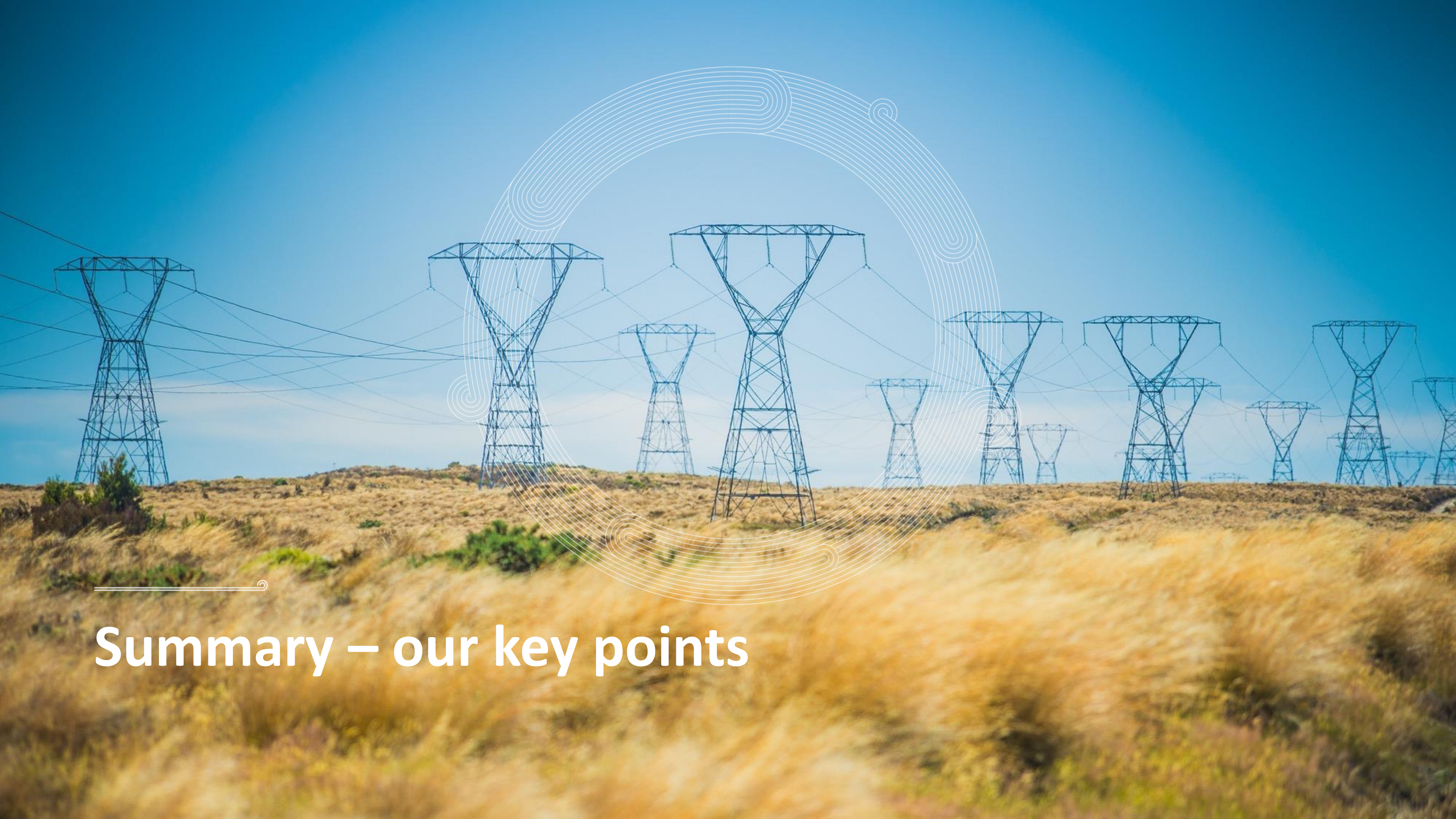
TRANSPOWER

Presentation to MDAG

Price discovery under a 100% renewable electricity supply – stakeholder engagement

29 September 2021



Summary – our key points

Transpower's investigations into what 2030 could look like include a world with 100% renewables

