact our General Manager, Strategy, Richard Hobbs on Richard.hobbs@transpower.co.nz.

Executive Summary

The essence of the original Te Mauri Hiko’s modelling and assumptions remain largely unchanged in our base case assumptions.

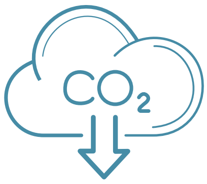
The key points underpinning *Whakamana i Te Mauri Hiko* are taken from the revised 'Accelerated Electrification' scenario's base case assumptions and estimates for New Zealand's energy future:

Our electricity system provides economic advantages

With approximately 80 per cent of electricity already generated from renewable sources, and with a wealth of future renewable options, New Zealand is well-positioned to lead the world in decarbonisation through electrification and renewable generation investment. Substituting imported oil and coal with domestic renewable electricity will deliver strong and sustained economic benefits, not least through increased energy security and significantly improved long-term balance of payments.

... And risks

Electrifying New Zealand's economy will see New Zealand more dependent on one source of energy – electricity. This concentration risk must be reflected in market and policy settings to incentivise and reward investment in a reliable and resilient electricity sector. This report continues to highlight the primary risk and challenge of meeting New Zealand's dry year risk with a weather-dependent system.



"New Zealand is well-positioned to lead the world in decarbonisation through electrification and renewable generation investment."

Electrification will drive decarbonisation

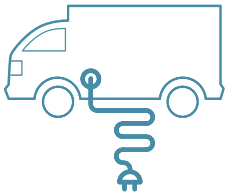
New Zealand appears to be unable to meet its climate change commitments without electrifying its economy with low-emission, renewable electricity. Nearly sixty per cent of New Zealand's total energy requirements will be from electricity in 2050, up from 25 per cent in 2016.

Electricity demand will increase by 68 per cent by 2050

Whakamana i Te Mauri Hiko estimates a 68 per cent increase in required electricity generation by 2050. This revised estimate factors in the potential for demand-side efficiency gains, particularly in process heat and transport. This estimate is broadly consistent with the assumptions and modelling from the ICCC, MBIE and Productivity Commission.

Transport and process heat must be priorities

Assuming adequate policy settings, by 2050 two thirds of New Zealand's transport energy requirements could be powered by electricity. The use of electricity in the industrial sector is estimated to almost double as a percentage of national energy demand, due to process heat electrification.



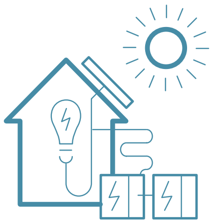
"Assuming adequate policy settings, by 2050 two thirds of New Zealand's transport energy requirements could be powered by electricity."

Renewables will dominate

Future power stations will be increasingly renewable, with new technologies and improving economics for renewables seeing 95 per cent of New Zealand's electricity generation mix renewable by 2035 and 100 per cent by 2050 in a normal year – up from approximately 80 per cent today.

A renewable future is the most affordable

Harnessing New Zealand's renewable resources will cut overall energy costs for New Zealand consumers. The average household energy bill – including transport fuels – is estimated to decline by approximately 27 per cent in real terms by 2035. As with any economic transformation, however, policy makers and the industry must work together to ensure no parts of the community are left behind.



"Harnessing New Zealand's renewable resources will cut overall energy costs for New Zealand consumers."

The Grid lies at the heart of the decarbonisation opportunity

Transpower will need to drive the development of New Zealand's national grid to enable the connections and interconnections upon which our customers and our economy depend. We will need to collaborate and plan with our customers to understand their future requirements, streamline our connections processes and improve the information we provide to prospective connectors.

Delivering this opportunity will require substantial investment

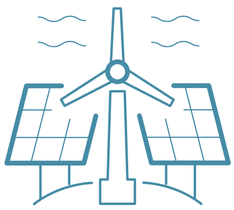
Achieving an accelerated electrification future will require 40 new grid connected generation projects by 2035, 30 connections to accommodate increased electricity demand, 10-15 new transmission interconnections and other network investments needed to enable energy to reach consumers.

Our workforce is inadequate for the future

Already there is a significant gap in New Zealand in terms of skilled workers in the electricity industry. With every sector of the industry soon to be requiring much greater volume of skilled electrical labour, immigration and vocational education settings must be adjusted to encourage and incentivise development of a highly skilled workforce in New Zealand.

Policy must be integrated, effective

Effective policy must send the right market signals to support electrification and then remove any barriers to those signals being acted upon. Currently National Policy Statements on renewable energy projects, freshwater and electricity transmission would benefit from being better connected to each other and more explicitly stating the positive benefits of renewable electricity generation, electricity transmission and hydro electricity generation to New Zealand, our economy and climate change outcomes.



... and timely and targeted

Clear, decisive policy is needed to provide investor certainty and confidence around the electrification of the economy. For example, integrated policy designed to support the electrification of transport, such as through ensuring timely price parity and smart charging for EVs, for example, can kick start a step-change in decarbonisation.

"Clear, decisive policy is needed to provide investor certainty and confidence around the electrification of the economy."

Regulatory change has a critical role to play

Regulatory change is needed to accelerate, de-risk and reduce costs of consenting new renewable generation projects, their associated transmission investments, and remove disadvantages on 'first mover' renewable generation or process heat investors requiring grid connections. Resource Management Act (RMA) reform is critical as continued consenting delays will compromise our ability to meet New Zealand's climate change targets.

Regulators need clearer direction on climate change

Transpower is regulated by the New Zealand Commerce Commission and the Electricity Authority. Transpower believes the Commission requires clearer direction on the treatment of long-term projects that are directly associated with delivering benefits in a climate change context. Under current regulatory settings there is inadequate recognition of the benefits of emissions reductions. Similarly, the Electricity Authority has not yet been provided with a clear enough mandate to explicitly focus on the benefits of climate change outcomes.

Market settings matter

The New Zealand electricity market has generally worked well over the past 20 years. It has evolved significantly over that time and is likely to continue to evolve to reflect and support New Zealand's energy transition. Given the speed of change, particular focus will need to be applied to ensure future market changes can occur in a timely way in order to support decarbonisation.

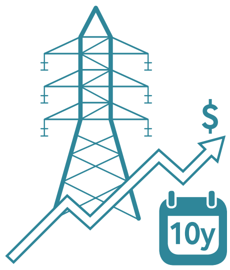
"Meeting New Zealand's winter peak demand periods is an ongoing challenge for the secure supply of electricity."

Electricity pricing must enable effective peak / demand-side management

Meeting New Zealand's winter peak demand periods is an ongoing challenge for the secure supply of electricity. As more intermittent renewable generation introduces more volatility and complexity to the system, it is critical that the market is able to deliver clear price signals to energy users for demand-side management. A market that is able to deliver clear demand-side signals to enable peak management will be important. Markets and pricing signals for distributed energy resources must incentivise residential and commercial consumers to contribute to peak demand solutions.

Electricity networks are vital

New Zealand has 29 regional electricity distribution businesses that take electricity from the grid to distribute to local households and businesses. These networks must ensure they invest adequately in order to be ready to deliver a markedly different energy future – one in which electric vehicles must be able to shift energy consumption away from peaks, local process heat applications switch to electricity, batteries are embedded inside the network and more distributed energy solutions are running across the network. Much of New Zealand's electricity network is ageing and will require investment over the next 10 years in order to be up to the task of delivering secure, reliable energy under a new energy future.



Much of New Zealand's electricity network is ageing and will require investment over the next ten years in order to be up to the task of delivering secure, reliable energy under a new energy future.

New Zealand needs an Integrated System Plan (ISP) to guide decarbonisation

A clearly articulated whole-of-system plan for the electricity grid is vital to bringing New Zealand's energy sector together around a clear, common vision and context. ISPs are common in other countries and developing a robust ISP for New Zealand is required now. Transpower is currently developing an Integrated System Plan titled 'Net Zero Grid Pathways'.

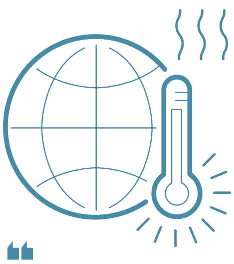
Meeting our climate change commitments

One of the purposes of *Whakamana i Te Mauri Hiko* is to contribute to generating some clarity and direction in a highly uncertain future as to what we need to deliver to meet our climate change commitments.

New Zealand has two principal climate change commitments:

- Our Paris commitment: A 30 per cent reduction of gross greenhouse gas emissions below 2005 levels (or 11 per cent below 1990 levels) for the period 2021-2030.
- Our domestic 'net zero' commitment: Net zero emissions of all greenhouse gases other than biogenic methane by 2050.

These are challenging targets that will require a transformation of our economy and how we generate and consume energy. Emissions reductions from outside the energy sector, particularly using forestry to absorb and store atmospheric carbon, have a critical role to play, but is outside the scope of this document.



"Our domestic 'net zero' commitment: Net zero emissions of all greenhouse gases other than biogenic methane by 2050."

For both targets, particularly the longer-term net zero target, electrification of the economy is critical, though many other steps will also need to be taken, including harnessing biomass and hydrogen.

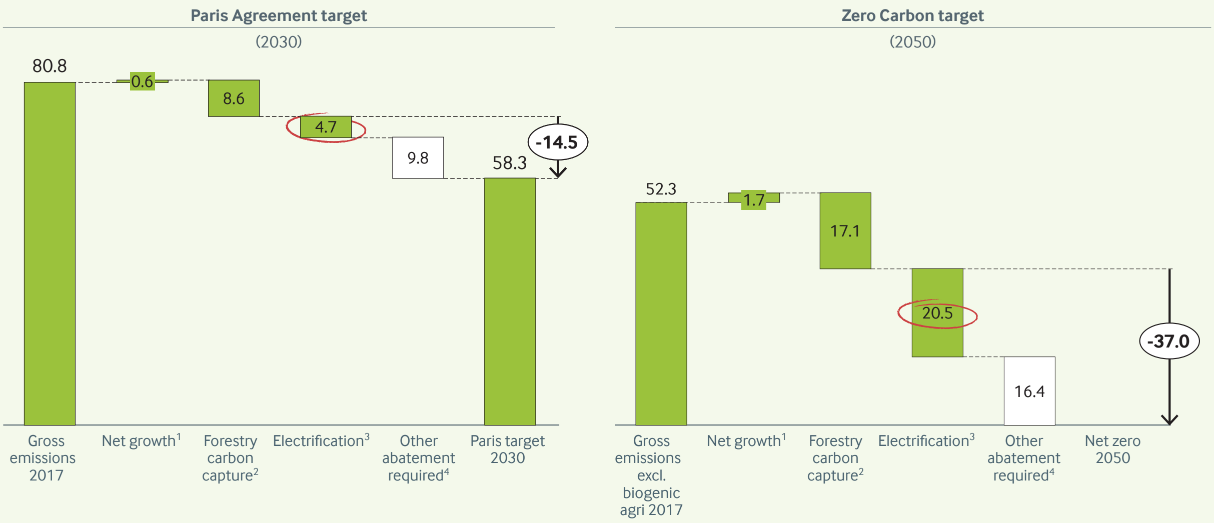
Even with base case electrification and widespread forestry abatement, there is still a large gap in terms of emissions reductions and every contribution will count and must be encouraged. Regardless, for New Zealand's net zero target, the single most material step that New Zealand can take now is beginning the electrification of our economy.

Figures 1 and 2 demonstrate *Whakamana i Te Mauri Hiko*'s base case contribution of electrification towards New Zealand's climate change targets, the size of the emissions reductions gap, as well as the estimated cumulative emissions reductions from the processes of electrification and increasing the volume of renewable electricity.

Electrification provides material emissions reductions towards meeting New Zealand's 2030 and 2050 targets

Figure 1: **Contribution to emissions targets**

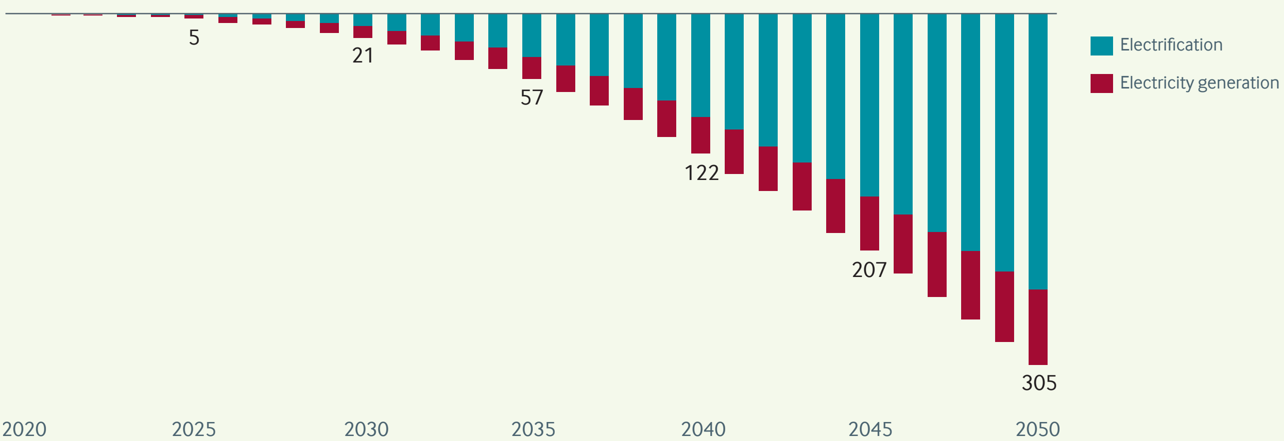
(MT CO_2e)



[1] Net growth is composed of additional energy requirements in transport and process heat combined with efficiency gains from delivering those energy requirements with improving fossil fuel technologies;
[2] MfE forecast of forestry carbon sequestration recognised under Paris Agreement in 2030 extended to 2050 based on planting an estimated 0.6m additional forestry hectares;
[3] Emissions reduction from electrification estimated in Whakamana i Te Mauri Hiko base case;
[4] Abatement required from other sources required to achieve each target.

Figure 2: **Cumulative energy sector emissions relative to 2020**

(MT CO_2e, Accelerated Electrification)



How we think about our energy future

Whakamana i Te Mauri Hiko represents thorough exploration of potential energy futures out to 2050. The work has been undertaken by Transpower's people, supported by consultants and experts. The work has involved a great deal of conversation with New Zealand's energy sector, including market participants, customers and government agencies.

Transpower has also engaged at length with various other national grid operators in other parts of the world. Other grid operators have reported to us that they are already receiving a significant increase in grid connections with some acknowledging that they have been unprepared for substantially more renewable energy projects and have inadvertently blocked or delayed the development of these projects as a result.

Whakamana i Te Mauri Hiko has developed a range of possible energy scenarios, factoring in different social and economic contexts both domestically and globally. It has mapped supply and demand estimates for each scenario out to 2050 and estimated how energy demand will shift and be met. This includes modelling around required transmission investment that directly contributes to Transpower's strategy and planning processes.

As the original *Te Mauri Hiko* stated in 2018, no scenario planning 30 years out will be entirely accurate, but there has been a robust process of detailed exploration, analysis and modelling that underpins these scenarios and estimates. The fact that the assumptions in the base case scenario in particular supports the supply and demand assumptions of other organisations further increases our confidence around the integrity of the scenarios.

Our energy scenarios

Whakamana i Te Mauri Hiko is largely focused on our primary base case scenario,

titled
'Accelerated Electrification'.

Part of the value of constantly reviewing our energy assumptions is that we gain increasing confidence in our modelling and the data and developments that support it.

The base case: 'Accelerated Electrification'

Accelerated Electrification presents a realistic yet aspirational scenario for the New Zealand economy and electricity industry. It anticipates a large-scale transformation that will require integrated, coordinated planning and action from across the economy and government.

Accelerated Electrification was developed as the base case as it appears to be the most likely. It envisions a generally positive global context: growing political and social pressure to decarbonise, and electrification being supported by the New Zealand government as a high priority means of decarbonising the economy. It also reflects a continuation of expected trends and changes and no sharp social or economic disruptions.

The scenario assumes that government policy will evolve to support electrification but has not assumed any specific policies and does not depend on the adoption of any one policy change. The underlying economic, technological and social forces promoting widespread adoption of electric vehicles and electrifying process heat are strong.

Accelerated Electrification assumes a strong role for increasing energy efficiency, smart demand solutions to assist in managing peak demand and increasing levels of solar and accompanying battery installations. It estimates a reduced electrical intensity of New Zealand's gross domestic product by 1.7 per cent per annum.

The outcomes of achieving an Accelerated Electrification future are very positive: the development of a genuinely low carbon economy, reduced household expenditure on energy, significantly improved terms of trade and using the New Zealand brand to showcase to the world how to lead the response to climate change.

This is the scenario that Transpower is using to ensure our organisation is working towards a single view of our energy future, and which is being integrated into Transpower's strategic and operational planning processes.

Electric 'Tiwai Exit'

The Tiwai Point aluminium smelter is New Zealand's largest electricity consumer. Directly connected to the Manapouri Hydro Power Station as well as to the South Island's transmission grid, Tiwai uses approximately 12 per cent of New Zealand's total annual electricity demand.

In late 2019, the Tiwai Point aluminium smelter announced it was considering exiting New Zealand. This scenario is based on this possibility making a large volume of South Island renewable electricity supply available for increased electrification.

The scenario assumes the same context as the Accelerated Electrification base case with the only difference being Tiwai's staggered exit between 2021 and 2025 and the requirement to expand transmission capacity to move more electricity north to sources of demand.

At the time of producing this report there is some uncertainty around the aluminium smelter's long-term commitment to New Zealand. Transpower is prepared for the possibility that the smelter chooses to exit New Zealand and is clear on the investment requirements. Planning in terms of how to move surplus energy north is well developed.

Higher electricity demand: 'Mobilise to Decarbonise'

The Mobilise to Decarbonise scenario was developed to test a range of uncertainties that could result in higher demand for electricity than set out in the base case.

The assumptions behind the scenario is that the world is 'sitting on its hands', 'on a track to a climate disaster'. The scenario assumes that at some point the world gets serious and moves into rapid action. When this occurs, we will mobilise and the response to climate change will be much stronger and urgent. It is not the rate of development of technologies that will change under this scenario, but rather the strength of the decarbonisation effort.

The Mobilise scenario sees significant efforts to reduce activity that changes the climate. That is distinct from efforts to continue current activities in a less damaging way.

The Mobilise to Decarbonise scenario assumes that New Zealand emerges as an international 'safe haven.' The country's economic performance is stronger than in the base case and, as a result, more attractive policy incentives for decarbonisation are adopted sooner.

Slower case: 'Measured Action'

The 'Measured Action' scenario tests a variant of the base case in which slower electrification of transport is realised. It assumes the same context as the base case with the only difference being electric vehicle adoption occurring more slowly.

This scenario could emerge if battery technology development stalled, global supply chain issues emerged, counter-productive government policy was introduced or if regulatory settings failed to encourage electric vehicle uptake.

