THE ENERGY FUTURE

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POWERING NEW ZEALAND TODAY + TOMORROW

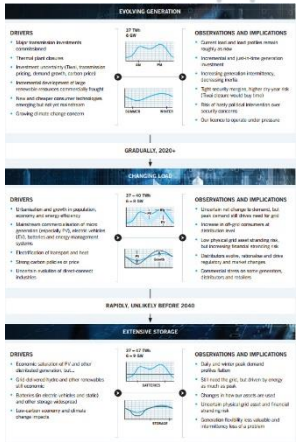
THE FUTURE OF THE PAST

Demand tied to growth in population, economy, and distributed generation/storage

- Transmission Tomorrow 2 did not account for large-scale electrification across multiple industries or Paris Accord

Future electricity demand will be driven by external factors: rapid adoption of technology and demand for climate change action

- Socio-political demand for climate change action will materially impact demand for electricity in years ahead
- Models must account for the rapid adoption of advancing technology
- What is the potential impact on electricity demand if other industries also decarbonise to meet New Zealand's Paris Accord commitments?



GLOBAL OPTIMISM AND SUPPLY/DEMAND

	Now to 2030	2030 to 2050
Climate change	 • Increasing recognition of climate change impacts and threat of abrupt change • Temperatures increase towards 1.6 degrees above 1900 global average • Renewable energy and electrification of transport and industry are prioritised	 • Direct and 2nd order impacts of climate change grow as temperatures exceed 1.6 degrees • Humanity avoids disruptive climate change thanks to geoengineering and large emitters reaching net-zero
World order	 • Globalisation continues, populations and economies continue to grow without major conflict • 2nd global financial crisis in 2020s but is navigated successfully • Inequality continues to grow	 • Geopolitical and economic insecurity continues to grow but without catastrophe. China and India successfully rise to pre-eminence • Inequality grows and is exacerbated by unemployment following AI deployment
Technology	 • Widespread adoption of electric and autonomous vehicles, robotics, smart homes, 3D printing, solar PV and batteries, and new forms of renewable utility energy generation	 • Future technologies arrive. These include electric air and sea transport, artificial intelligence, nanotechnology, new forms of energy generation such as the artificial leaf, and geoengineering • Stage 1 technologies improved and cheaper

	Now to 2030	2030 to 2050
Global scenario	 • Increased climate change but no abrupt change, stable world order and widespread adoption of current technologies	 • Climate change exceeding 1.6 degrees, world order remains integrated, current technologies improved and future technologies adopted
Climate response	 • More climate change impacts. Pressure grows to reduce greenhouse gases • NZ takes a strong pathway to mitigating climate risk by electrifying transport and industrial heat, and pursuing 100% clean electricity generation	 • Increasing impacts of climate change experienced – in the east there are more droughts and in the west there is more rain • Climate policy response continues
Industry development	 • NZ takes a coordinated approach to industry development via the Climate Change Commission and agreed distributed electricity system protocols • New players like Amazon enter the NZ electricity market	 • By the end of the period electricity makes up a much larger portion of total energy demand • Coordinated development leads to widespread distributed generation/ storage, and optimised new utility generation/storage