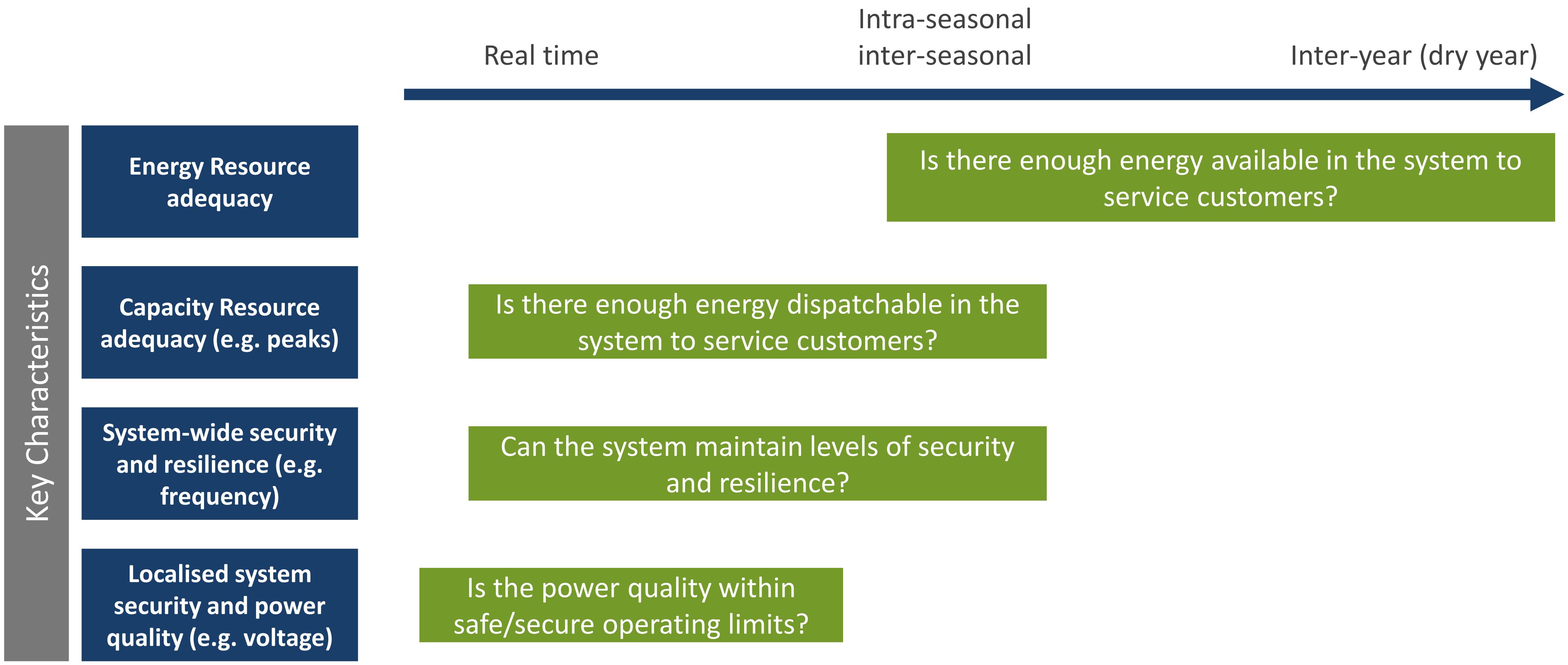
Key trends	Current	A possible future in 2030
Decarbonised: Transition to 100% renewables	• 85% renewable electricity • Mostly synchronous generation • Security of supply managed by market • Thermals to meet peaks and dry years • Small amount of DER	• **100% renewable electricity** • More asynchronous and inverter based generation • Will energy only market manage security of supply? • New tech solutions needed for peaks and dry year • Increased reliance on DER to balance intermittency
Decarbonised: More electrified economy	• High reliance on electricity in the economy • Electricity not relied on heavily for transport • Few, traditional demand growth sources – new industry, new housing	• Very high reliance on electricity in the economy • Electricity relied on heavily for transport and in industry • Many different demand growth sources – hydrogen, data centres, EVs, process heat
Distributed: More distributed electricity grid	• Small DER penetration • Limited performance requirements in Code but small penetration means this is not yet an issue • Limited use of demand-side and battery technology to manage peaks	• Millions of DER able to manage peaks in real-time (EVs, batteries, smart appliances) • Multi-directional power flows • More consumer participation & more market players • Potential issues caused by inverter based DER
Digitised: Increasing digitisation and use of digital tech	• Increasing data and data management requirements • Gradual use of automation for control and switching • Increased use of data-driven decision making	• Increased complexity and volume of data • Expectation from operators and customers that controls, and communications will be automated and data-driven • Opportunities to improve consistency and efficiency