While charging infrastructure challenges can be rapidly overcome, delayed regulatory impediments could provide a material block to EV adoption. This is a principle risk highlighted in this scenario.

Similarly, EV adoption is hampered in the scenario by the possibility of both supply and demand-side obstacles.

Lower case: 'Business as Usual'

The 'Business as Usual' scenario was developed to test a future in which significant electrification fails to eventuate.

This scenario envisions a future in which other policy mechanisms to manage the effects of carbon, such as forestry abatement, are prioritised over emissions reduction via electrification.

Reduced economic and policy incentives to electrify, combined with slower than expected technology development, results in lower levels of electrification of transport and process heat.

Supply and demand: what does our base case energy future look like?

The foundations of *Whakamana i Te Mauri Hiko* are our view of what New Zealand's energy supply and demand mix looks like and how it is most likely to change over the next 30 years.

'Supply' and 'demand' are commonly-used concepts. Throughout this document when we use the term 'demand' we are really talking about energy volume – the volume of energy required to meet consumer and system requirements and ensure reliability.

Supply and demand modelling 30 years into the future in a world of rapid technology change and social, economic and political uncertainties is a process that is mostly science, supplemented with some art. The purpose is not to try to get things precisely 'right' – rather the purpose is about developing and articulating the understanding and most likely set of outcomes at the time based on the very best understanding and analysis.

The way we seek to understand our future must be a constant process of updating, evaluation, learning and actively contributing to a broader body of work.

Electricity demand growth

In planning for how the electricity network will need to evolve, we must understand electricity supply and demand growth.

Under the Accelerated Electrification base case, demand growth is primarily influenced by population growth, electricity consumption per person (including as a result of switching away from fossil fuels) and increasing electrical efficiency. The electrification of process heat and transport, in conjunction with a growing population, contributes to a 68 per cent increase in electricity demand from 42 TWh in 2020 to 70 TWh by 2050.

Meeting peak demand will be covered in more detail later in this report but it is important to note that while electricity demand is estimated to increase by 68 per cent, peak demand only increases by 40 per cent, reflecting the increasingly important role of demand response solutions.

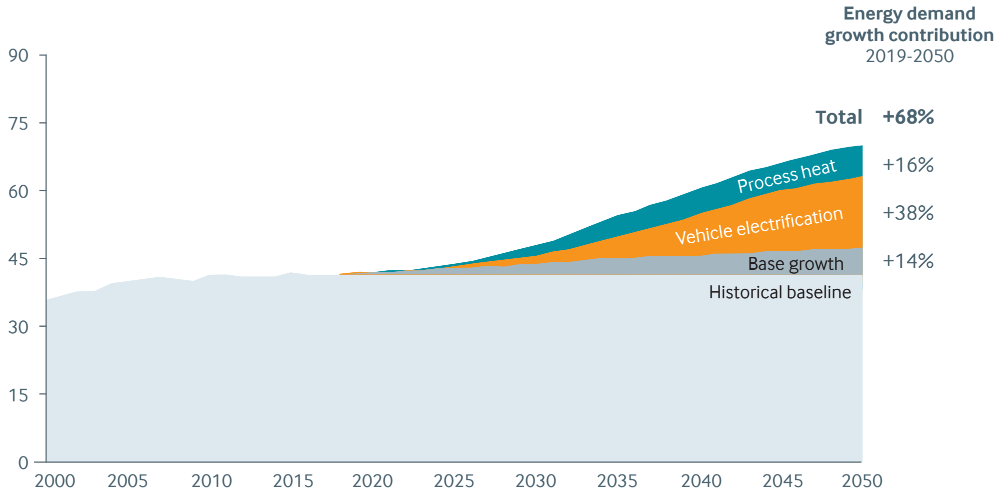
The 'ramp'

Whakamana i Te Mauri Hiko refers to the 68 per cent growth in energy demand between now and 2050 as 'the ramp'. Figure 3 shows why. The ramp in energy demand is slow in the five years between 2020 and 2025, from 42 to 44 TWh, but materially grows in the 2025–2030 period, in which total energy demand increases by approximately 10 per cent from 44 to 48 TWh.

The Accelerated Electrification base case estimates sustained, strong growth in electricity demand between 2025 and 2050, driven primarily by transport electrification and then the electrification of process heat.

Figure 3: **Gross energy demand**

(TWh, Accelerated Electrification)



> **Base case estimates energy demand grows by 68% with over half of growth contributed by vehicle electrification**

It's timely to look at both energy efficiency and electrical efficiency here. Despite assumptions around positive economic performance and population, base electricity demand growth – ignoring possible gains from fuel switching – out to 2050 is largely flat. This is a consequence of increasing efficiency balancing out energy growth as a result of a growing economy.

The base case assumes a much greater contribution from energy efficiency initiatives than in the original Te Mauri Hiko, and these assumptions flow through into reductions of energy and peak demand.

As a result of energy efficiency, New Zealand will do more with energy in 2050 but will also require less fuel to do it. Technology already allows electrical energy to be converted into heat and transport energy with much greater efficiency than technologies requiring the burning of fossil fuels. Technology enabling even more efficient conversion of electricity to energy is estimated to only increase over the next 30 years.

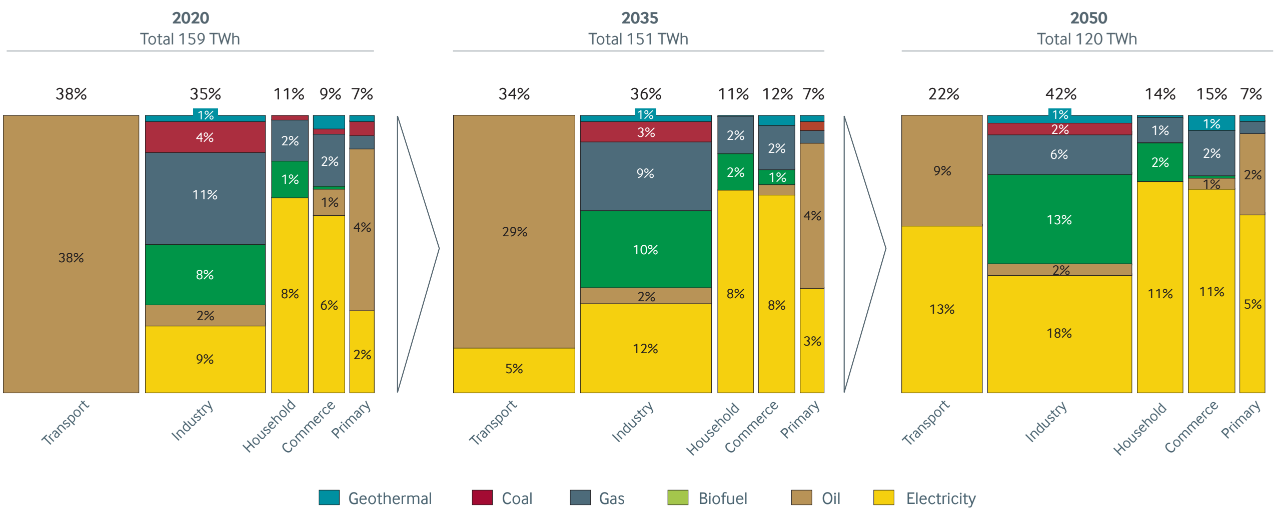
By way of a current example, a typical car with a two litre internal combustion engine requires 77 kWh of petrol to drive 100 kilometres, while a Nissan Leaf electric vehicle (EV) requires only 16 kWh of electricity to cover the same distance – it's nearly five times as energy efficient.

Similarly, a heat pump heating 100 litres of water to 100°C requires 3 kWh of electricity but requires 12 kWh of coal or natural gas to deliver the same result.


Destination
Scheduled
Due
Papakura/N 0956 14
Papakura/N 1016 34
GI=via Glen Innes /N=via Newmarket /LS=Limited Stops C=Cancelled *=Arrival due/departing
5

Figure 4 shows how New Zealand's energy mix could be electrified by 2050. Electricity demand as a proportion of total delivered energy demand is estimated to increase from 25 per cent today to 58 per cent by 2050. Note, other fuel switching possibilities such as coal to gas, gas to hydrogen, and the use of biomass/biofuel have not been considered in this analysis but will have a role to play in the displacement of fossil fuels out to 2050. Efficiency improvements in the use of fossil fuels such as hybrid vehicles and the use of waste heat recovery all have contributions to make in meeting our emissions targets.

Figure 4: **Estimated delivered energy demand share by type and sector**



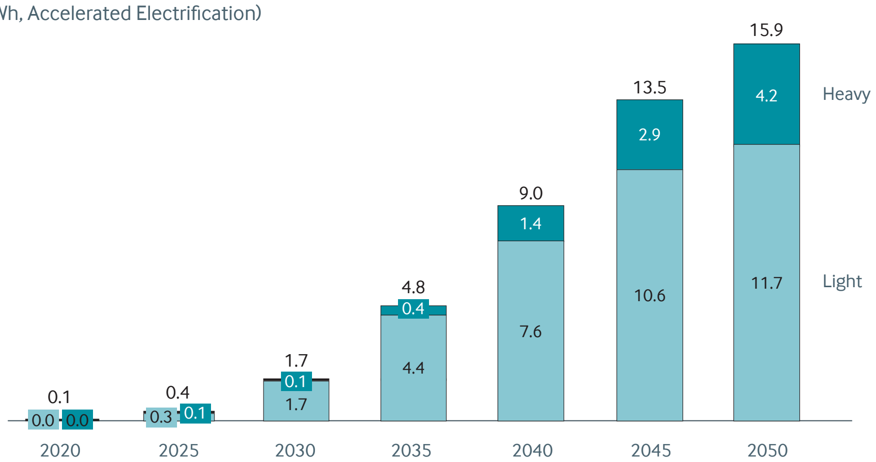
Electrification of transport

The two areas that drive the most carbon reductions in *Whakamana i Te Mauri Hiko*'s base case are the electrification of transport and process heat. Given how critical these two areas are to New Zealand's energy future, we take a closer look at each of them here.

Transport is currently dominated by fossil fuels and accounts for approximately 40 per cent of all of the delivered energy in New Zealand. *Whakamana i Te Mauri Hiko*'s base case estimates that electrification of light land and heavy transport has the potential to increase electricity demand by 5 TWh by 2035 and 16 TWh by 2050.

Figure 5: Transport electricity demand by type

(TWh, Accelerated Electrification)

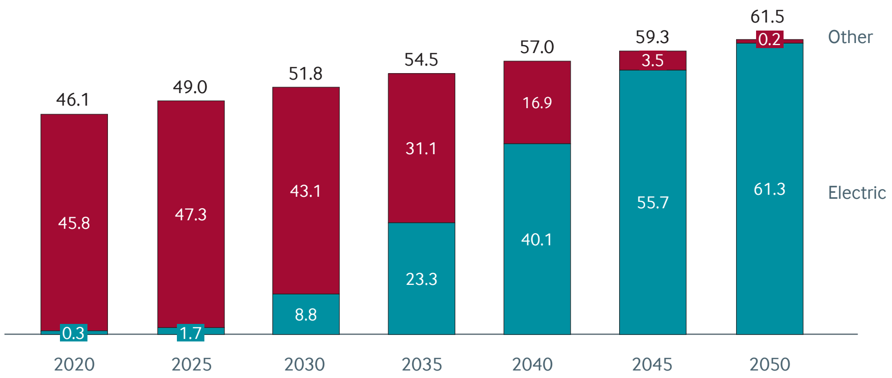


Light vehicles

The electrification of light vehicles is already underway, but is expected to ramp up in earnest in the late 2020s and early 2030s, requiring an additional 4 TWh of electricity by 2035 and 12 TWh by 2050. The estimated growth in energy demand is driven by the total light vehicle kilometres travelled (VKT), the improving market share of EVs and the fuel efficiency of EVs.

Figure 6: **Light transport distance travelled by fuel type**

(VKT, billions, Accelerated Electrification)



Population growth and the rise of additional delivery services such as ride share companies (Uber, Ola, Zoomy etc) are estimated to drive growth of light vehicle kilometres travelled by one per cent per annum. The improving economics of EVs relative to internal combustion engine (ICE) vehicles are estimated to accelerate the market share of EV imports to over 80 per cent by the early 2030s.

EVs are expected to reach sticker price (upfront cost) parity for large vehicles as early as 2022 in Europe. EVs already, or will soon, outperform ICE vehicles on operating costs, emissions, reliability, acceleration and sticker price, and will be comparable on many other important factors, including range and safety.

Further, the ability for EVs to reduce transport carbon emissions are assumed to be increasingly seen as an attractive opportunity for policy makers to achieve emissions reduction targets. In fact, this is not just an assumption: the United Kingdom has brought forward a ban on the sale of new petrol and diesel-powered vehicles from 2040, to 2035 at the latest. This move is in response to expert advice that the Government would fail to reach its own net zero 2050 goal unless the 2040 ban was brought forward.

EV fuel efficiency has been assumed to improve over time, partially offset by the current trend towards larger, heavier vehicles as the fleet begins to convert.

Post-2030, electricity demand from light vehicle transport is uncertain. Wider adoption of electric micro-mobility may increase the average fuel efficiency of light transport by substituting cars with electric scooters, bikes, and other small vehicles which may in turn increase total vehicle kilometres travelled.

Autonomous vehicles have the potential to reduce the cost of light vehicle transport, increasing vehicle kilometres travelled, while also improving the convenience of shared transport, which reduces vehicle kilometres travelled. Emissions from the production of autonomous vehicles is also likely to be lower than for conventional vehicles. Further, the potential of emerging technologies such as virtual reality, flying public and private vehicles and the use of electricity to power marine transport have the potential to materially change how people access services and the energy required for transport.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3707
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Heavy vehicles

In *Whakamana i Te Mauri Hiko*'s base case, heavy land transport is estimated to contribute 0.4 TWh of electricity demand by 2035 and 4 TWh by 2050. The electrification of heavy vehicles is expected to lag the electrification of light vehicles but will likely still result in increased electricity demand. This is likely to start with electrification of buses which is already occuring.

Heavy vehicles are more difficult to electrify because freight requires a large range and payload capacity to be economically attractive. An electric truck with a large range would require a very large battery with current battery power densities which would reduce the size of the available payload and impact the economics. The reduced payload may be partially offset by a differential road user charge (RUC), but it is unclear when power densities will make electric heavy trucking economically viable.

Hydrogen fuel cells offer a renewable solution to heavy transport in the medium-term but require twice the electricity to generate the hydrogen through electrolysis compared to a heavy electric truck. One area in which hydrogen-powered heavy vehicles may contribute is in high-payload, long-distance freight where a denser fuel like hydrogen may be more suited.

If cheap electricity is readily available due to the overbuilding of renewable generation, for example, hydrogen-powered heavy vehicles may be an increasingly attractive and viable solution.

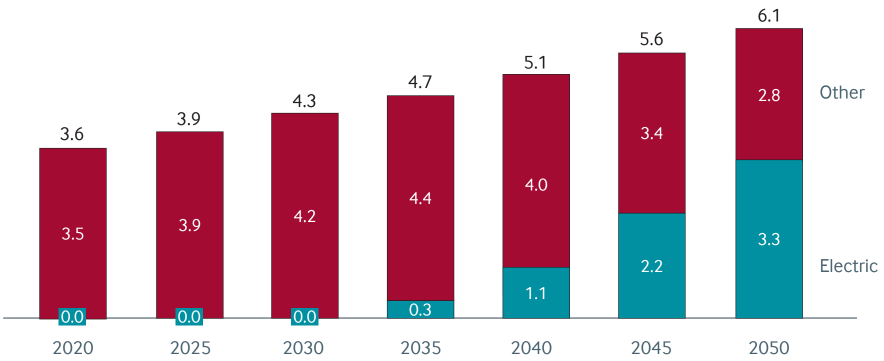
One important challenge for hydrogen-based heavy vehicles is that scale in light electric vehicles and battery production will likely reduce the capital and operating costs of heavy EVs over hydrogen-powered heavy vehicles.

Biofuels could also become a green fuel for heavy trucking in future and there is already a biodiesel production facility in South Auckland converting tallow to renewable diesel, although the economics are challenging. Biofuels are possible as a transition technology between current fossil fuels and the widespread adoption of electrification and hydrogen.

While we may see electrification of light sea and air travel by 2050, this report has not actively considered electrification of heavy sea and air travel, which is more uncertain and unlikely to create material demand within the next 10-15 years. However, it is assumed that heavy transport, particularly road transport, will increasingly electrify post-2030.

Figure 7: **Heavy transport distance travelled by fuel type**

(VKT, billions, Accelerated Electrification)



Electrification of process heat

Process heat – heat used for industrial processes, such as manufacturing – accounts for 36 per cent of all delivered energy in New Zealand's energy sector, including water and space heating from residential and commercial sectors. Process heat contributes eight per cent of New Zealand's total greenhouse gas emissions.

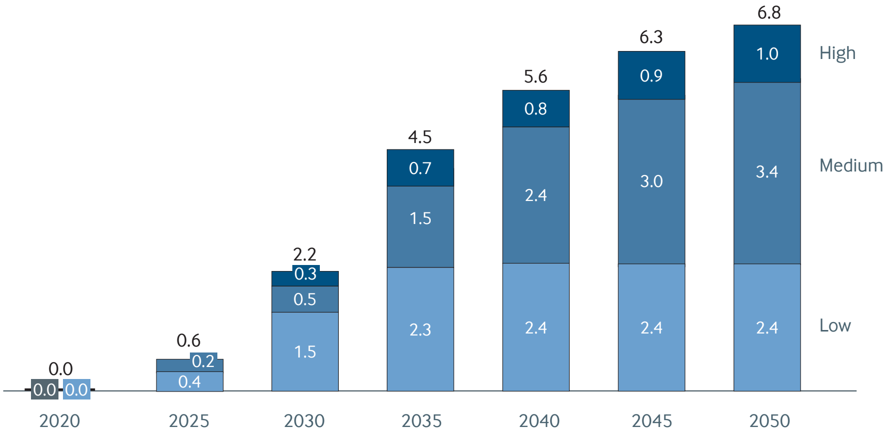
New Zealand's top five energy-consuming industrial processes are petroleum refining, pulp and paper, dairy production, timber processing, and metal manufacturing.

Process heat is commonly divided into low, medium and high-grade heat. Low-grade heat is classified as heat for processes which do not exceed 100°C; medium-grade heat is between 100°C and 300°C and high-grade heat exceeds 300°C. The majority of process heat energy across all grades is currently met by burning gas and coal, with a material contribution from biomass where it is an available by-product of nearby processes.

In the base case, *Whakamana i Te Mauri Hiko* estimates that electricity demand from process heat could grow to 2.2 TWh by 2030, 5.6 TWh by 2040 and 6.8 TWh by 2050.