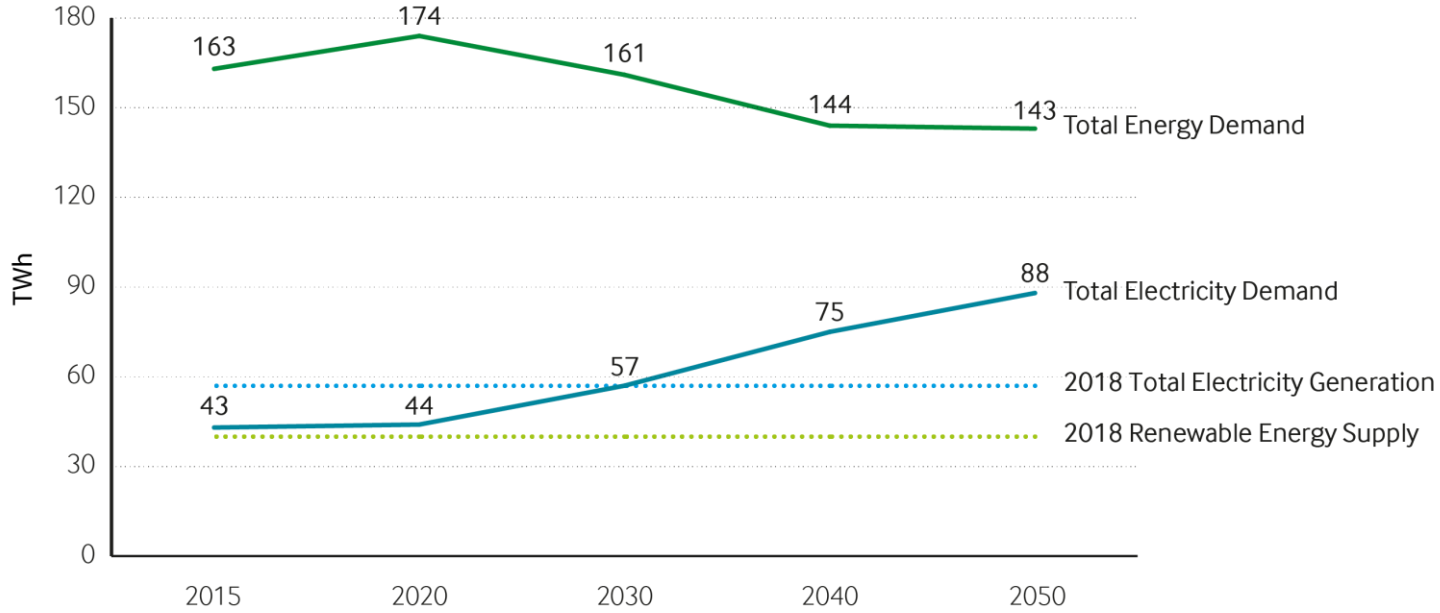
Scenario	Disruptv. climate change* avoided?	World remains integrated?	Future tech adopted?	High-level Story
NZ Inc	✓	✓	✓	A bright global situation with future technology but more climate change impacts. NZ takes a strong stance towards meeting climate change commitments and encourages industry development.
Vibrant Haven	✓	✓	✓	Similar to Base Case but with global climate, economic and security uncertainty growing more strongly and making NZ seem like a safe haven for people and capital. Electricity demand grows more rapidly.
Mobilise	✓	✓	✗	Similar to Base Case but with a technology stall that inhibits the world's ability to mitigate climate change with advanced technology. Instead, consumption must reduce. Electricity demand grows more slowly.
Struggling alone	✗	✗	✗	Disruptive climate change develops, world systems dis-integrate and future tech is not available. Some isolated, lower tech, safe havens struggling. Drivers of electricity demand reduce dramatically.