Two main challenges need to be navigated

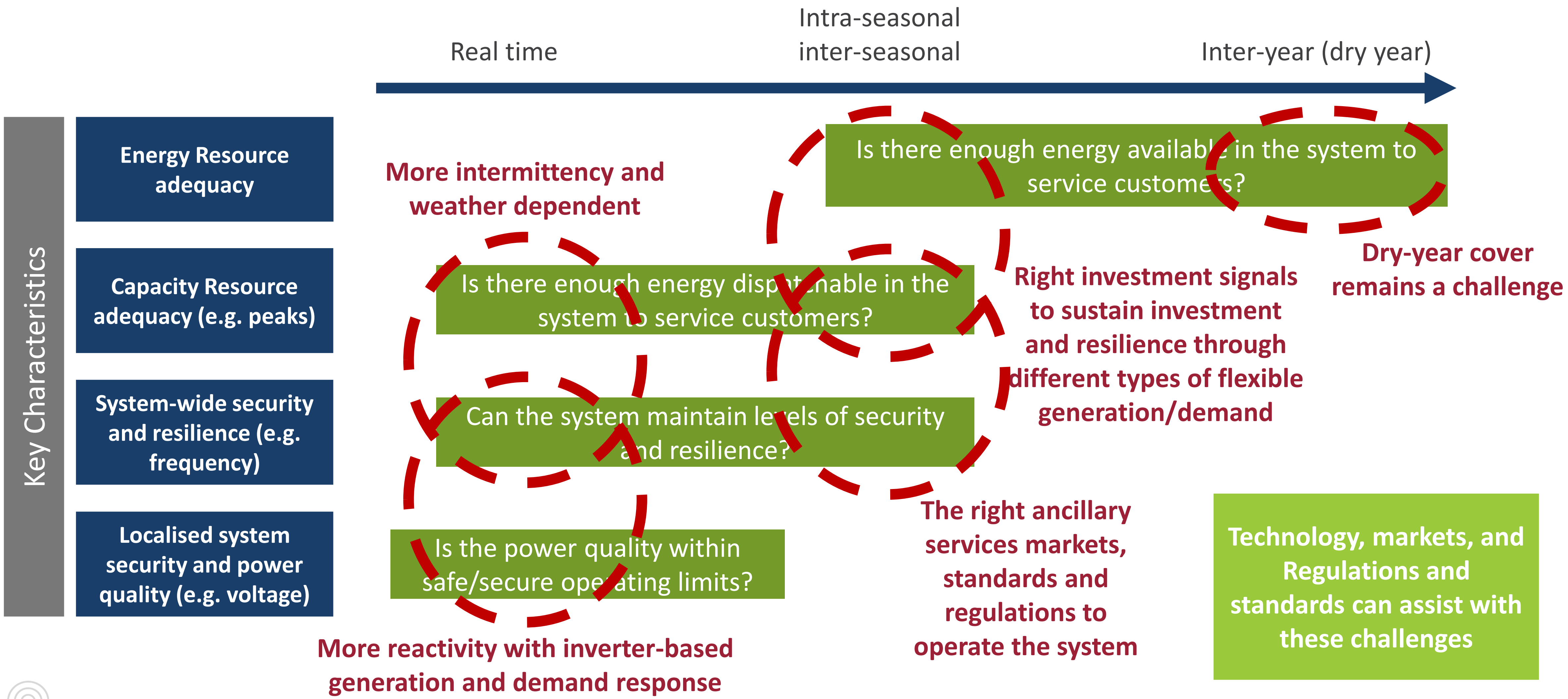
1. The market and regulatory settings required to transition to 100% renewables

2. The market and regulatory settings required to operate and remain at 100% renewables

A power system has a number of key characteristics that need to be met within different timeframes



At 100% renewable, intermittency and generation diversity is a challenge



Detailed presentation

Transpower's investigations into what 2030 could look like include a world with 100% renewables

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Two main challenges need to be navigated

1. **The market and regulatory settings required to transition to 100% renewables**

2. The market and regulatory settings required to operate and remain at 100% renewables

A power system has a number of key characteristics that need to be met within different timeframes

Real time — Intra-seasonal inter-seasonal — Inter-year (dry year)

Key Characteristics

Energy Resource adequacy	Is there enough energy available in the system to service customers?
Capacity Resource adequacy (e.g. peaks)	Is there enough energy dispatchable in the system to service customers?
System-wide security and resilience (e.g. frequency)	Can the system maintain levels of security and resilience?
Localised system security and power quality (e.g. voltage)	Is the power quality within safe/secure operating limits?

What challenges could arise as we transition to 100% renewables?