Figure 8: **Process heat energy demand by temperature**

(TWh, Accelerated Electrification)



Electrification is expected to be driven by falling costs and improved performance of electric heat pumps and boilers for higher heat applications, stronger incentives for manufacturers, increasing pressure from consumers and increasing fossil fuel and carbon prices.

Economic solutions for electrifying low and medium grade heat are available today and solutions for high grade heat are emerging. High Temperature Heat Pumps (HTHPs) can supply low and some medium-grade heat and are becoming increasingly economic as the coefficient of energy performance between electric heat and coal/gas heat improves. The cost of these heat pumps are falling as units are produced at scale, as new technologies are commercialised, and as installation practices become standardised.

South Island industry is expected to lead the country in the adoption of electrified process heat due to its lack of a reticulated gas network. Without gas, industry mostly relies on coal as the main fuel for process heat. Assumptions in this report are that it will become increasingly difficult to use coal beyond 2030 due to a combination of rising carbon prices, social and environmental pressures, and company sustainability commitments.

The electrification of process heat is already underway. For example, Synlait commissioned its first electric boiler in its South Island plant in 2019.

Electricity supply growth and a shifting generation mix

Whakamana i Te Mauri Hiko has modelled a future demand scenario that is supported by a range of other modelling and analysis. However we must also explore how that demand is most likely to be met.

A step change of investment in renewable electricity generation and accompanying grid connections and interconnections will be needed to deliver the volume demanded in the base case scenario.

This investment must ensure reliable cover for New Zealand's winter evening peaks and dry years and provide greater levels of resilience and cover to an economy that will be increasingly dependent on electricity. It must achieve these outcomes while some of the traditional baseload thermal power stations, which have backed up our hydro-dominated system, are progressively phased out of the market and replaced with peaking capacity.

Whakamana i Te Mauri Hiko estimates that, under the base case, the combination of distributed generation and storage (such as batteries), the improving economics of wind and solar generation, the phase out of coal generation, and the availability of new geothermal and low levels of new hydro generation will combine to deliver an electricity supply system that is 95 per cent renewable in 2035 and 100 per cent renewable in a normal year by 2050. This is discussed further in the section *'Achieving 100 per cent renewable electricity'*.

Alongside the phase out of baseload thermal plant in favour of flexible gas-fired peaking capacity, other elements of New Zealand's current electricity generation mix are likely to shift markedly as increasing volumes of new generation come from new sources, such as utility solar and batteries. While the bulk of electricity generation projects will remain grid connected, we expect increasing volumes to come from smaller-scale generation, such as wind and solar, embedded in distribution networks and solar installations on residential and commercial roofs.

New Zealand's electricity mix will become much more diverse. Without considering possible hydrology changes as a result of climate change, *Whakamana i Te Mauri Hiko* estimates hydro generation to stay largely static out to 2050. In the context of a growing overall market, hydro is estimated to drop to 36 per cent of New Zealand's electricity mix, increasing its value in meeting peak demand.

Geothermal generation increases incrementally to 18 per cent, wind generation grows rapidly to comprise 28 per cent, solar makes up 13 per cent of the market and five per cent comes from other 'on demand' sources (assumed to be a mix of biomass, hydrogen, cogeneration, or other renewables with pumped hydro energy storage). Gas generation using carbon capture and storage is not an assumption in the modelling but is a possible option for emissions reduction out to 2050.

The figures below chart the estimated electricity supply and capacity mix by type over time to 2050.

Figure 9: **Delivered electricity by generation type**

(TWh, Accelerated Electrification)

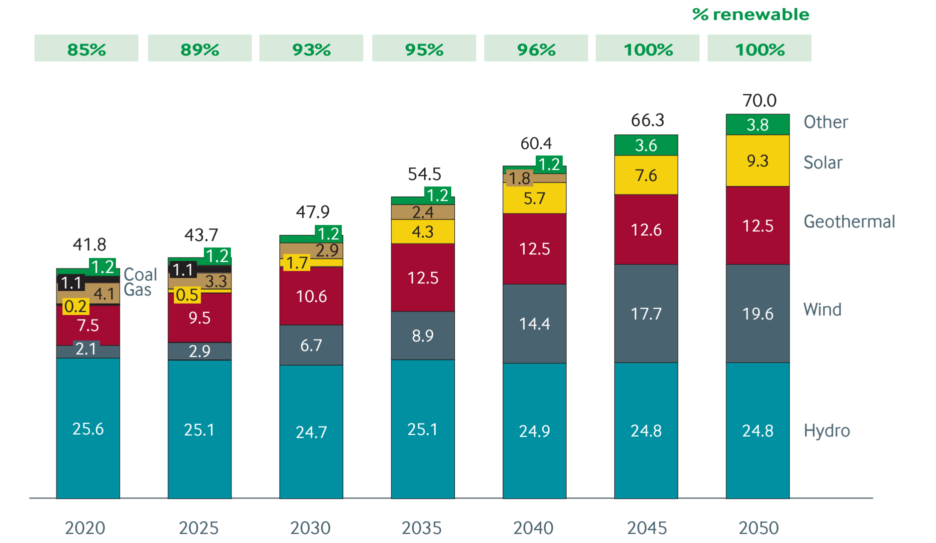
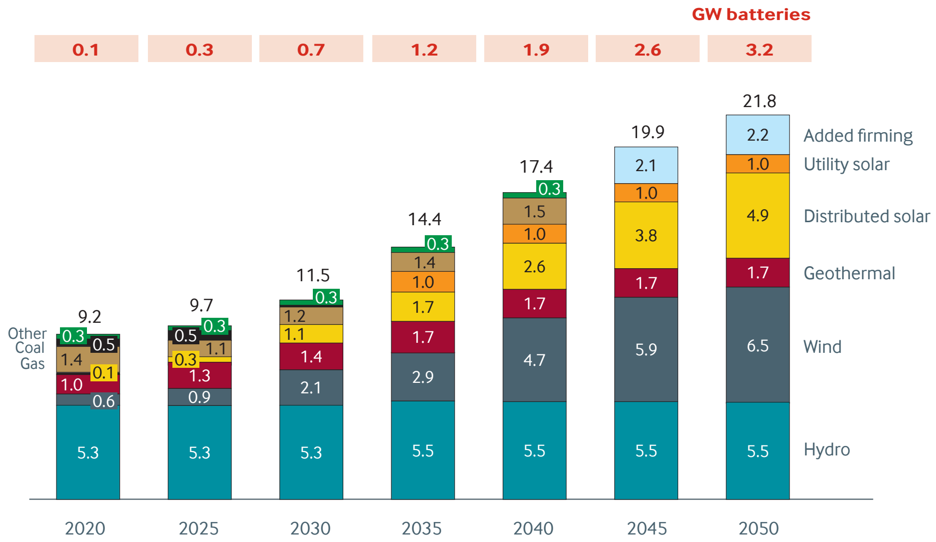


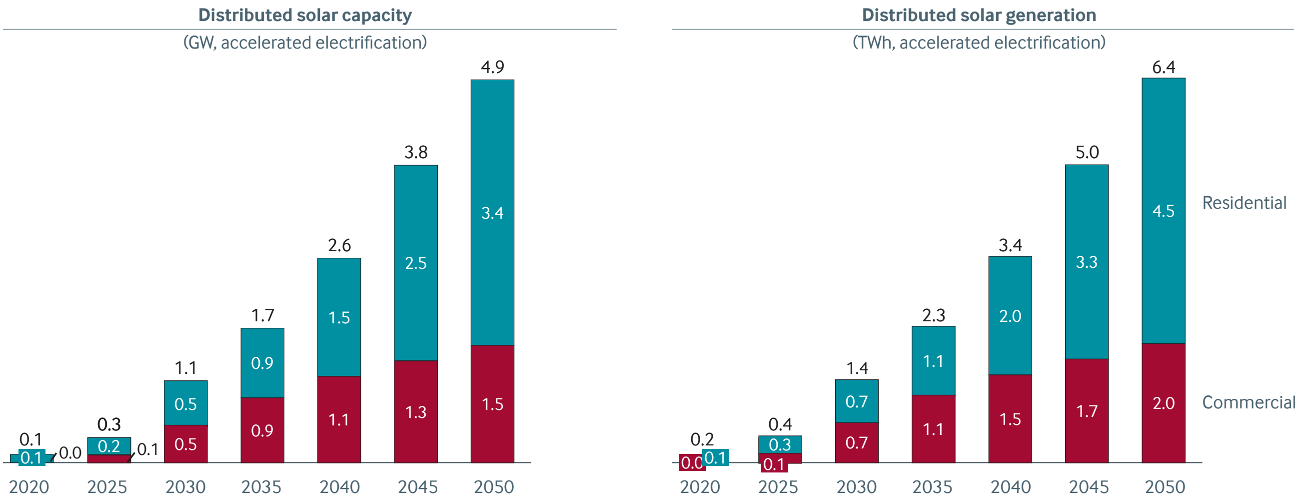
Figure 10: **Generation capacity by type**

(GW, Accelerated Electrification)



The base case estimates that distributed solar PV generation reaches 2 TWh by 2035 and 6 TWh by 2050. Distributed solar uptake is expected to be driven by the continued falling cost of solar panels, improved installation processes, economic incentives and changing social values. This is the area of the biggest adjustment from the original Te Mauri Hiko assumptions, which made an assumption that overstated the contribution from solar.

Figure 11: **Distributed solar**



As New Zealand's demand peak is in the evening, distributed solar is less economically attractive to consumers unless deployed alongside battery storage. This paper assumes partial parallel deployment of distributed solar with battery capacity.

Batteries

Storage allows for wind and solar that is produced off-peak and in excess of demand to be stored in batteries and released to meet peak demand. Although not currently without cost and technology challenges, batteries are assumed to emerge as a significant opportunity for meeting New Zealand's energy storage challenge and contributing to daily peak demand periods.

In addition to EV batteries, 750 MW of distributed battery storage within electricity networks is estimated to be deployed by 2035, growing to 2,500 MW by 2050. *Whakamana i Te Mauri Hiko*'s base case assumes that, from 2032, 30 per cent of households with solar PV panels install an 8 kW distributed battery to enhance the economics of consumers' solar investments.

Uptake of distributed batteries is expected to be supported by ongoing cost reductions from $2,200 per kW today to $1,500 in 2035 and $1,000 in 2050.

The base case also estimates that 400 MW of utility scale batteries will be deployed by 2035, growing to 700 MW by 2040, beyond which Transpower sees greater uncertainty about which technologies will meet storage and capacity needs. Utility scale batteries are attractive from a system and investor perspective for several reasons. First, utility scale batteries enable intermittent generation developers to 'time-shift' their off-peak generation into the peak in order to earn a higher price.

Second, batteries provide a wide range of services that provide an economic return, including managing peaks, deferral of transmission and distribution investments, and ancillary services such as supporting system stability.

Third, utility scale battery costs are expected to reduce by five per cent per year, becoming viable for deployment in the late 2020s.

Achieving 100 per cent renewable electricity

Whakamana i Te Mauri Hiko estimates approximately 95 per cent renewable electricity by 2035 and 100 per cent by 2050, in a normal year. It's important to be clear on what exactly 100 per cent renewable means, what is required to reach it and what it might cost.

Whakamana i Te Mauri Hiko's modelling estimates that by 2035, approximately 400 MW of baseload gas-fired electricity generation will have been phased out of the market and replaced by four flexible 100 MW gas-fired peaking power stations. Thermal plants operating in the market will be firming an almost entirely renewable and increasingly intermittent generation base and are likely to be on standby and not generating for long periods of time.

The second half of this paper dedicates some time to discussing the market settings that will need to exist to support having gas-fired peaking capacity in the market, even when it is not running.

Getting to 95 per cent renewable generation by 2035 is challenging but achievable. It also represents the lowest cost generation mix for consumers. However, getting from 95 per cent to 100 per cent renewable electricity by 2050 will be highly challenging and potentially expensive.

This paper is not advocating for any one approach but seeks to raise a range of factors to consider and to highlight the current uncertainties in meeting this challenge.

There is an important distinction between 'renewable' and 'zero emission'. For example, gas-fired peaking plants could still be in operation in 2050 using developing carbon capture and storage technology – this would not be renewable, but it would be zero emission.

As hydrogen technology is developed there is the future potential to run peaking capacity on 'green hydrogen' created from renewable electricity.

The second half of this paper focuses in some depth on the challenges of meeting both daily peak demand and the dry year risk, which is currently a feature and ongoing challenge of our electricity system.

With greater levels of intermittent generation on the system – primarily wind and solar – one way to meet dry year risk is to 'overbuild' renewable capacity to ensure reliability. This has not been costed but is likely to be a very expensive solution that fails to address the reliability challenges with weather-dependent energy; however, as the price of renewable energy continues to drop – again, particularly for the likes of solar and wind – this may yet become a cost-effective solution.

Our hydro-electricity base will be a significant part of the solution. As the generation portfolio grows and evolves, hydro generation is assumed to play less of the baseload generation role that it has played to date, and more of a role in using stored water to meet peaks.

Batteries at both a utility and distributed scale will have an important contribution to make in terms of ability to store energy to meet daily peaks, but face challenges in terms of meeting dry year demand.

Biomass is a possibility. In the UK, the Drax Power Station has installed capacity of 3,906 MW and three quarters of that capacity runs on biomass in the form of compressed wood pellets. The power station produces approximately 12 per cent of the UK's renewable electricity, with these pellets imported from the United States. Drax is also trialling carbon capture and storage which, if effective, could see the power station achieve carbon negative status.

As New Zealand commits to significant forestry as a source of carbon abatement there is the opportunity to harness a growing domestic supply of renewable biomass.

There are other alternative technical solutions which should be considered but which are highly uncertain. Longer-term chemical storage solutions may be developed, such as longer duration batteries and hydrogen storage as ammonia, but technical and commercial viability is currently unclear.

The purpose of *Whakamana i Te Mauri Hiko* is not to back certain generation projects over others. Rather it seeks to provide analysis of potential options that could contribute to decarbonising our economy. In this spirit, we cannot rule out the potentially game-changing contribution of new large-scale hydro generation. Expensive and with obvious environmental impacts, a large pumped hydro storage scheme could be developed which could materially assist in reaching 100 per cent renewable generation and meeting peak demand and dry year challenges.

Such a development would almost certainly require government intervention to make possible.

Other genuinely disruptive options might emerge but are highly uncertain, for example connecting New Zealand and Australia's electricity grids, nanotechnology-based solar generation and re-engineered photosynthesis to create liquid fuels.

Affordability

Electrification of the economy can play a vital role in reaching our climate change targets, and we can estimate how our energy sector might change to deliver it, but at what cost? The conversation around moving from 95 per cent renewable in 2035 to 100 per cent in 2050 brings this into sharp focus.

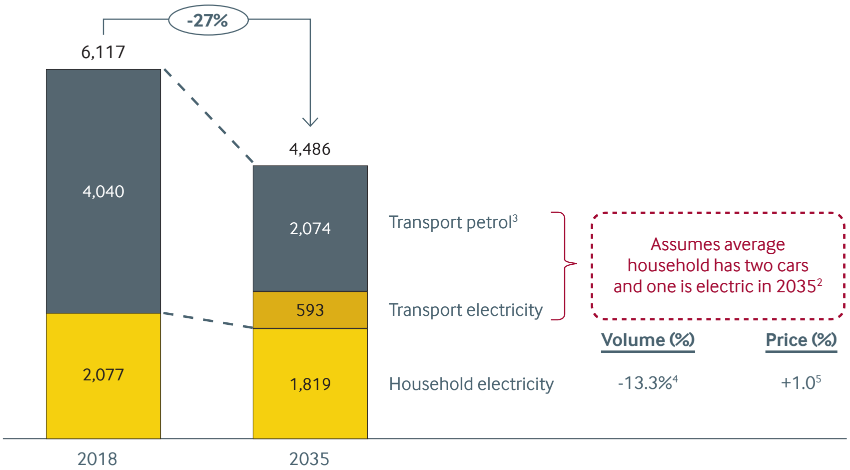
Electrification is only likely to occur if electricity is affordable and competitive against other forms of energy. *Whakamana i Te Mauri Hiko* acknowledges that the price of energy is a strong social and political concern and that this is unlikely to change.

While the future price of electricity is uncertain, *Whakamana i Te Mauri Hiko* notes that its base case for New Zealand's emerging generation mix is similar to that of the ICCC's 'Accelerated Electrification' scenario which estimated that future residential electricity prices should remain approximately the same as they are today out to 2035.

> **Electrification of household transport and efficiency gains reduce the average household energy bill by 27% by 2035**

Figure 12: **Estimated average annual household energy costs[1] in 2035**

($2018, real)



1 Assumes average household uses two petrol cars in 2018 and does not have reticulated gas in the home.
2 Assumes average household has one EV and one petrol car, broadly in line with forecast of 43% of VKT being electric in 2035.
3 Assumes a $50/T CO2e carbon cost which increases price by $0.06 assuming 2.3 kg CO2 emissions per L of petrol combusted, no other price increase considered, assumes 9.5L/100km travelled, excludes commercial VKT.
4 Assumes historical household electricity efficiency reductions continue at a CAGR of -0.6% per annum.
5 Assumes a 1% increase in electricity price, consistent with ICCC estimates.

Whakamana i Te Mauri Hiko's base case is that electrification will lead to significantly lower overall energy costs for consumers by 2035. Electrification of a typical household – four people, two cars (of which one is electric) – factoring in flat petrol prices, rising carbon prices, increasing electrical efficiency, the rise of EV ownership and relatively static electricity prices, is estimated to see a 27 per cent reduction in overall household energy costs by 2035.

Ensuring energy affordability is a core pillar of the energy trilemma and *Whakamana i Te Mauri Hiko*'s estimates around energy affordability reflect the need for different ways of thinking about energy. As the economy electrifies it will be important that the focus of consumers and policy makers is on *integrated energy costs* rather than considering different forms of energy in isolation. This shift is already occurring as consumers start to move towards EVs given the significant cost benefits of powering their transport requirements with electricity over petrol and diesel.

A 'just transition'

A large-scale energy and economic transformation as outlined in *Whakamana i Te Mauri Hiko*'s base case represents a unique opportunity for New Zealand. Electrification presents the most likely way to significantly reduce average household energy costs. Electricity represents the lowest likely source of energy for many industries.

As with any large-scale transformation, however, care must be taken to ensure the benefits of electrification are equitably shared and that sections of our community are not left behind or inadvertently disadvantaged.

One area that will require particular focus for policy makers and the energy sector is around peak energy demand management. If electric vehicles cause peak demand to increase at a rate that is faster than energy demand, the additional costs of meeting this peak demand will be shared across all consumers, including those in energy poverty, who may be unable to afford an electric vehicle. However, if peak energy demand management is enabled through smart charging and price signals, and peak demand does not grow as fast as energy demand, this will lead to higher utilisation of network infrastructure which will benefit all consumers.