Demand Scenarios

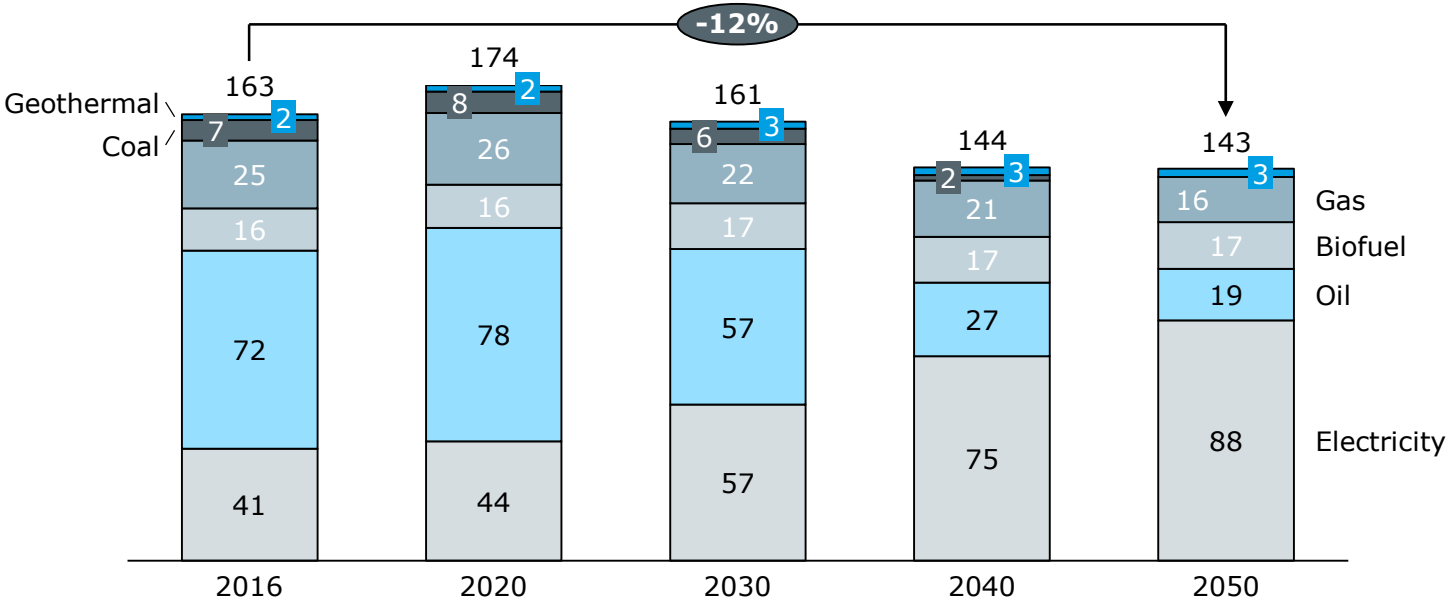
	Amount of dist'd solar?	Peakers retired?	Main source of new util. gen?*	High-level Story
Clean NZ	Medium	Yes	Wind	A continuation of current trends which sees a large increase in distributed solar generation, the eventual retirement of our coal and gas peakers, and new utility geo and wind being provisioned to meet demand growth
Peakers Permitted	Medium	No	Wind	Similar to Base Case but with gas generation retained and built as a means of ensuring security of supply during the winter and a dry year
Mass Solar	High	Yes	Solar	Similar to Base Case but with much more distributed solar generation driven by advances in nano-technology which reduce cost and increase capacity
Big South	Medium	Yes	Hydro	Similar to the Base Case but with a much larger proportion of the new utility generation provisioned in the South Island and as hydro