- At the same time as the transition, demand increases through electrification requiring more energy and more capacity (met by renewables / intermittent generation)
- There will be a need for more flexibility and demand-side participation
- Potential issues that could arise for resource adequacy:
  - Capacity to meet peaks
  - Energy to meet dry year
- The EA's Future Security and Reliability (FSR) project, supported by the System Operator, will focus on the physics of maintaining a secure and resilient power system as the energy generation mix evolves. This includes investigating challenges such as system strength, inertia and intermittency (system balancing).

Whakamana i Te Mauri Hiko shows that the increase in demand through electrification can be met with 100% renewables

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

(TWh, Accelerated Electrification)

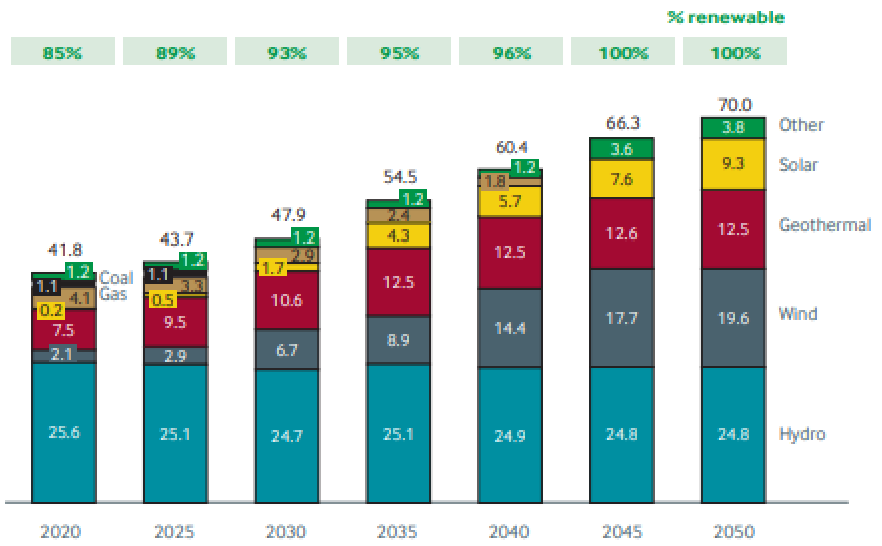
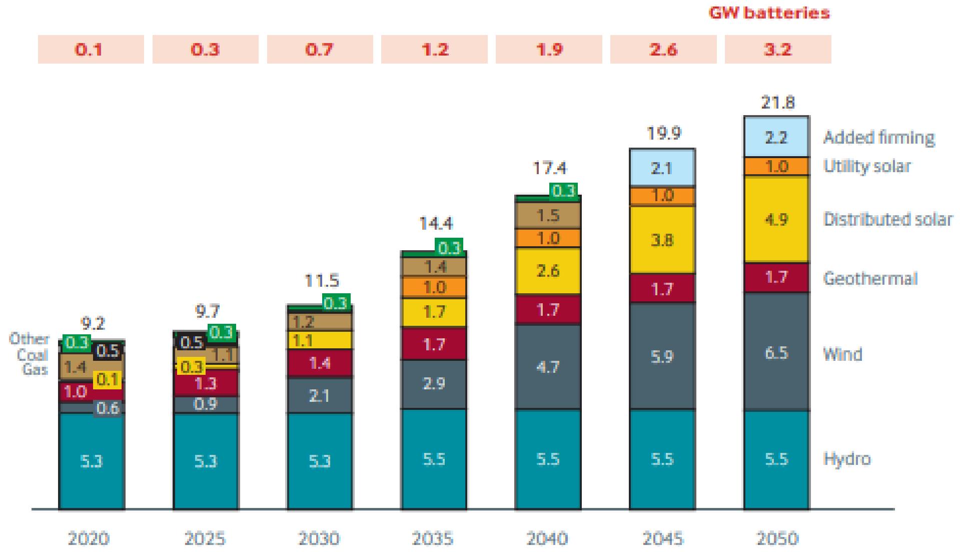


Figure 10: **Generation capacity by type**

(GW, Accelerated Electrification)