From a policy perspective, mandatory EV smart charging is a very good example of the need for an equitable approach. Mandatory smart EV charging will be critical because it will alleviate the risk that a group of less price sensitive consumers might choose to continue to charge their EVs during peak demand periods, despite higher prices. This would trigger unnecessary network investment, potentially drive higher peak energy costs and compromise security of supply – the costs of which are spread across all consumers.

Clear pricing signals will be required to enable effective peak demand management, including from distributed energy resources. It will also be important that the financial benefits of being able to respond to these market signals are not isolated to the early adopters of technology – for example, those who are able to invest early in domestic batteries, EVs and smart charging infrastructure.

We must also not lose sight of the industrial sector in this transition. We note the Interim Climate Change Committee (ICCC)'s estimate of modest electricity price increases in the industrial sector out to 2035 under its base case scenario. While there are potentially significant cost benefits from energy efficiency and electrification to industry, care must also be taken that international competitiveness of trade exposed industries is protected through the transition period.

Alternative scenarios

Whakamana i Te Mauri Hiko is clear on its Accelerated Electrification base case scenario as the most likely outcome for New Zealand's energy future.

There is still a great deal of uncertainty and the process of scenario development allows us to explore the implications of that uncertainty and identify how plans might need to be adapted as the future unfolds.

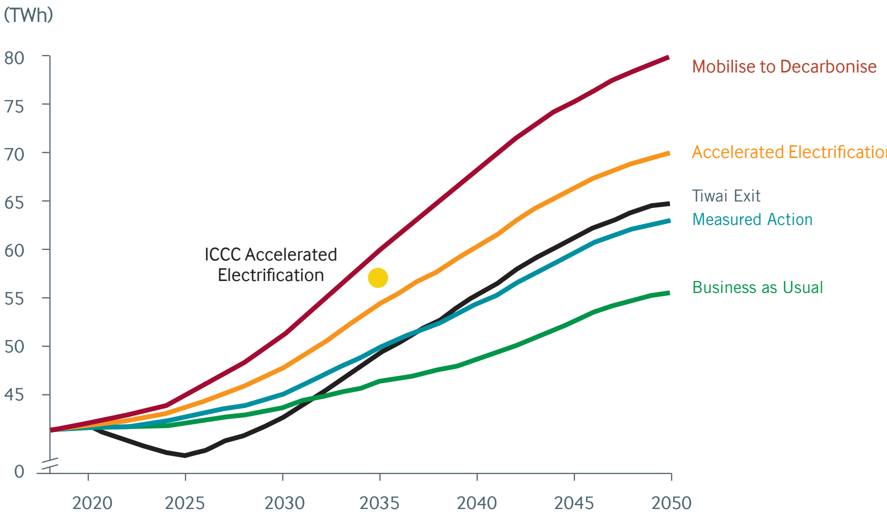
Whakamana i Te Mauri Hiko has developed four additional alternative scenarios to ensure a robust examination of a wide range of possible electricity futures.

Under all scenarios, *Whakamana i Te Mauri Hiko* anticipates a material transformation of New Zealand's energy sector. The scenario analysis finds that annual electricity demand could range from ~56 TWh in 2050 in 'Business as Usual' to ~80 TWh in 2050 in 'Mobilise to Decarbonise', which is approximately equivalent to compound annual growth rates of 0.9-2.1 per cent from today's gross demand.

Figure 13 illustrates the electricity demand assumptions for each of the scenarios, also noting the Interim Independent Climate Change Committee's estimate of electricity demand by 2035.

Transpower's modelled futures range from 56-80 TWh of gross demand by 2050.

Figure 13: **Electricity demand assumptions for each scenario**



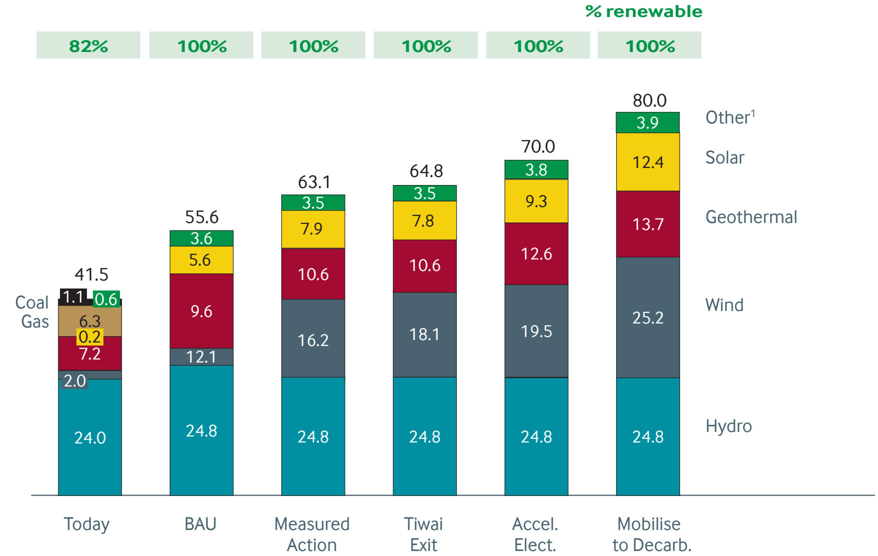
Across the scenarios, differences in gross demand estimates are largely driven by different assumptions regarding EV and process heat electrification rates and underlying population and economic growth rates. One scenario deals with the possibility of the Tiwai Point aluminium smelter exiting New Zealand as the key variable of the base case assumptions.

Under all scenarios, New Zealand will need to build material new utility-scale wind and solar generation, and accessible battery storage in order to meet annual and peak demand growth in normal years.

The figures below illustrate the estimated electricity supply and capacity mix by type at 2050 for all scenarios.

Figure 14: **Delivered electricity by generation type**

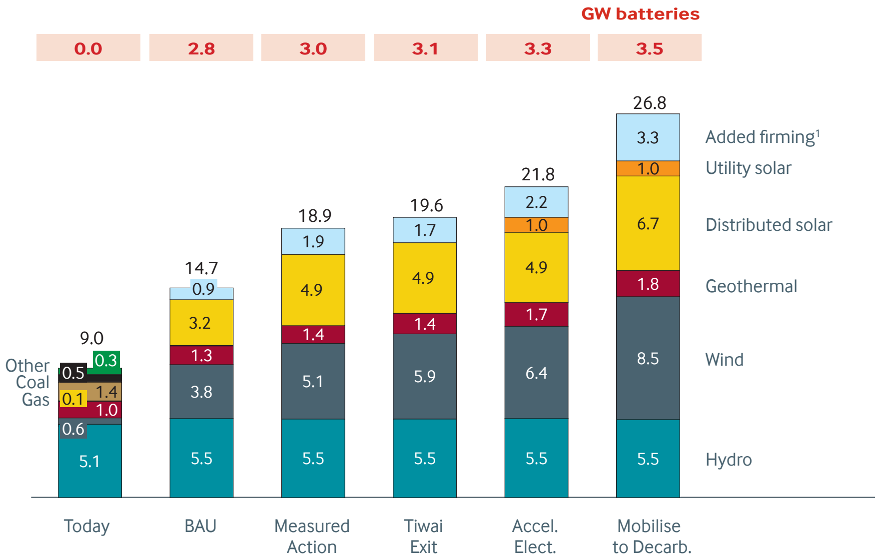
(TWh, 2050)



[1] Other energy beyond 2040 is assumed to be supplied by a mix of biomass, hydrogen, cogeneration, gas with carbon capture and storage, or other renewables with pumped hydro energy storage

Figure 15: **Generation capacity by type**

(GW, 2050)



[1] Meeting peaks will require a mix of firming technologies including distributed and utility batteries, cogeneration, pumped storage, hydrogen based thermal plants, or gas with carbon capture and storage

Hydro continues to contribute a large share of annual electricity supply across all scenarios, reducing from 58 per cent of supply today to between 44 per cent by 2050 in Business as Usual and 31 per cent in Mobilise to Decarbonise.

New wind and solar generation provides the main sources of variable electricity supply growing by between 10 to 23 TWh for wind by 2050 and five to 12 TWh for solar by 2050.

Some gas is retained under all scenarios in 2035 to contribute to peaking and dry year supply security. By 2035, gas is estimated to reduce from 15 per cent of annual electricity supply today to three per cent in Business as Usual and five per cent in Mobilise to Decarbonise. The modelling assumes the phase out of approximately 400 MW of baseload gas at Taranaki Combined Cycle (TCC), replaced by the build of four 100 MW flexible, open-cycle gas-fired peaking power stations in the base case.

Figure 16 sets out the electricity demand estimates by scenario.

Figure 16: **Gross electricity demand breakdown by scenario**

2050	Business as Usual	Measured Action	Tiwai Exit	Accelerated Electrification	Mobilise to Decarbonise
Gross electricity demand	**55.6**	**63.1**	**64.8**	**70.0**	**80.0**
Process Heat	3.3	6.8	6.8	6.8	9.3
Transport electrification	9.1	11.8	15.9	15.9	17.9
Base demand growth	1.7	3.0	0.6	5.8	11.3
Historical electricity demand	41.5	41.5	41.5	41.5	41.5

From the 'what' to the 'how'

This section of *Whakamana i Te Mauri Hiko* has set out what we believe the most likely configuration of New Zealand's energy future could look like. It charts the possible evolution of electricity in decarbonising our economy and breaks down the most likely contributions from different energy and technology sources.

The following section sets out what needs to be done and what needs to be changed to realise this future.

PART 2

Whakamana i Te Mauri Hiko

Empowering our Energy Future

The need for action and ownership

Decarbonising our economy through our energy choices will require intensive collaboration, planning and action. It will require a constructive working relationship guided by a common vision between the industry, consumers, regulators and the Government. It will require the right market design to guide investment.

It will require a great deal of investment but, perhaps above all, it will require courage and leadership. Each part of the industry will need to take ownership for ensuring their part of the electricity industry is well-prepared to develop the infrastructure to enable decarbonisation. Sustained investment will be required across each part of the electricity value chain – if one part of the chain is not ready, the risk is that we will all move at the slowest pace.

We must collectively and as individual organisations take responsibility for ensuring that obstacles to decarbonisation are removed and the right incentives are in place.

With the ramp in demand now less than five years out, and with possible thermal plant retirement on the horizon, the focus now must be on taking action to ensure the ramp is met with minimal disruption.

Never before has leadership from the electricity sector been more pivotal to New Zealand's social, environmental and economic future.

This section of the report is focused on 'empowering our energy future'. It focuses on what we believe must change to enable decarbonisation and it commits Transpower to action around the things it can control and contribute to.

On those issues that are not necessarily within Transpower's control, we commit to constructive, clear advocacy and the sharing of information in service of realising our energy future.

Building our low carbon infrastructure – grid connections and upgrades

Meeting the *Whakamana i Te Mauri Hiko* base case will involve a sustained high volume of investment and construction in the sector, as well as action from consumers.

Transpower is committed to being transparent and direct about what it must deliver.

Our most recent modelling estimates that by 2035 approximately 40 new power stations (including five large-scale battery installations) will need to be connected to the grid. This equates to nearly 5 GW of new grid connected generation at a roughly estimated cost of approximately $8 -10 billion, including transmission connection costs. To put this in perspective, as much generation will need to be built in the next 15 years as was built in the past 40 years.

Approximately 70 new grid scale connections will be required over the same period: 40 to connect the new power stations and 30 connections to accommodate increased electricity demand on the grid due to electrification.

This represents an average of close to five new connections per year, a significant increase above the connection workload that Transpower has delivered over the last 30 years.

This energy transformation is not theoretical - it is already happening. Over the last year, Transpower has experienced a surge in connection requests, including significant levels of international inquiry from potential generation developers interested in investing here.

On top of this investment, *Whakamana i Te Mauri Hiko* identifies that there will need to be 10-15 large interconnection (grid upgrade) projects by 2035 to accommodate the increase in both demand and supply.

Transpower's required planning horizon is 15 years, yet the demand, investment and build ramp is 2025–2030. The whole period 2020-2030 is a growth period – investments over the next five years will be required to ensure the 2025-2030 ramp is smoothly executed and positions New Zealand well to continue the journey to a low carbon future by 2050. Failing to make the right investments over the next five years could see the investment requirements between 2025-2030 falter, compromising New Zealand's decarbonisation programme or requiring more aggressive, disruptive decarbonisation later on.

Building a strong grid to deliver a renewable future

Building new grid connections or upgrading existing connections will only solve part of the challenge Transpower faces. Transpower will also need to ensure that the grid that transports power from generators to consumers is reinforced to support decarbonisation, rather than impede it.

A grid interconnection is built with the same components as a grid connection (lines and substations) but their purpose is different. Where connections serve one clearly-defined customer or group of customers, interconnections link different parts of the grid together, enabling more electricity to flow efficiently through it and benefit connected parties across a much wider area.

Of Transpower's 10 -15 forecast interconnection projects out to 2035, seven are major interconnection upgrades across the backbone of the grid, which require Commerce Commission approval and are discussed in Transpower's Transmission Planning Report.

On top of these seven large-scale grid upgrades, between three and eight regional transmission upgrades are also likely to be required. The smaller, regional interconnection projects are widely ranged as they will be contingent on how demand and supply grows across the regions. Regional interconnection projects are sensitive to the decisions of generators and load centres in their area.

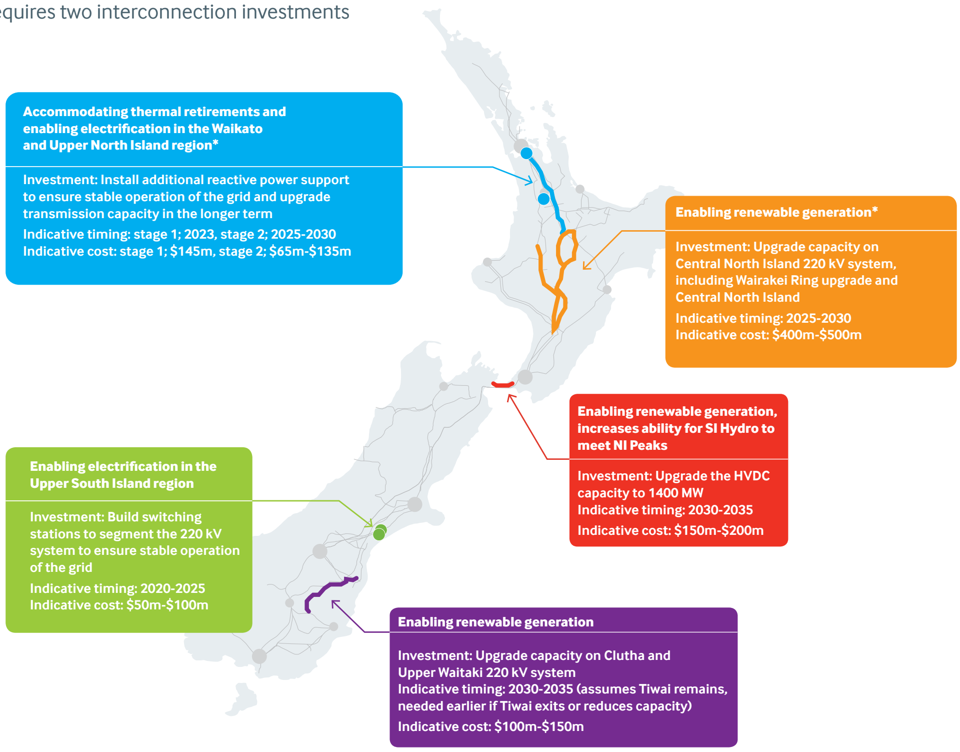
For *Whakamana i Te Mauri Hiko*'s base case, Transpower conducted a high-level load-flow analysis to determine interconnection requirements and identified interconnection projects that are likely to be required over the next 15 years.

Combined with new and upgraded connections to the grid, these seven 'grid backbone' interconnection projects lie at the heart of Transpower enabling the realisation of *Whakamana i Te Mauri Hiko*'s base case of Accelerated Electrification.

Figure 17 shows the locations of each of these interconnections and provides an overview of what each involves, what the likely timing requirement is and the approximate cost of each.

Figure 17: **Interconnection project descriptions and locations**

* Requires two interconnection investments



The interconnections have been staged to ensure the grid can sustain growing electricity flows without over-investing and creating unnecessary costs, which would ultimately fall on the consumer.

The total amount of money available to Transpower for these investments is determined by the Commerce Commission and the proportions that are paid by each connected party are determined by the Transmission Pricing Methodology (TPM), determined by the Electricity Authority.

The total cost estimate for these 10-15 interconnection projects is between $1 billion and $1.5 billion, with each of the projects forecast to be completed within the next 15 years.

If we are to see the electrification of the New Zealand economy with a 68 per cent increase in electricity volumes by 2050, these investments will be critical to enabling the additional electricity to move smoothly across the grid to consumers.

The need for interconnections is not new to Transpower, and the key projects that will enable New Zealand's transition to a low carbon future are at different stages of planning or delivery, however, *Whakamana i Te Mauri Hiko*'s base case has heightened the urgency.

Transpower must move quickly to ensure the grid meets the standard required to deliver New Zealand's future electricity needs and does not stall or inhibit the rest of the country's efforts towards achieving net zero carbon.

The order of grid upgrades

The role of the grid is to move electricity from generation sources to consumers. Historically New Zealand has generated most of its electricity from South Island hydro and the role of the grid has been to deliver it to North Island load centres.

Somewhat counterintuitively, grid investment typically moves from North to South to enable this northward energy flow. Removing transmission bottlenecks close to load centres and moving grid upgrades progressively from the North to the South has historically been the most effective way to sequence grid investments.

The potential for a Tiwai Point exit resulting in large volumes of hydro needing to be moved north would require the traditional North to South investment sequence to be flipped. In the advent that approximately 600 MW of hydro was made available to the market, the interconnection investment programme would need to be reprioritised to start at the bottom of the South and move North.

A possible Tiwai Point exit would represent both some challenges and opportunities. Transmission upgrades to get surplus hydro out of the South Island to North Island demand centres are already well in the planning phase and there are also opportunities to electrify coal-fired process heat applications in the lower South Island.

Transpower is actively planning for *Whakamana i Te Mauri Hiko*'s base case scenario estimates, however it continues to plan and prepare for other scenarios in order to be able to rapidly respond to significant changes in market conditions.

What must change to deliver our energy future

This paper has articulated the potential grid investment and build requirements that Transpower will need to deliver to realise its base case. However, having a well-prepared grid alone will not ensure the contribution of the electricity industry to New Zealand's climate change commitments.

Every part of the electricity system in its broadest sense – i.e. regulators, policy makers, industry and other stakeholders – will need to carefully consider if things can be changed, accelerated, removed or enhanced in order to facilitate widespread and rapid electrification. The weakest link in the electricity supply system – those that do not invest sufficiently to enable smooth electrification – run the risk of slowing the rate of progress for all participants.