Supply Scenarios

TREND 1: MODELLED SUPPLY AND DEMAND

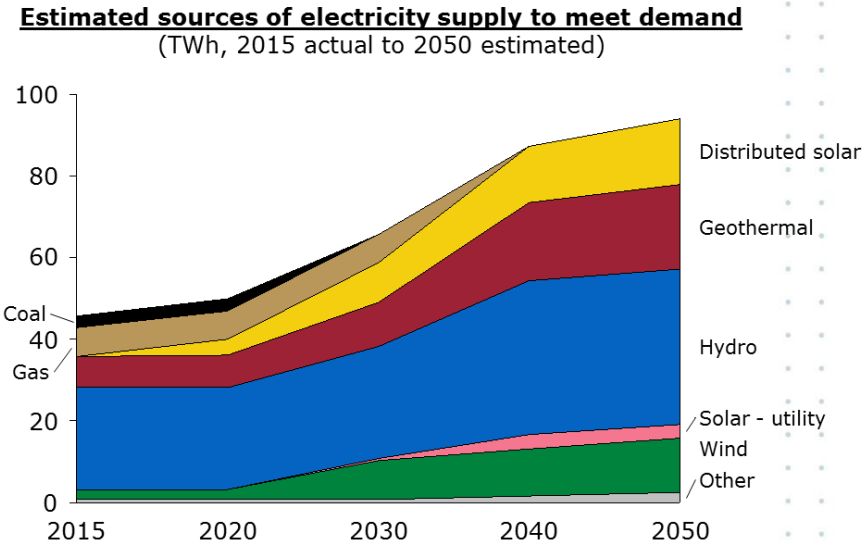


TREND 1: TOTAL ENERGY CONSUMPTION BY FUEL TYPE

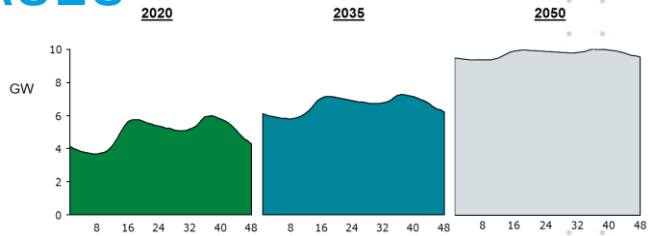


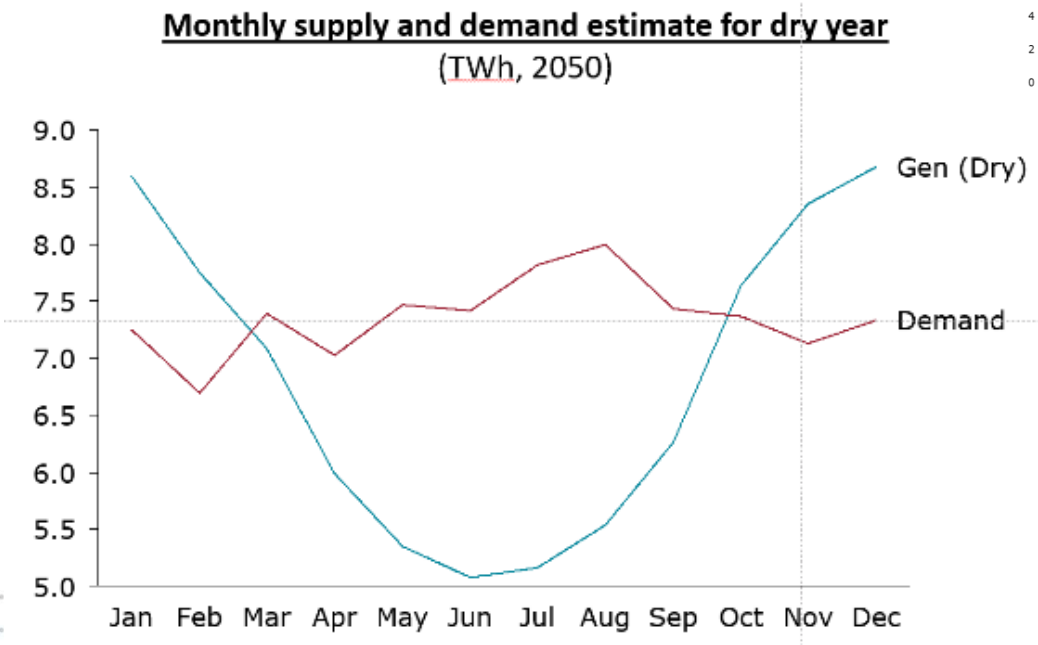
TREND 2: ESTIMATED SUPPLY SOURCES

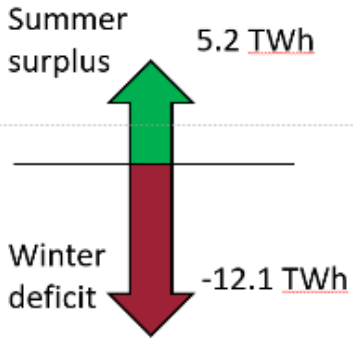
- In the base case, the electricity supply gap is estimated to grow to 22 TWh by 2030 and 61 TWh by 2050
- 16 TWh of solar is estimated to be deployed by 2050
- The rest of the electricity generation gap estimated to be provisioned through wind, geothermal, and hydro
- The resulting electricity generation portfolio is much more diverse than today



TREND 3: HALF-HOURLY PEAK INCREASES







SOME PROVOCATIVE COMMENT

- Electricity demand could double by 2050
- New generation is expected to be provisioned through a lot of solar, wind and geothermal
- The daily peak should be met comfortably, but will be highly dependent on access to distributed storage
- Residential battery packs expected to scale with micro solar penetration and are estimated to provide 5.5 GW of accessible storage
- Electric vehicle storage could peak at 8 GW in 2035 then reduce to 2 GW as autonomous fleets become ubiquitous
- New Zealand’s dry winter exposure is estimated to increase, without a satisfactory solution identified
- Transmission requires many new connections, and approaches constraints by 2050