Whakamana i Te Mauri Hiko believes urgency is starting to be reflected across the sector and that a common direction for New Zealand's energy future is now established. Thanks to engagement from government, officials and regulators alike, we are currently in the middle of important consultations around the Resource Management Act and realising a renewable energy future.

The Electricity Authority is also taking the welcome step of consulting on its strategy. These consultations are identifying and discussing obstacles to the decarbonisation of our economy being realised, as well as the possible solutions.

The electricity sector is coming together, work is being done, we are having the right conversations. There is cause for optimism but, as per the theme of this paper, we must combine this optimism with urgency.

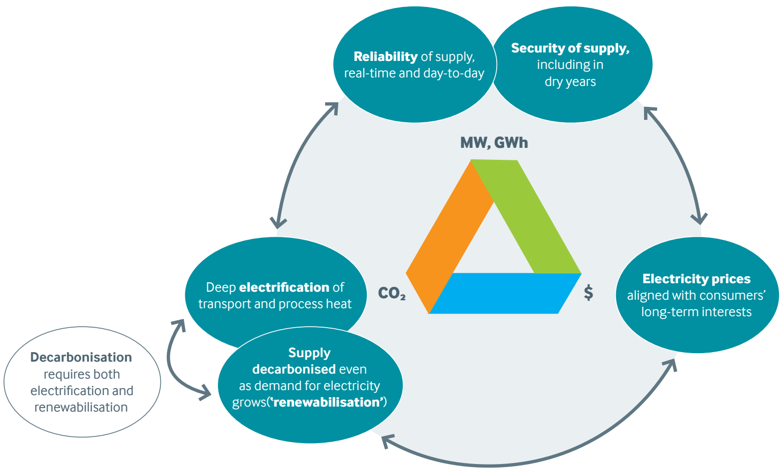
This section of the paper discusses the 10 most important changes that *Whakamana i Te Mauri Hiko* has identified as essential to enabling effective decarbonisation of our economy and the realisation of a new energy future.

Delivering our energy trilemma

Before we discuss what changes must occur, we need to be clear on what constitutes success and what does not. Decarbonisation of energy cannot be the electricity industry's only priority; nor can it be Transpower's.

While tackling the threat of climate change remains a pressing global challenge, we must also ensure that at all times we continue to provide our economy with reliable, secure supplies of electricity. We must continue to build a strong, resilient and secure electricity system at the same time as rapidly growing it to electrify our economy. At the same time energy must be affordable. This is our energy trilemma.

Figure 18: **Energy trilemma**



> **Successfully decarbonising energy requires balancing security, reliability, affordability, renewables and electrification**

Maintaining a reliable, affordable and secure supply of electricity to consumers and our economy is our industry's license to drive decarbonisation. We must continue to earn the trust and confidence of our consumers and stakeholders. In an environment in which there will be a range of increasing challenges to the operation of a stable grid – more intermittent generation, the requirement for more peaking capacity and evolving voltage and frequency impacts to manage – we must not take our eye off the ball of continued supply security even as we work to transform our energy systems.

The 10 areas of change

In a rapidly evolving context in which accelerating technology is dovetailing with growing social, political and environmental concern around climate change, the need for change is the new constant.

In seeking to generate clarity on exactly what needs to change in order to realise our new energy future, we acknowledge that we are all in this journey together. While we face challenges, particularly around dry year peaks, we also acknowledge that as a country and an industry we are in a privileged position. We have a wealth of renewable resources to work with, a high current renewable generation base and economic conditions that support investment.

We must ensure we identify and then make the changes we need in order to realise that future and make the best of the opportunity we face. There are multiple areas in which Transpower can contribute to change but we start this discussion with the items directly within our full control.

1. STREAMLINING OUR CONNECTIONS PROCESS
2. INTEGRATED SYSTEM PLANNING
3. GETTING THE INCENTIVES RIGHT FOR ELECTRIFICATION AND RENEWABLES
4. REMOVING BARRIERS TO LOW CARBON INFRASTRUCTURE
5. DEMAND-SIDE MANAGEMENT OF PEAKS
6. ENSURING GENERATION MEETS PEAKS
7. MANAGING DRY YEAR RISK
8. PROTECTING SYSTEM STABILITY
9. ACCESS TO SKILLED WORKFORCE
10. COLLABORATION

1 STREAMLINING OUR CONNECTIONS PROCESS

Streamlining the processes by which Transpower connects customers to the grid is the most obvious and immediate way that we can make changes to enable rapid decarbonisation. We can deliver a faster, easier and more-efficient connection process and are committed to doing so.

Transpower must ensure that it is ready to meet the ramp and growing complexity of generation and load connections in *Whakamana i Te Mauri Hiko*'s base case, as well as preparing for the possibility of other scenarios emerging.

Transpower's existing connection service has been developed to meet the needs of customers in a relatively stable and predictable world – one characterised by relatively low-volume, large-scale, conventional technology, long lead-times and established participants.

Until recently, most connection projects were for customers with established relationships with Transpower, who wanted to connect large projects where the cost and time required to deliver a connection was small relative to the total project cost. These customers and their projects had typically been on Transpower's radar for several years prior to project commencement.

But the needs of customers and the nature of connections are changing. Already, Transpower is experiencing increasing connection requests, and these are set to continue to increase.

How we communicate with customers and investors needs to improve. Transpower needs to improve the information that it provides the market on the connections process and provide more insight into grid performance and availability. We need to help customers and investors in enabling them to make informed investment decisions. This could take the form of highlighting where there is grid capacity in the system by region and when that is expected to either grow or reduce.

New customers such as international renewable generation investors and industrials may require additional connection services ranging from information on New Zealand's electricity system and how to connect, to a 'one stop shop' connection service which delivers everything from the generation substation through to the grid. New technologies such as solar farms, batteries and electric process heat applications will require different connections that can be delivered within tighter timeframes. Electrification will drive an increase in the number of new and upgraded Grid Exit Points required to meet rapid EV uptake.

Transpower is not standing still. An internal project has been launched to streamline the connection process and prepare the business to scale in response to the ramp. Process improvement opportunities identified are estimated to have the potential to reduce project delivery time by approximately 30 per cent, but this is just the beginning.

Building on the work completed by international network operators, Transpower will look for additional step-change improvement opportunities and will work with industry to ensure connection processes such as consenting, property acquisition and regulation avoid creating unnecessary delivery delays.

Culturally, Transpower is committed to being open, accessible and receptive to new ideas or suggestions from the industry or our customers that we are here to serve.

SPEED OF DEPLOYMENT – THE TESLA CASE STUDY

One of the drivers behind Transpower's commitment to streamlining connection processes is not just the scale of new estimated connections, but the increasing speed at which major renewable projects and energy storage projects can be deployed. We must be ready to enable these projects without delaying them.

That will require an increasingly agile, rapid approach to project execution from Transpower.

By way of an example of increasing speed of energy build, Tesla's Elon Musk promised the South Australian Government in 2017 that he would build them the world's largest utility battery within 100 days, or it would be free.

The 100 MW battery was completed in 63 days at a cost of approximately AU$90 million. We must be ready for this future.

2 INTEGRATED SYSTEM PLANNING

The scale of investment required from across the industry is unlikely to occur in the absence of an integrated whole-of-system plan – a roadmap as to how the electricity grid can evolve to achieve a decarbonised energy sector and economy

Integrated System Plans (ISPs) are common internationally. They guide investment decision making and ensure all parts of the sector have an appropriate level of clarity and insight into the operation and evolution of the broader system.

Without an ISP, we have an industry that lacks shared understanding of how the electricity system is planned to evolve, risking the possibility that an important contribution might not be made at the required time. The absence of an ISP runs the risk of an industry that can operate in silos and in ways counterproductive to decarbonisation.

With Transpower conducting the role of System Operator, as well as the body charged with highlighting emerging security of supply issues, Transpower has the whole-of-industry oversight to enable it to develop an ISP for New Zealand.

An ISP is clearly needed in New Zealand right now and Transpower is preparing it. Transpower has started the development of a 'Net Zero Grid Pathways' integrated system plan which will provide an indicative 15-year roadmap for the grid and electricity system that is consistent with a net zero carbon future.

As the industry environment becomes more dynamic, other participants will require much more information about the future shape of the grid in order to make the decisions that are important to their business. For a renewable electricity generation investor, understanding where there is capacity on grid is important.

Net Zero Grid Pathways will provide that context and data.

The intended audience of this ISP will be broader than that of Transpower's traditional Transmission Planning Report (TPR). The TPR's intended audience is planners in distribution and generation companies, and other technical members of the industry to help inform decisions. The ISP will be a relevant document for a wide range of audiences including the broader energy industry as well as political and regulatory stakeholders.

Due to the inherent uncertainty in trying to estimate what the future looks like, Transpower wishes to draw on the experience and knowledge of the broader industry to inform the assumptions that feed the planning and forecasting process. The ISP process will be targeted to a much broader audience, including customers, potential investors, regulators and political stakeholders, as well as the broader electricity industry.

The development of the Net Zero Grid Pathways plan will be an open and collaborative process that will allow Transpower to seek feedback on the assumptions that feed the system planning process and for industry to receive information about how the grid might develop in the future.

By describing how the grid and the broader industry may evolve, Net Zero Grid Pathways will give participants a view as to how their future behaviour might impact and shape the grid. This context will be useful to aid an informed industry discussion about the future development of the electricity system.

It is Transpower's intention that the proposed Net Zero Grid Pathways document would provoke the types of conversations that were prompted by the Australia Energy Market Operator (AEMO's) 2018 and 2020 Integrated System Plan (ISP) releases which have created a basis for shared understanding of the future of Australia's electricity system.

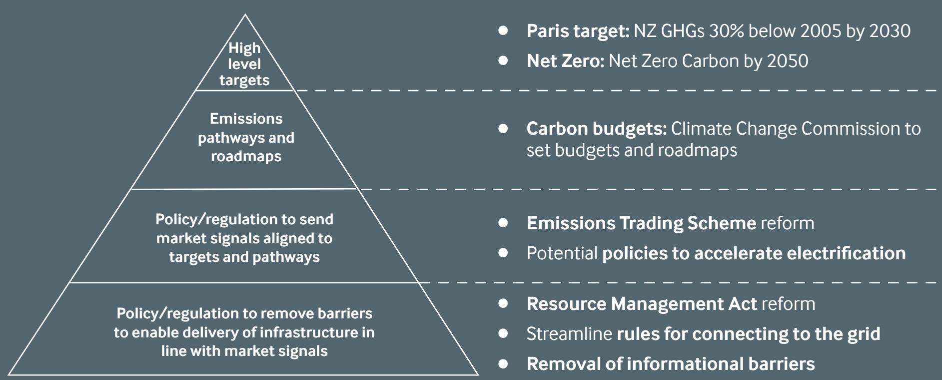
Such an ISP in New Zealand is now critical to guiding and coordinating the electrification and decarbonisation of the New Zealand economy. Transpower will publish a first draft of the ISP and begin a process of industry consultation around the end of 2020, with a final document targeted for mid-2021.

Policy and regulation

Points three and four that follow cover required changes to policy and regulatory settings which Transpower considers important to incentivising electrification and removing obstacles to decarbonisation.

While responsibility for policy, somewhat obviously, rests with policy makers, effective policy cannot be generated in a vacuum and industry participants cannot absolve ourselves from responsibility for contributing to dialogue that influences policy and regulatory settings.

We believe we have a responsibility to engage constructively with government, officials, regulators and with our industry colleagues to ensure we paint a clear and compelling picture as to the policy and regulatory regimes we need to deliver decarbonisation for New Zealand.



At a high level, we see the role of policy and regulation as not just setting the targets – which are critically important and without which little changes – but also the sending of the right market signals and ensuring regulations and rules remove obstacles to investment.

3 GETTING THE INCENTIVES RIGHT FOR ELECTRIFICATION AND RENEWABLES

During periods of rapid social, environmental and technology change, policy and regulations can struggle to adapt and keep up. This is a global challenge.

Energy in New Zealand is now a highly topical example. We must look at both policy and regulatory settings as opportunities to drive decarbonisation.

By way of one example, both the ICCC and *Whakamana i te Mauri Hiko* have modelled transport and process heat electrification on a Business as Usual and Accelerated Electrification base case scenario out to 2035. The emissions gap between a Business as Usual approach and Accelerated Electrification for transport and process heat in 2035 is 5.7 $MtCO_2$-e and 4.1$MtCO_2$-e for the ICCC and *Whakamana i te Mauri Hiko* respectively.

This is the size of the opportunity that policy and regulation can have a critical role in realising.

Effective policy can drive positive outcomes. It is not Transpower's intention to promote certain policy initiatives outside of our core operations as that is not an area of expertise, but in a very general sense, we make the point that further policy initiatives are likely to be required in both the electrification of transport and process heat.

Whakamana i Te Mauri Hiko welcomes the Government's current consultation on amending the Emissions Trading Scheme (ETS) and allowing the cap on emissions pricing to double. We believe the ETS is the single most important market mechanism for the sending of market signals in favour of decarbonisation. A reformed ETS that allows a more robust carbon price will help drive decarbonisation outcomes across the economy.

However, the ETS must be complemented with a range of supporting policy to achieve widespread and rapid decarbonisation.

We also welcome the 2019/2020 consultation run by MBIE on Accelerating Renewable Energy and Energy Efficiency. This has been a high-quality consultation that asked the right questions and presented very good options.

Again, we are now having the right conversations at the right level. Rapidly translating these consultations into effective policy must be the next priority.

One of the opportunities in policy development is to look outside of New Zealand to the rest of the world. While energy policy can be contentious in a domestic context, there is much occurring in the rest of the world that provides valuable context for policy makers and the energy industry.

By way of a few examples:

- EV feebate systems are relatively common and have driven material uptake in EV purchasing through helping deliver 'sticker price parity'
- Some countries are banning the sale of new petrol and diesel-powered vehicles, for example in the UK by 2035
- Some countries are phasing out the use of coal under legislation
- Policy incentivising or mandating the energy efficiency of appliances, including lighting.

Without expressing any analysis in support or opposition to any policy, New Zealand has a range of policy options available to it in line with these initiatives. We also need to consider policy responses or market changes to enable effective demand-side management, including from domestic distributed energy resources and EVs, in helping manage peak demand periods. Incentivising greater energy efficiency is also vital in terms of avoiding peak demand pressures and lowering energy costs to consumers.

Policy makers and government agencies including MBIE, the ICCC and Productivity Commission have all highlighted the opportunity from electrification and potential economic incentives that may be valuable in accelerating uptake. Ensuring policy is well coordinated and targeted will be critical to its success.

4 REMOVING BARRIERS TO LOW CARBON INFRASTRUCTURE

Regulatory change is now needed to accelerate, de-risk and reduce the costs of consenting new renewable generation, associated transmission investment, and to remove disadvantages on 'first mover' renewable generation investors.

There are three important categories of regulation that affect investment in renewable generation and enabling associated transmission infrastructure.

First, the **Resource Management Act (RMA)** which governs how New Zealand's environment is managed and provides the framework within which Transpower and other industry participants seek approvals for transmission, distribution and generation investments. The RMA also provides the framework for considering relevant National Policy Statements, such as the National Policy Statement for Renewable Electricity Generation, the National Policy Statement on Electricity Transmission, and the National Policy Statement for Freshwater Management – among others – into decisions on RMA planning documents and approvals.

Secondly, **the Grid Investment Test (GIT)** is applied by the Commerce Commission to ensure investments in the transmission grid minimise long-term costs to electricity consumers by providing a framework for assessing potential investments by Transpower based on their costs and benefits to New Zealand under multiple scenarios.

Thirdly, the issue of **First Mover Disadvantage**, in which the first connector to the grid covers the full cost of a connection until another party connects. This can disadvantage and discourage first movers from connecting due to the way costs are apportioned and needs to be directly addressed via changes to transmission pricing.

Transpower is concerned that without significant and coordinated regulatory changes, there is the potential for delays and increases in the cost of renewable electricity investment and associated transmission investment, markedly hampering New Zealand's decarbonisation commitments.

The RMA

The Productivity Commission, ICCC and MBIE have all identified risks related to decarbonising New Zealand's energy sector that result from the RMA. The risks include long lead times on resource consents which can delay generation and transmission investment, insufficient weighting for renewable generation, uncertainty regarding hydro water allocation, the lack of clarity and cohesion between different National Policy Statements, and the implications of recent case law which reinforces the need to "avoid" effects on certain environments (such as areas of the coastal environment with outstanding natural features or outstanding natural character).[1]

Generally, the same RMA regulatory issues apply to transmission investment as apply to generation development.

[1] Environmental Defence Society Inc v New Zealand King Salmon Company Ltd [2014] NZSC 38; Environmental Defence Society Incorporated v Otago Regional Council [2019] NZHC 2278

The consenting time required to connect new generation to the grid has not been a constraining factor in the past due to the associated lead times for renewable generation projects. However there is now the distinct possibility that consenting processes for transmission connections may delay commissioning of new renewable power stations and batteries as they become faster to build.

The importance of obtaining approvals under the RMA for interconnection projects will increase as demand for grid capacity grows in response to peak demand increases, the need for balancing supply and demand across regions as intermittent generation grows, and electricity becomes more relied on as an energy fuel source.

Whakamana i Te Mauri Hiko supports changes to the RMA that will:

- Strengthen the Electricity Transmission and Renewable Electricity Generation National Policy Statements to more positively reflect the value of renewable electricity and associated transmission connections to the future of the planet
- Ensure greater cohesion between national policy statements – particularly the Electricity Transmission, Renewable Electricity Generation and Freshwater National Policy Statements – in relation to the value of renewable electricity and decarbonisation to New Zealand.

While these changes will help, it's important to be clear that the RMA barriers to renewable generation and grid connections require more structural reform as a priority. Transpower broadly supports MBIE's proposed regulatory review options (noting the parallel review of the RMA) but considers they do not go far enough.[2]

In short, there are three primary outcomes required: approvals to be granted for the investments required to decarbonise the economy; for approvals to be granted much faster; and to reduce uncertainty around consenting outcomes.[3]

The Grid Investment Test (GIT)

The Commerce Commission applies the GIT in determining whether to approve significant transmission upgrades proposed by Transpower. The primary purpose of the GIT is to ensure Transpower's investments in grid assets optimise benefits to consumers. The Commerce Commission uses the GIT with appropriate rigour to ensure each significant grid investment decision does so.

The settings within the GIT are very important to the speed with which Transpower is able to make major grid investments. The GIT would benefit from review to ensure it is adequately able to reflect the long-term benefits of climate change mitigation and connecting new renewable generation into its decision making processes.

The GIT is a necessarily technical and robust process, however, currently this process is squarely focused on ensuring direct consumer benefit. Transpower believes it is unable to adequately consider the longer-term consumer benefit of enabling decarbonisation of the economy.

This is a good example of a regulation and process that was well designed for the past, and which has served New Zealand well, but now needs to change. Transpower believes the Commission should be able to consider broader issues of consumer and national interest in the application of the GIT.

2 Please refer to MBIE's discussion document on 'accelerating renewable energy and energy efficiency' for detail.
3 Transpower's submission on the MfE discussion document "Transforming the resource management system: Opportunities for Change, Issues and Options Paper" expands on the reform required.

Whakamana i Te Mauri Hiko has demonstrated the significant long-term energy savings to consumers that come with rapid decarbonisation. Ensuring the Commission can also consider the longer-term future benefits of decarbonisation to consumers is now important to Transpower being able to make appropriate and timely investments in the decarbonisation of New Zealand's economy.

First mover disadvantage

Whakamana i Te Mauri Hiko is concerned with the way in which 'first movers' – the first party making a new connection to the grid – is disadvantaged and discouraged from doing so. Under the current settings, any new connector is deemed to be the beneficiary of it and covers the full cost of the connection, even if the capacity of the connection exceeds their requirements. This can inhibit the development of renewable energy clusters or clusters of electrifying industry that could share connection costs.

Transpower agrees with MBIE when it says that the first mover problem can delay the generation investment needed to enable decarbonisation and reduce the ability of Transpower to access economies of scale from sizing connection assets sufficiently to serve the potential supply and demand growth in a region.[4]

Transpower also believes that the first mover disadvantage issue may delay investments in the electrification of process heat. For example, industrial demand will electrify in stages and this will likely be cheaper for the early stages of electrification to connect to distribution networks rather than the grid. As electrification grows over time, subsequent investment in the local network connection will be made when an initial grid connection could have been more efficient and cost-effective and potentially enabled more rapid electrification.

Whakamana i Te Mauri Hiko is also concerned about the 'first mover' issue impacting on remote, disadvantaged communities that could benefit from significant generation development projects.

Transpower welcomes MBIE's recognition of this problem and the acknowledgement that change is required. However, Transpower has a strongly held view that the solution to this challenge lies not with the Grid Investment Test, but with amendments to the Transmission Pricing Methodology.

We welcome support for the broadening of the GIT to more fully consider the benefits of decarbonisation, but believe changes to the TPM must be made to effectively address the first mover disadvantage issue.

Transpower proposes an approach as follows: if a new grid connection enables significant electrification, or opens up a cluster of renewable generation opportunities, the first mover pays for the capacity they require through a commercial contract with Transpower. The remaining costs are bundled into Transpower's Regulated Asset Base and these costs are shared across all consumers.

As new users of the transmission capacity come on stream, they purchase access to the excess capacity on standard commercial terms and that capacity then rolls out of Transpower's Regulated Asset Base so that consumers no longer pay for it. As the excess capacity is increasingly utilised by end users, the cost to consumers moves to zero.

[4] MBIE, 'Accelerated Renewable Energy and Energy Efficiency'

Under this model, general consumers pay for the electrification and decarbonisation benefits, rather than the first connector funding it all, but progressively pay less and less. At the same time, the benefits of a decarbonising economy will increasingly show up in lower overall energy prices to the long-term benefit of consumers.

In advocating for this approach, Transpower wants to be crystal clear that our proposal is that any such initially over-sized connection investment would be independently and robustly assessed by the Commerce Commission. Having the Commission independently assess whether the proposed connection investment generates long-term net consumer benefit is a critically important step in providing assurance of the integrity of the programme.

This step provides consumers with the certainty and confidence that the investment is to their long-term benefit.

This takes us back to the need for the GIT to be reviewed to be able to consider the broader long-term consumer benefits of decarbonisation, but the solution to the first mover challenge lies primarily with transmission pricing in the first instance.

In a similar vein, New Zealand's Electricity Industry Participation Code sets out the responsibilities for market participants. In the Code, the participation of batteries in ancillary services markets is currently limited, even though they are well suited to provide many of theses services. Our codes, regulations and ancillary services must be 'technology agnostic' in order for the full value of new technologies to be fully realised across multiple products. We acknowledge that the Electricity Authority is currently working through these issues and we support this programme of work.

Empowering regulators to support decarbonisation

The discussions around the need for the Commerce Commission to be given the right to consider the consumer benefits of decarbonisation are representative of the change that must occur across the regulatory landscape in order to drive decarbonisation.

For example, while the Electricity Authority is currently consulting on its strategy in which climate change is a focus, the Authority does not yet have a reference to climate change in its mandate. We support this changing.

In terms of what we see as global best practice for regulators, the UK's Office of Gas and Electricity Markets (OFGEM), a national energy regulatory agency, published its decarbonisation action plan in February 2020. The plan commits to nine specific actions, including publishing a regulatory strategy for EVs, to guide decarbonisation: https://www.ofgem.gov.uk/publications-and-updates/ofgem-s-decarbonisation-action-plan.

Time is now very tight to affect regulatory change in New Zealand, but doing so has never been more important for the decarbonisation of our economy.

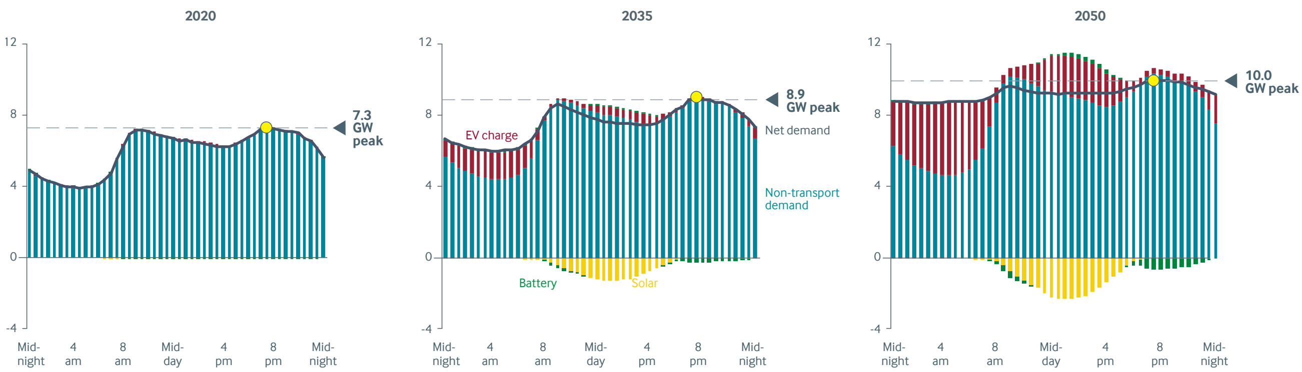
5 DEMAND-SIDE MANAGEMENT OF PEAKS

Whakamana i Te Mauri Hiko has already touched on New Zealand's peak demand challenges and highlighted the critical role of effective demand-side management in meeting them.

The base case scenario sees an approximately 68 per cent annual increase in gross electricity demand by 2050, but with peak demand growing at a much lower 40 per cent. Peak demand is estimated to increase from 7.3GW today to 10GW in 2050.

Figure 19: **Peakiest day profile**

(GW, Accelerated Electrification)



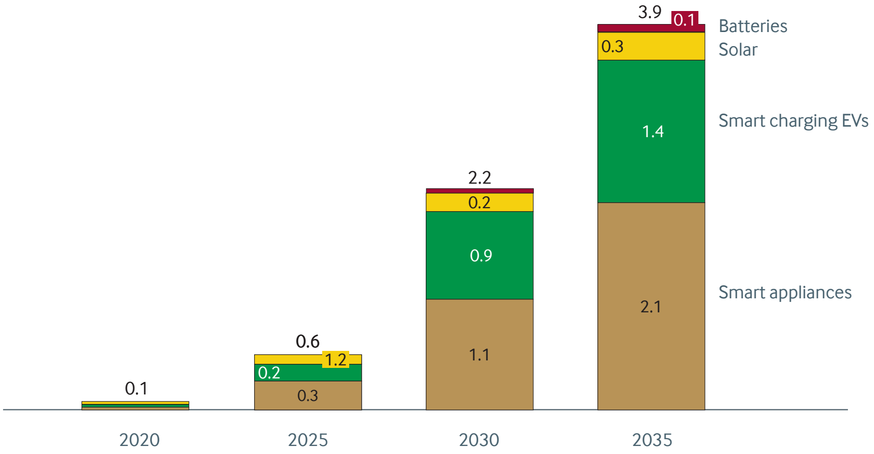
Having materially lower peak demand growth than energy demand growth is essential to the success of delivering energy security and affordability alongside decarbonisation. Meeting peak demand in New Zealand is a unique challenge as a result of our high renewable generation base. As a result, how we respond to peak demand pressures will require unique solutions that we will need to develop and pioneer ourselves, rather than learn from others.

In demonstrating why demand-side management is so vitally important to management of peaks, by 2035 *Whakamana i te Mauri Hiko's* base case estimates there will be 3.9 million distributed energy resources (DER) deployed across New Zealand, with major contributions from the arrival of smart appliances and smart EV charging.

> **Peakiest day peak load grows from 7.3 GW in 2020 to 10.0 GW in 2050 in the base case**

Figure 20: **Distributed energy resources by type**

(Millions, Accelerated Electrification)



Benefits of demand-side management

Effective demand-side participation offers an opportunity to decarbonise our economy most affordably.

By way of example, every GW of avoided peak demand would ultimately save consumers approximately $1.5 billion.

To facilitate meaningful peak reduction from DER some infrastructure will be needed. However, the modest cost of establishing DER markets for New Zealand are likely to realise disproportionate benefits by:

- Avoiding unnecessary investment in peaking generation (typically gas-fired)
- Deferral of transmission and distribution investments
- Enabling congestion management on electricity networks
- Encouraging renewable generation through providing the demand-side flexibility required to firm intermittent energy (wind and solar)
- Encouraging consumer investment in renewable solar and battery systems
- Encouraging electrification through enabling the full demand-side value of assets such as process heaters and batteries (including those in EVs) to be realised
- Enabling efficient integration of DER into the electricity system.

Enabling demand-side management

Meeting our peak demand challenge is contingent on effective demand-side management. There are four pillars that must be the focus for the policy development to guide effective demand-side management:

1. **Pricing**
2. **Distributed energy resource markets**
3. **Technology standards**
4. **Platforms.**

1. **Pricing:** The current energy price sends strong time-of use signals to minimise the cost of electricity production and transmission congestion, but does not reflect network investment costs or distribution network congestion, and is often muted by the prevalence of flat-rate tariffs.

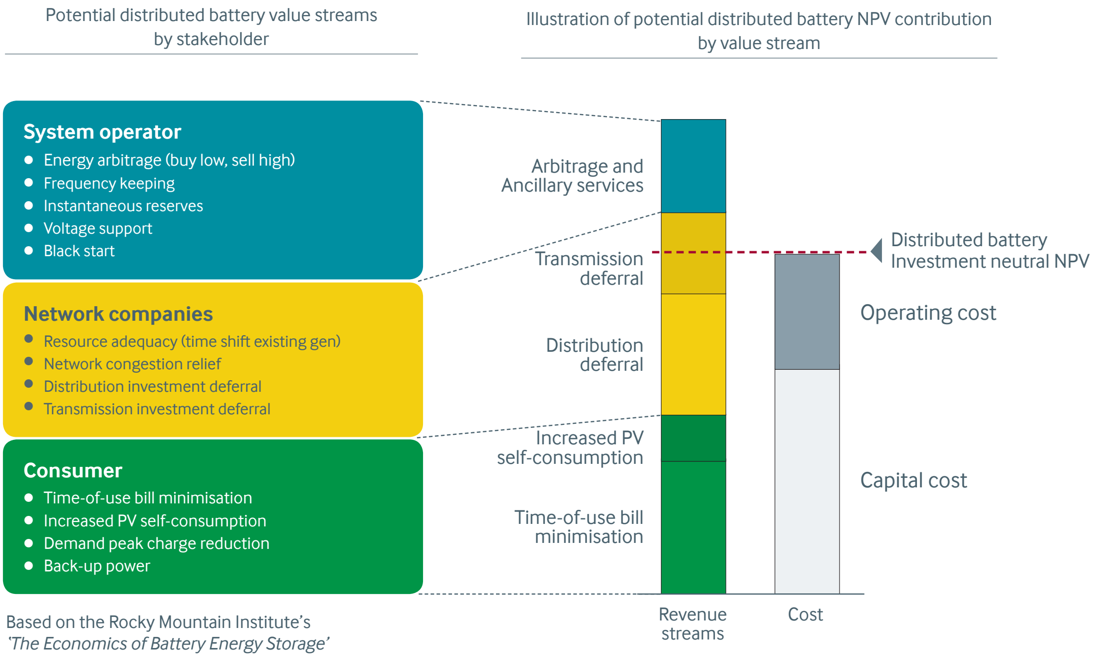
   Transmission, distribution and retail time-of-use pricing is essential to incentivise and reward consumers for investing in distributed energy resources (DER) and providing valued services. Without the correct price signals, customers are unable to respond to minimise their price and therefore system costs. Transpower is especially concerned that transmission pricing settings retain peak price signals. These price signals via transmission prices are needed to encourage the shifting of energy consumption from peak periods, thereby minimising the need for avoidable transmission, distribution and generation investment.

2. **DER markets:** Market development is required to enable new value streams to be accessed by consumers, and 'fill the gaps' that energy and network pricing does not currently address.

   For example, when providing services to networks for peak reduction, the DER provider may also be able to access value from energy or ancillary markets. This would provide some technologies with the true economic value they provide. For example, to incentivise battery investment, the market must ensure consumers are able to be paid for multiple services valued by a range of stakeholders.

   Work undertaken by the Rocky Mountain Institute has identified that distributed batteries can provide 13 services ranging from consumer demand management and solar generation time-shifting, to investment deferral for network owners and system stability services for the system operator. The four areas where market development should be prioritised are for distribution deferral and congestion, transmission deferral, wholesale spot energy and ancillary services. Figure 21 highlights the importance of the market unlocking the additional value streams in order to incentivise distributed battery investment.

Figure 21: **Summary of distributed battery value streams**



Based on the Rocky Mountain Institute's *'The Economics of Battery Energy Storage'*

3. **Technology standards:** Technology standards need to rapidly and continually evolve to ensure distributed technologies such as residential batteries are able to connect and communicate effectively with New Zealand's grid.

   Mandatory EV smart charging is critical because it will alleviate the risk that a sub-set of less price sensitive consumers might choose to continue to charge their EVs on-peak, despite higher prices. This would ultimately trigger unnecessary network investment, potentially drive higher peak energy costs and compromise security of supply - the costs of which is then spread across all consumers.

4. **Platforms:** Software platforms will be required to allow for customer devices, such as distributed energy resources and appliances, to interface and communicate with markets, electricity networks and the electricity system.

Perhaps the most significant example of such a platform is a Distributed Energy Resources Management System which rewards consumers for the effective integration of their DER in the meeting and avoiding of peaks.

Distributed Energy Resource Management Systems (DERMS)

Distributed energy resources (DER) are growing in number and variety. Heating and cooling systems are DERs that are extensively deployed at industrial, commercial and domestic levels.

Batteries, whether in EVs or stationary, and whether combined with intermittent generation (solar or wind) or not, are here and we expect their number to increase rapidly. Enabling DER to be deployed and integrated effectively while optimising consumer returns on DER investments requires a platform that connects DER with those that value its response: distribution and transmission owners, the System Operator, and retailers. Such a platform is known as a Distributed Energy Resource Management System (DERMS).

DERMS platforms are becoming established technologies. An effective DERMS supports security of electricity supply in three ways:

1. A DERMS ensures consumers can get the most out of their DER investments, incentivising them to invest in technologies that reduce utility scale peak demand pressure.

2. It enables transmission and distribution owners to manage their networks.

3. Finally, a DERMS enables existing retailers and distributors along with new players like aggregators to participate and innovate in DER without compromising system operation.

Options for New Zealand DER markets

Transpower and a group of other organisations have recently been investigating how a range of platforms could be used to operate DER markets for New Zealand. Transpower has identified some draft principles and three conceptual DER market options that we are seeking to contribute to the discussion and advance with the industry and stakeholders.

Development of DER markets for New Zealand should satisfy a number of principles:

- **Simple and profitable consumer participation:** It should be easy for consumers or prosumers (consumers who also produce energy) who own DER to engage in the market and find the highest value uses for their DER, potentially across different market platforms.
- **Support multiple markets:** It should be easy for retailers, aggregators and network companies to establish different competitive markets for demand response to address their own needs and provide maximum value to DER owners.
- **Encourage competition, innovation and customer choice:** These principles are always important, but particularly so for DER participation, which is an emerging, rather than mature, activity in New Zealand.
- **Integration with the wholesale market:** DER markets needs to operate at wholesale as well as retail levels. DER needs to be able to be aggregated – bundled up into a large volume of energy – and then dispatched. This will increase visibility of DER activity to the market and System Operator, facilitating its effective integration across the network.
- **Support secure system operation:** An active DER market will support secure system operations through DER engaging with the market and easing network congestion. To achieve this, information on connected DERs and actual and planned DER activity will need to be readily available to the System and Network Operator, to inform their real-time and planning-time security analysis.
- **Minimise transaction and industry costs:** The costs of participating in demand-side markets should be minimised in order to lower barriers to entry and increase participation.
- **Evolutionary approach:** DER markets are emerging in New Zealand. DER markets must be allowed to evolve naturally over time with the changing penetration of DER and rapid shifts in energy technology. We should not try to 'solve' the DER market today with an enduring, one-size-fits-all solution but instead be comfortable with actively monitoring and incorporating changes to design when required.

DER market options

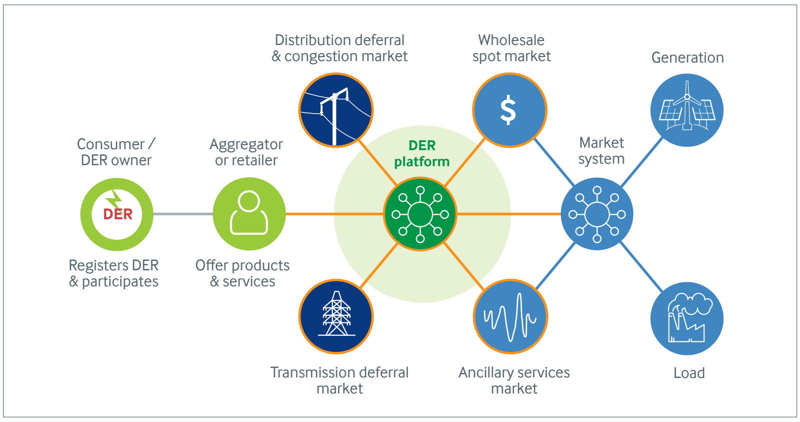
In considering how DERMS could be used to operate DER markets in New Zealand, Transpower has considered the high-quality work from the Innovation and Participation Advisory Group's (IPAG's) *Advice on creating equal access to electricity networks*[5], the Electricity Network Association's (ENA's) *Network Transformation Roadmap*[6] and *Australia's Open Energy Networks*[7], along with our own demand response experience.

5 Innovation and Participation Advisory Group (IPAG): www.ea.govt.nz/development/advisory-technical-groups/ipag/
6 Electricity Network Association (ENA): www.ena.org.nz/
7 Conducted by the Australian Energy Market Operator (AEMO) and the Australian Energy Networks Association (ENA): www.energynetworks.com.au/projects/open-energy-networks/

Transpower has reviewed these important pieces of work and identified the following three potential market structures. Transpower is not expressing a preference for any one market option but looks forward to engaging with the industry to advance discussions around effective market design.

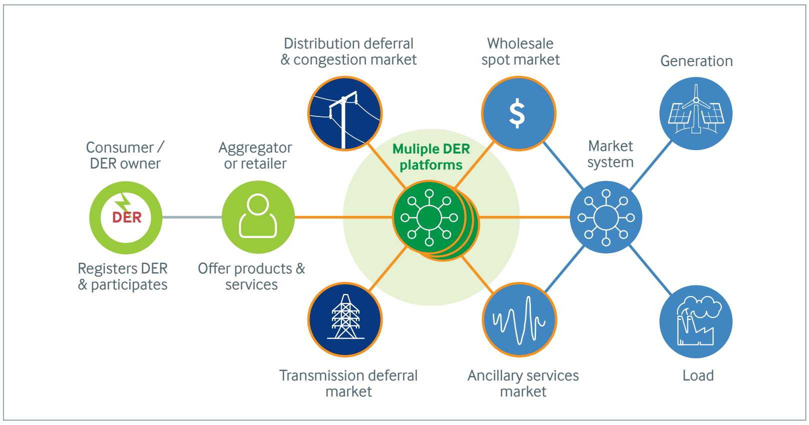
1. **A centralised DER market**

   A single DER platform operates the entire national DER market. Consumers or DER owners who want to participate in the market could do so directly through this platform. A challenge is that the operator of a single, centralised DER platform may not be able to manage the close relationships with small DER providers that retailers and energy aggregators could via their own platforms.



2. **A decentralised DER market**

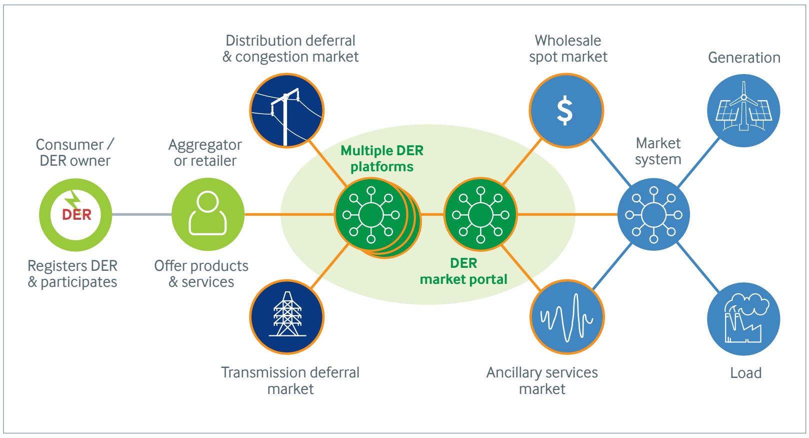
   Any number of DER platforms can exist and interface directly with the wholesale market. Potential DER participants can choose which platform they want to interface with. Ensuring DER platforms can interface effectively with the System Operator is an important design consideration for this model.



3. **A hybrid DER market**

   Under this model there is a central DER market portal / platform that collects bids and offers from any number of other DER platforms, providing an effective single interface to the market system. Aggregated DER could be bid and offered as 'dispatchable demand' or as a virtual power plant (VPP) or virtual large battery.

   Other DER platforms could operate in the retail markets and distribution systems but could only participate in the wholesale spot or ancillary service markets via aggregation into the central DER market portal.



Energy efficiency

In addition to demand-side management, energy efficiency will also make a material difference to mitigating peak demand growth. It needs to be encouraged and incentivised.

A recent study by EECA demonstrated the savings from the widespread uptake of modern technologies like Light Emitting Diode (LED) lamps, heat pumps, energy efficient water heating and electric motors could provide the equivalent of 4,000 gigawatt hours of extra energy, before any new renewable electricity generation was required.

The bulk of this energy saving would occur during the most valuable periods (night and in winter) when peak demand is highest. Smart appliances, insulation and high efficiency heating solutions are all examples of how pressure can be taken off periods of peak demand with the right investments.

Without sustained investment in realising energy efficiency gains, more generation capacity and investment in network and transmission infrastructure will be required. As energy efficiency lowers the ongoing costs for households and businesses, market changes are not required to incentivise adoption, but government policy should continue to evolve to more strongly accelerate adoption.

> **Policy and markets need to enable reduction of peak demand to minimise the cost of transition to a net zero future**

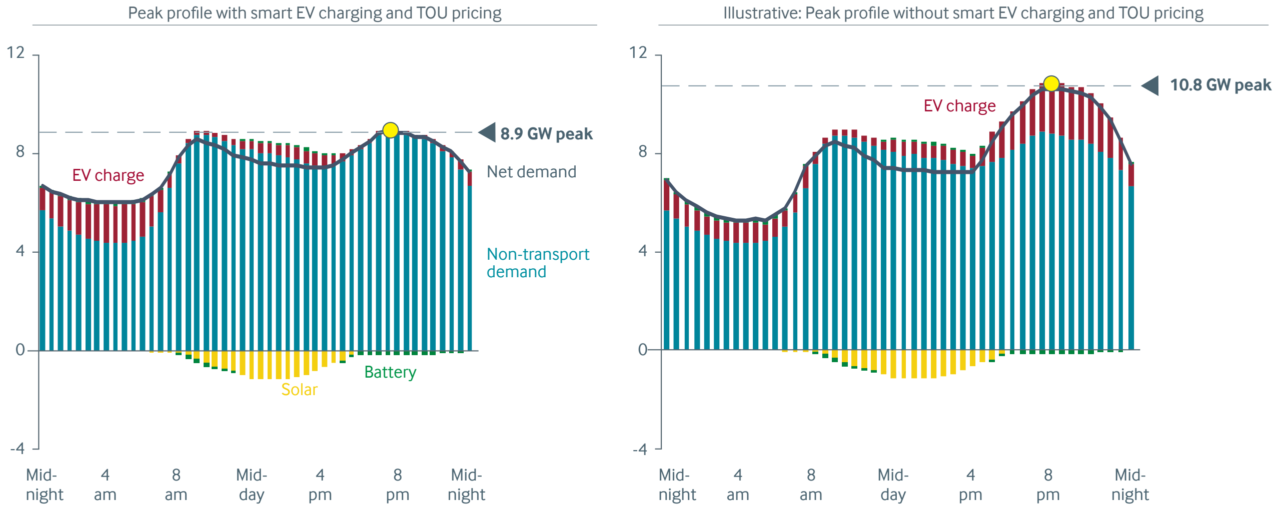
Smart EV charging

Figure 22 shows how vital it will be that the electricity market, particularly local electricity networks, is able to defer peak EV charging and move it to off peak periods. Smart EV charging is estimated to reduce New Zealand's winter evening demand peak by 1.9 GW (18 per cent) by 2035. Given the profound impact of smart EV charging on peak demand and its ability to significantly flatten our energy profile, this must be an area for immediate market design and policy focus.

By way of context, if this 1.9 GW of peak capacity was to instead be met with gas-fired generation, the total cost of the gas generators and associated transmission and distribution infrastructure would be approximately $3 billion.

Figure 22: **Peak Profile Periods**

(2035, GW)



Ensuring investment signals deliver security of supply

The electricity market has worked over the past 20 years to ensure that supply remains secure, and has evolved to fit the changing industry landscape over this period. We expect that it will continue to evolve to meet the context of a Net Zero future for New Zealand.

Transpower does not see an immediate need for change to ensure security of supply and we are not advocating market redesign. However, if the need for further market evolution to ensure security of supply arises in the future, it would be beneficial for the industry to have had a discussion about possible solutions to potential shortfalls in peak or dry year cover.

Having this discussion now ensures that the industry can be well prepared and will allow us to move quickly if the need were to arise. We don't profess to have the answers. This is a conversation that will require broad participation throughout the industry.

We present here a range of potential solutions to contribute to this discussion and look forward to input from others as we build shared understanding of how the electricity sector can support New Zealand's net zero future.

The issues we are focused on here are daily peak demand and dry year risks. These risks are related but also quite separate. Daily peak demand is a capacity issue – we need to have generation capacity available to meet the peaks, particularly during a dry year. The dry year challenge is an energy issue – there is a shortage of energy (namely water) with which to convert into electricity to meet energy demand. The following table shows a simple assessment of some of the technology options that have been considered to meet both peak and dry year risk.

Technology	Ability to contribute to peak demand	Ability to contribute to dry year	Comments
Gas (Combined cycle)	◐	●	Lower flexibility challenges economics, emits carbon
Gas (Open cycle/Peaker)	●	●	High flexibility, emits carbon
Hydrogen peaker	●	●	Currently very expensive
Biomass	●	●	More expensive than gas, needs net zero fuel source
Short duration pumped hydro energy storage	●	◐	Dry year contribution limited by size, sites need to be identified
Long duration pumped hydro energy storage	●	●	Consenting may be difficult
Renewable overbuild	○	●	Could be expensive
Batteries	●	○	May need multiple value streams to be economic
Renewable overbuild and batteries	●	●	Could be expensive
Additional HVDC capacity	●	○	Allows SI hydro to contribute more to NI peaks
Demand response	●	○	Allows peaks to be managed, potentially at least cost
Large scale load interruption	○	●	Prolonged shutdown of major loads, likely to be expensive

Points six and seven discuss peak and dry year risks in more detail and explore the open question around whether the current market settings will be adequate to meet both of these risks through to 2050.

It's important that the conversation around dry year and daily peak demand are not interpreted as problems a long way into the future. In March 2020, the System Operator released its draft Annual Security of Supply Assessment of New Zealand's winter energy margin (dry year issue) and North Island winter capacity margin (peak demand issue).

Under the medium demand scenario, which aligns with the Accelerated Electrification base case, assuming no new generation build, it forecasts that New Zealand runs into North Island winter capacity margin (peak) challenges as early as 2024/2025 and national winter energy margin (dry year) challenges by 2027.

Figure 23: **New Zealand Winter Energy Margin**

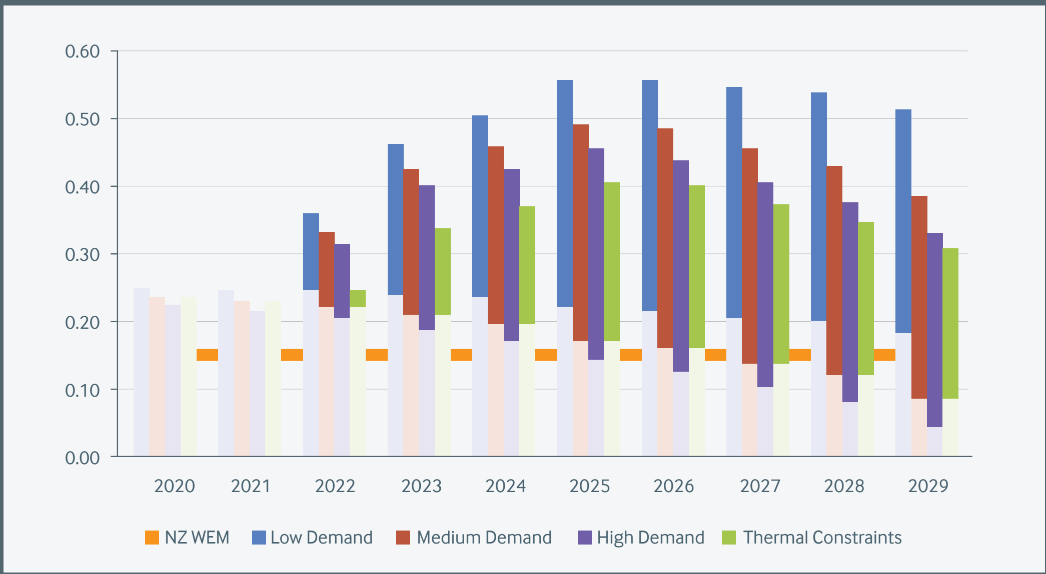
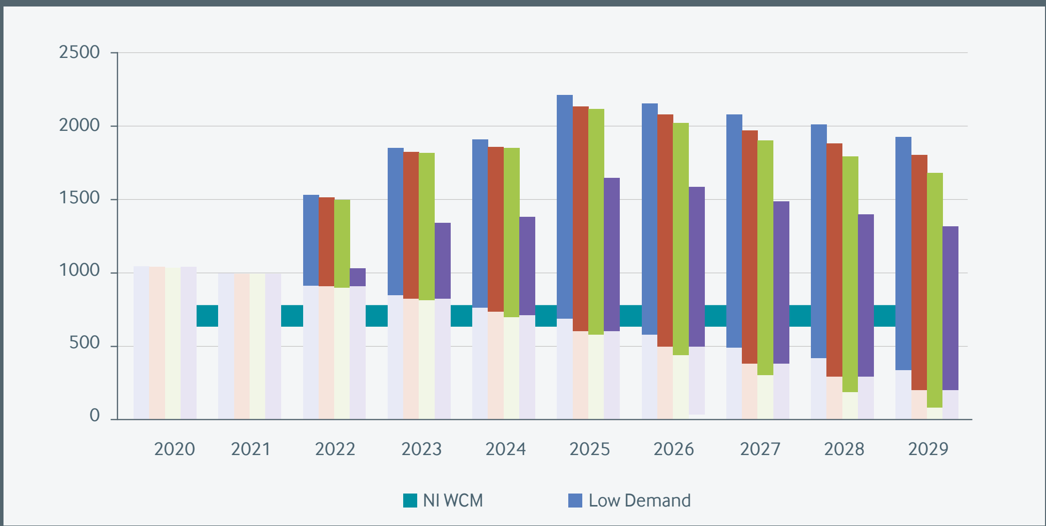


Figure 24: **North Island Winter Capacity Margin**



Transpower is aware of large-scale generation options in the planning phase that could help to address these issues, but does not yet have certainty around the commitments to develop them, or the likely timing requirements.

These security issues are likely to be exacerbated as energy demand ramps between 2025 and 2035 due to electrification.

6 ENSURING GENERATION MEETS PEAKS

Meeting *Whakamana i Te Mauri Hiko's* generation development ramp will require a step change increase in the amount of generation developed. The base case estimates approximately $8-10 billion in grid connected generation investment will be required by 2035, followed by another $6-9 billion by 2050.

While demand-side management contributes to the base case assumptions of peak demand growth of 40 per cent out to 2050 compared to daily demand of 68 per cent, material electricity generation is also required to meet peaks.

Some of the possible solutions to meeting peak demand may also solve issues around dry year risk. The widespread deployment of utility-scale batteries and EV batteries feeding back into networks can provide valuable energy sources to contribute to peaks but cannot currently contribute to dry year risk. The use of gas-fired peaking plant can help solve both.

The key to meeting peaks is having controllable energy sources, which become ever more challenging as the percentage of weather-dependent renewable energy increases on the system.

The importance of market-based signals

Before discussing some of the various options around addressing peak demand and dry year risk, in principle Transpower supports security of supply mechanisms which signal need to the market and provide participants with the opportunity to remedy the situation without significant intervention. The current market conditions may be sufficient to incentivise addressing peak demand and dry year risk. This remains an open question, however, if additional market-based signals are required, preserving market mechanisms wherever possible will be important to preserving investor confidence.

These mechanisms could be supplemented with a clear, triggered assurance if the market does not resolve the concern. One example is Australia's Retailer Reliability Obligations. Under this regime:

- the Australian Energy Market Operator (AEMO) identifies any security of supply concerns within the next five years and signals these to the market. The market is then provided the opportunity to remedy the concerns.
- If any of these concerns still remain within three years and three months, then AEMO can trigger the Retailer Reliability Obligation.
- Once triggered, liable entities will be on notice to enter into sufficient qualifying contracts to cover their demand. A Market Liquidity Obligation placed on generators ensures that there are contracts available to smaller players. This additional security of supply mechanism still places the onus on the market to competitively remedy the concerns.

- If the concerns remain one year out, then all retailers must disclose their contract positions to the Australian Energy Regulator who may pursue enforcement action against non-compliant retailers. AEMO may then commence procurement of emergency reserves with costs being recovered through a Procurer of Last Resort mechanism.

This mechanism aims to introduce a proxy market for over-the-counter firming contracts and provides the regulator and System Operator with emergency powers if this mechanism proves insufficient.

We present this example for demonstrative purposes only. In the New Zealand context, the Customer Compensation Scheme might be adjusted to provide similar outcomes, or other similar mechanisms might be investigated.

Thermal generation

Out to 2035, *Whakamana i Te Mauri Hiko* estimates that gas-fired electricity generation remains relatively constant in terms of installed capacity, but 400 MW of baseload gas is replaced with four 100 MW gas-fired peakers. Over time, these peakers may use a range of emerging technologies such as green hydrogen for fuel, carbon capture and storage to produce zero emissions generation or the use of biomass.

Whakamana i Te Mauri Hiko acknowledges and shares the environmental sensitivities around the use of thermal generation yet also places a very high value on the security of supply provided by controllable generation in the context of meeting system requirements and demand during peaks. We note the ICCC has also acknowledged the likely role of peaking plants as New Zealand transitions to a decarbonised energy future.

We welcome reduced generation from thermal plant out to 2050, but also note its increasing importance in meeting peaks. Herein lies the dilemma.

In 2035, *Whakamana i Te Mauri Hiko* estimates that gas peaking plants in the New Zealand market will have a utilisation rate only one third of the utilisation rate of gas-fired plants today. We will run much less gas-fired generation but when it runs, it will be critical to keeping the lights on.

The open question that *Whakamana i Te Mauri Hiko* poses is, given the declining utilisation rate of gas-fired generation combined with the rising prices of gas and carbon, the nature of take-or-pay gas supply contracts and ongoing costs associated with connection to the gas supply pipeline, are market settings likely to be adequate to enable investments into the future?

The issue of meeting peak demand will become more challenging as peak demand increases by 40 per cent out to 2050. Both the challenge of meeting dry year and peak demand risk will be exacerbated by the exit of thermal plant. In particular, Transpower is actively planning for the eventual retirement (date unknown) of the Taranaki Combined Cycle gas-fired power station and the coal-fired Rankine units at Huntly.

Both of these plants contribute to system stability and Transpower needs to ensure it is ready to respond when decisions are made around the future of these assets.

While there are challenges to address, some positive steps are being taken to ensure peak demand is met. *Whakamana i Te Mauri Hiko* sees the contribution of hydro generation decreasing as a percentage of the capacity mix out to 2050, with hydro being increasingly deployed as peaking capacity.

Transpower is also working on the investment proposition for an HVDC upgrade in the early 2030s to allow more South Island hydro generation to meet North Island peaks. Should this be required, initial estimates suggest that the cost per MW of building additional capacity in the HVDC transmission link is about three quarters of the cost of building gas-fired peaking power stations. Such an HVDC grid upgrade could effectively deliver comparable results as building green peaking capacity for less cost than gas-fired plants.

Batteries also promise to deliver great value in both avoiding peak demand and then also meeting peaks.

As discussed in point five, market settings must allow for batteries to realise their true economic value across multiple value streams. The market must adequately recognise the value of battery installations to consumers and to the electricity system to encourage investment in them.

There are a number of other possible solutions that could help address both the dry year risk and the peak demand issue as discussed in point seven.

7 MANAGING DRY YEAR RISK

A dry year occurs when reduced rainfall leads to lower hydro inflows, meaning less energy is stored in hydro lakes to be used for hydroelectric generation. As hydro generation currently supplies 58 per cent of New Zealand's annual electricity demand, dry years pose a significant and ongoing challenge to New Zealand.

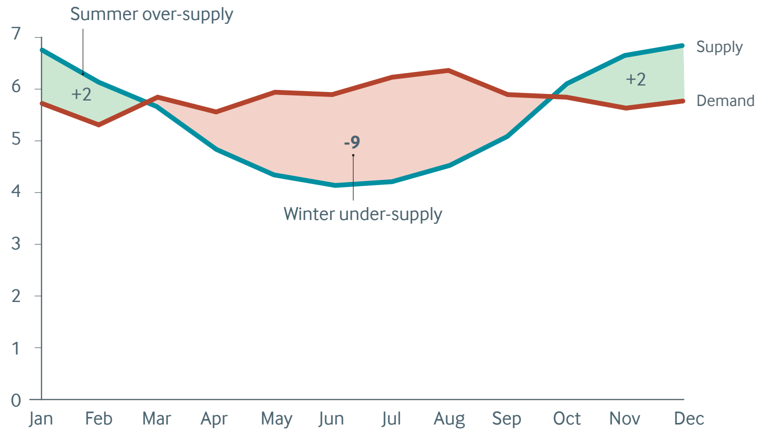
In the past, such as 1992, 2001, 2003 and 2008, dry years have been severe enough for New Zealand consumers to be asked to conserve electricity. As we transition to a decarbonised economy, this risk increases and requires much greater focus to manage. Drivers for this increasing risk are growing peak and energy demands, combined with retirement of baseload gas capacity and growth in weather-dependent renewables.

In *Whakamana i Te Mauri Hiko*'s base case, approximately 30 TWh of annual electricity demand growth by 2050, combined with greater reliance on intermittent generation and reduced thermal capacity, leaves New Zealand exposed to a potential 9 TWh dry year supply shortage by 2050.

Meeting dry year winter supply remains the number one challenge both now and through to 2050. Figure 25 shows how the supply and demand gap is currently estimated in a dry year. It serves to highlight the urgency with which solutions must be developed.

Figure 25: **Monthly supply and demand estimates for dry year**

(TWh, 2050)



In a normal year our current hydro storage is generally sufficient to allow us to transfer the summer surplus energy from summer to winter, but the winter dry year deficit requires significant energy from elsewhere.

The long lead times associated with large-scale technological and regulatory changes, combined with the potential implications from failing to deliver dry year security of supply, ensure that the industry must collectively be investigating solutions now.

As discussed in the previous section, thermal capacity will need to be retained, at least out to 2035, in order to provide controllable supply to meet dry year demand, regardless of what fuels it. Biomass is potentially attractive as an option but has been limited by the economics of acquiring the biomass and transporting it to power plants equipped to use it.

As raised by MBIE, a strategic reserve mechanism could be created to protect thermal baseload capacity for use during emergencies when there is a risk of energy shortages. If a strategic reserve mechanism is favoured, Transpower believes a competitive market-based approach should be used to identify assets that may contribute to a strategic reserve mechanism. Other options include pairing market mechanisms with regulatory changes such as requiring higher lake levels leading into winter, and incentivising large-scale industrial demand response.

Transpower has a preference for market-based solutions, however, some 'silver bullet' options could be developed, such as pumped hydro, a hydrogen programme to cover dry year risk, or more strongly incentivising renewables overbuild. These options would likely require direct government involvement or support.

New pumped hydro storage schemes could be developed and they have the potential to solve this problem. However, such a scheme would be expensive, with a long lead time, subject to significant consenting risk and would force a potentially charged conversation around localised environmental impacts considered against the drive to reduce national emissions that contribute to climate change.

Overbuilding renewable generation to provide peak cover may require investors accepting higher spill and curtailment in normal years, lower average wholesale prices in normal years (from having excess supply), and lower utilisation on other generation assets. The overbuild option would need to be developed in parallel with the deployment of battery storage and current market settings may not reward investment.

Large-scale industrial and non-industrial demand response is possible but may be undesirable due to the potential economic and political impact of limiting production and consumption.

Regardless of which options are deemed to be the best, our dry year risk is a unique and significant challenge that has the potential to disrupt our journey towards a decarbonised economy and materially set it back.

This is the biggest challenge we face. It requires clear and decisive ownership of the decision around what New Zealand must do to address it.

Summary

Neither Transpower, nor this paper, profess to have all of the answers to the challenges discussed in this section, however, as an industry we need to be actively discussing the solutions to them now. The current market settings may well prove to be sufficient to deal with these issues but, as part of advancing this discussion, the following table summarises some potential additional market options for responding both to the peak demand and dry year challenges.

<table>
<tr><th>Market option</th><th>Primarily targets peaks</th><th>Primarily targets dry year</th><th>Comments</th></tr>
<tr><td>Increase Customer Compensation Scheme payments</td><td></td><td>✓</td><td>Mechanism that exists today which could be scaled up – requires retailers to pay a weekly charge if their customers need to reduce energy use</td></tr>
<tr><td>Firm energy market</td><td></td><td>✓</td><td>Procures additional 'firm energy' to cover dry years – it is the dry year equivalent of a capacity market</td></tr>
<tr><td>Increase lake level requirements leading into winter</td><td></td><td>✓</td><td>Would allow for more energy cover entering winter – may still require additional firm energy in a dry summer to reach higher lake levels</td></tr>
<tr><td>Strategic reserve mechanism</td><td></td><td>✓</td><td>Designed to protect thermal baseload capacity for energy shortages. Likely to be better designed as a market-based mechanism to provide other options</td></tr>
<tr><td>Retailer reliability obligation (RRO)</td><td colspan="2">✓</td><td>Requires retailers to contract sufficient 'on demand' resources. Only triggered when material reliability gaps are identified in advance. Could be designed to target peaks, dry year, or both</td></tr>
<tr><td>Capacity market</td><td>✓</td><td></td><td>Procures the availability of peaking plant and/or demand response</td></tr>
<tr><td>Ensuring market settings allow batteries to realise true economic value</td><td>✓</td><td></td><td>Requires batteries to access multiple value streams (e.g. network deferral, energy, ancillary markets) simultaneously.</td></tr>
<tr><td>Balancing market</td><td>✓</td><td></td><td>A balancing market that operates between one and five minutes could provide stronger price signal for flexible generation</td></tr>
</table>

8 PROTECTING SYSTEM STABILITY

Ensuring enough distributed and utility scale generation, storage, and network infrastructure is in place in time to meet the demand ramp starting between 2025 and 2030 is a necessary, but insufficient, condition for maintaining electricity security and enabling decarbonisation.

System stability must also be maintained at all times. The term 'system stability' sounds like somewhat immaterial jargon, but it goes to the integrity of the energy system and underpins system reliability. It is critical to the operation of the entire electricity system.

The type of power that is delivered to New Zealanders' homes is called Alternating Current (AC) power, where electrons flow forward and then backward in the wires that connect homes to the grid. This is different from Direct Current (DC) where the electrons flow in only one direction.

Voltage measures how hard the electrons push in the direction they are travelling. In most New Zealand homes, the voltage should be 240V, while parts of New Zealand's AC transmission grid can reach higher than 220,000V.

It is important that frequency and voltage stay within certain bounds and remain stable because all the appliances used in home and businesses, and all of the equipment that Transpower uses on the grid, are designed to work within those ranges. If voltage strays too far outside those ranges, or if frequency or voltage act too erratically within those ranges then it may cause appliances, or the equipment on the grid, to malfunction.

The type of typically large electricity generators used in gas, coal, hydro and geothermal power plants (synchronous generators) provide a great deal of system strength to their local part of the grid. As more thermal plants are retired and more intermittent generation is developed, system strength in those areas decreases and maintaining overall system stability will become more challenging.

Maintaining voltage stability will be increasingly demanding. Voltage issues can arise in areas of the grid where there is a large amount of demand but very limited supply. With the closure of some North Island thermal plants, maintaining voltage around Auckland is likely to become more challenging in the future. Transpower will need to monitor potential voltage issues and is currently investigating projects that may be required to manage voltage in a system with reduced thermal generation.

For context, system stability has become a major issue for Australia's grid, which now requires some new asynchronous generators to add synchronous condensers at a cost in the order of $20 million to help mitigate the impact of on the local grid.

A good example of the kind of investments required to protect system strength is the $145 million Waikato and Upper North Island (WUNI) interconnection upgrade planned for the next five years. This will be required to be in place and operational to manage grid stability challenges following the eventual retirement of the Huntly Rankine coal generation units.

Failing to manage system stability can have material impacts on electricity security and therefore affordability and decarbonisation. Transpower, predominantly in its role as System Operator, will continue to monitor system stability and advocate for timely and appropriate levels of market or network investment where required.

9 ACCESS TO SKILLED WORKFORCE

There needs to be sufficient workforce capability and capacity to deliver the investments required to enable the transformation. Already, Transpower and its service providers are struggling to recruit the skilled workers needed to make current levels of investments.

New Zealand's electricity industry workforce is estimated to include at least 8,000 people split between transmission, distribution, and generation companies, and contract service providers who provide the utility companies with professional services including engineering design, project management and delivery and asset maintenance.

We estimate we will need thousands more highly-skilled people in the electricity industry by 2035 to meet the demand ramp. This labour requirement is on top of ensuring the industry can secure resources to manage material levels of retirement over the next 15 years as our workforce ages.

For Transpower, since the 'big build phase' in the 1950s and 1960s, low turnover rates mean that workforce development processes have been designed to replace small numbers.

Conversations with industry participants and indicative analysis suggests that a similar trend has played out across the whole industry: flat electricity demand growth and low turnover has resulted in low workforce development requirements.

The demand ramp, growth in renewable generation and workforce concentration in age groups likely to retire in the next 15 years mean that the past trend will not continue.

But ramping demand is not the only workforce challenge. Supplying workforce demand has become more difficult due to the decline of vocational training, the relative weakness of the electricity industry's employment brand relative to other industries, stricter immigration laws and growing international competition for New Zealand-trained workers.

The decline in vocational training poses a significant challenge for New Zealand's energy transformation. A recent survey by the Tertiary Education Commission found that 42 per cent of 18-24-year-old respondents did not have a positive view of vocational training.

This view results in school leavers who may be very well suited for field roles being pushed into universities. The decline in demand for vocational training has resulted in closure of some training schemes while past restructures of nationwide apprenticeship schemes have made the remaining schemes fragmented and difficult to scale.

Meeting supply through targeted international recruiting, which has typically filled the workforce supply gap left by the vocational training pathway, has also become more difficult due to changes in immigration policy. The changes include the exclusion of constraint roles such as cable jointers from the Essential Skills List, and the salary cap rise from $55,000 to $79,560, which limits the ability to hire offshore for base field roles.

Finally, higher wages and early renewable generation investment overseas, particularly in Australia, has drained people who have trained to work in New Zealand's electricity industry. International competition is a trend which is likely to grow as electrification and renewable generation investment increases internationally and New Zealand is recognised as a source of capable people.

On top of workforce capacity, new capabilities will be required to deliver virtual network infrastructure, such as digital and technology innovation, automation, robotics, artificial intelligence and data science.

For New Zealand's energy transformation to be successful, each industry player needs to understand their own capacity and capability requirements, and to develop medium to long-term plans to resolve any constraints. Some organisations are already undertaking initiatives to ensure their workforce is fit for future, including Transpower, while others are feeling the pressure from a growing workload and may not yet have the capability required to develop and execute long-term workforce development strategies.

Cross-industry collaboration with government is required to develop clear workforce development solutions across the education, skills training and immigration sectors.

The supply of enough recruits into the industry is an issue that may be best addressed by industry-wide collaborative efforts. *Whakamana i Te Mauri Hiko* recommends that a robust industry-wide workforce investigation be completed as a priority in order to develop a shared understanding of the capacity and capabilities, and potential interventions required.

This investigation should integrate with the outcomes of the Government's Reform of Vocational Education programme.

10 COLLABORATION

Possibly the most significant change that needs to be made to realise our energy future lies in the way the industry and its stakeholders work together. Ensuring that the electricity sector can play its part in a net zero carbon future is not going to be easy. We will all need to rise to the challenge – Transpower, industry, government, regulators and all New Zealanders.

This is a challenge Transpower is committed to meeting. *Whakamana i Te Mauri Hiko* is a part of this commitment. It signals our commitment to be open, accessible and to work in partnership wherever possible with our customers and stakeholders towards the goal of electrifying our economy.

Like so much of our industry, the way we work reflects our context: we have come through a relatively stable, predictable period in the industry's history; a history in which we have used much of the same technology as was used in our electricity system 100 years ago. Of course, much has changed, but much has stayed the same.

That is now changing. Fast.

If we work largely in isolation as we have done over previous decades, delivering the opportunity of a decarbonised economy will be harder. We need to work in a more integrated way together and we all need to contribute to the areas we can make a difference.

There are some important parameters which deserve clarity here, including around the different parts of the sector and how they are required to behave. Operators of different parts of the electricity system must act commercially, market participants can collaborate within the constraints of competition law, policy-makers must develop solutions and establish regulations, and the regulators must apply those regulations. We must all contribute to the conversations and advocate clearly around policy and regulation.

Even within these parameters, we believe there is much greater scope for us to share our experiences with new technologies, cooperate and work together wherever possible in delivering the opportunity we are faced with.

The opportunity extends to our stakeholders as well. There is an opportunity for much closer cooperation between the electricity industry, policy makers and regulators in maximising the efficacy of decarbonisation policy. This report seeks to increase the dialogue amongst the sector and government.

Delivering the *Whakamana i Te Mauri Hiko* base case energy future will require the very best of this industry. It will require us to innovate, experiment, fail fast at times, learn and adapt. It will require us to come together around the vision of a decarbonised economy and thoroughly plan for it.

Conclusion

Whakamana i Te Mauri Hiko confirms that New Zealand faces a unique opportunity to transform our country and economy through how we produce and consume energy.

The scale of this opportunity is unprecedented. We face the opportunity to cut our reliance on fossil fuels and build a clean, prosperous, inclusive economy based around renewable, affordable energy. We can lead the world in demonstrating how to avoid the worst impacts of climate change and preserve our planet for generations well into the future.

However we must not gloss over the risks which can derail this opportunity and materially set back New Zealand's economic and environmental progress. If we fail to develop clear, coordinated, long-term investment plans across the whole of our sector and if regulation and policy do not adequately support the opportunity then we will not succeed in decarbonising our economy.

If we do not empower and enable our customers to actively participate in the emerging energy sector then we will not realise the *Whakamana i Te Mauri Hiko* base case opportunity.

Under this scenario we run the risk of increasing the cost of energy, retaining our reliance on polluting fossil fuels and struggling with energy security.

We now face choices as a country with divergent outcomes.

There's no middle ground – the status quo is to fail to meet our climate change commitments and to effectively give up on seeking to limit the impacts of climate change.

Our electricity and energy systems are highly complex yet the essence of what we need to succeed in decarbonising our economy is relatively simple: our country must come together around the opportunity to decarbonise our economy with a clear, common commitment. We must all want the benefits of a clean, decarbonised country and our policy makers, regulators and the electricity industry must prioritise delivering it.

We choose to be optimistic but urgency is now critical if we are to meet our climate change commitments and make our contribution to limiting the effects of climate change. *Whakamana i Te Mauri Hiko* charts a possible pathway to a decarbonised economy and gives us the confidence that it can be achieved. We are advantaged through the renewable resources that already underpin our economy and technology continues to evolve that we must harness and adopt with enthusiasm.

What we don’t have is the luxury of time.

We have made international climate change commitments and New Zealand’s international standing and reputation depends on us meeting them in just 10 years’ time.

What is needed now in New Zealand’s energy transformation is courage and leadership. Every part of our sector must come together and push harder, plan more effectively and stand for the possibility outlined in this document. We must support and work alongside our policy makers and regulators and encourage them to also push harder to support the delivery of the social, environmental and economic benefits of a sustainable, low carbon economy.

For Transpower’s part, we will continue to use the *Whakamana i te Mauri Hiko* platform to keep this discussion alive – to further develop our understanding, make the changes we need to make, communicate what we are learning and advocate for the solutions New Zealand needs.

The pathway towards decarbonisation is established. We understand what must be done and now is the time to act.

Thank you for taking the time to read *Whakamana i Te Mauri Hiko* and we look forward to engaging with you on the actions that come from it.

Figures

Source material

The conclusions drawn in the *Whakamana i te Mauri Hiko – empowering our energy future* project were compiled by exploring existing information from many sources, including:

Analysis	Major sources
Energy and electricity demand	Energy Efficiency & Conservation Authority, Ministry of Business, Innovation and Employment, StatsNZ, Treasury, Ministry of Transport, International Energy Agency, Bloomberg New Energy Finance, Sapere Research Group, Electricity Networks Association, Energy Futures Analysis
Electricity supply	Ministry of Business, Innovation and Employment, Bloomberg New Energy Finance, National Renewable Energy Lab, Electric Power Engineering Centre, National Institute of Water and Atmospheric Research, University of Auckland, Connell Wagner, Transpower, Energy Futures analysis
Electricity storage	Bloomberg New Energy Finance, National Renewable Energy Lab, StatsNZ, Transpower, Energy Futures analysis
Electricity transmission	Transpower planning team, Energy Futures analysis
Greenhouse gas emissions	Ministry for Environment, Ministry of Business, Innovation and Employment, BP, Energy Futures

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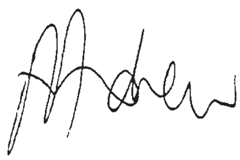
Contributors represent a diverse range of perspectives including generation, distribution, consumers, environment, innovation, economy, and academia.

While Transpower engaged with external parties to develop *Whakamana i te Mauri Hiko – empowering our energy future,* it is important to note the conclusions drawn are Transpower's own.



Kind regards,

Alison Andrew

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