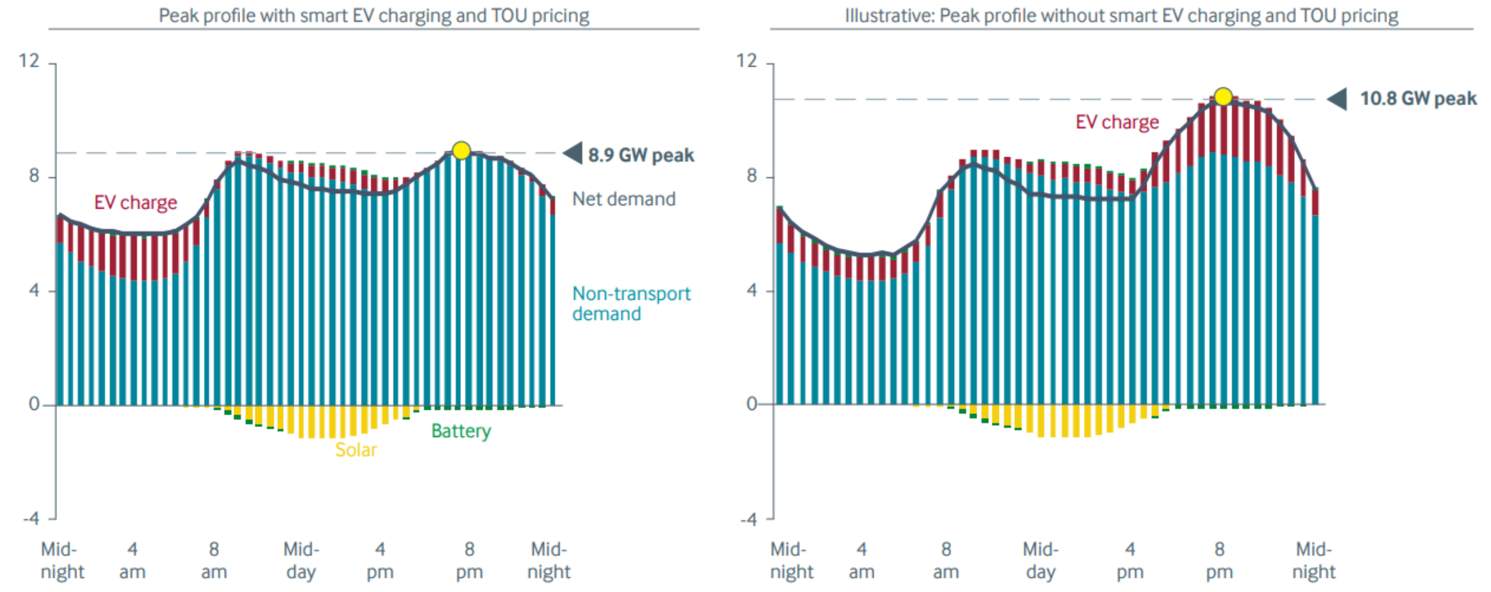


Source: [TP Whakamana i Te Mauri Hiko.pdf (transpower.co.nz)]

Flexibility and demand-side participation will be needed to meet peaks…

Example: Shifting EV charging to off peak would reduce the peak by ~2GW

(2035, GW)



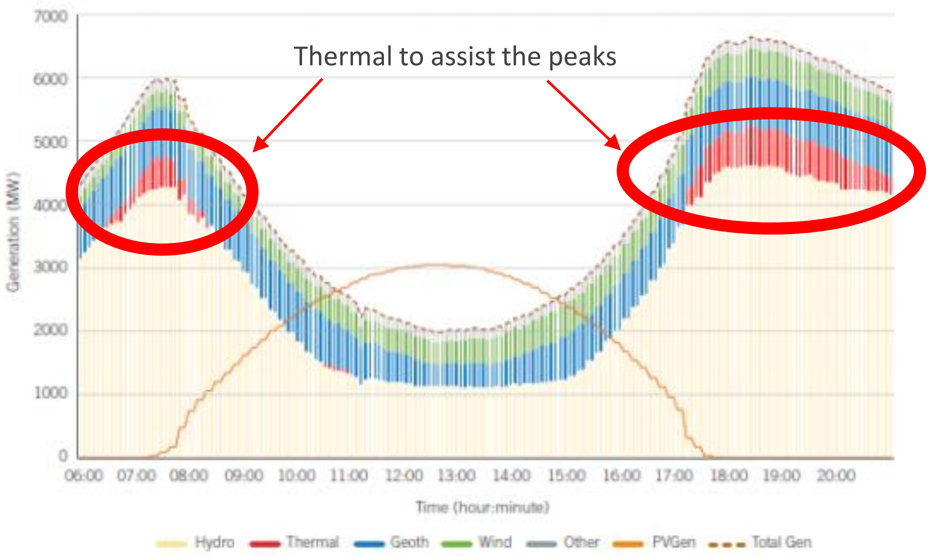
Source: [TP Whakamana i Te Mauri Hiko.pdf (transpower.co.nz)]

Context

Transition to 100% renewables

… and to keep the market economically efficient to keep costs down for customers

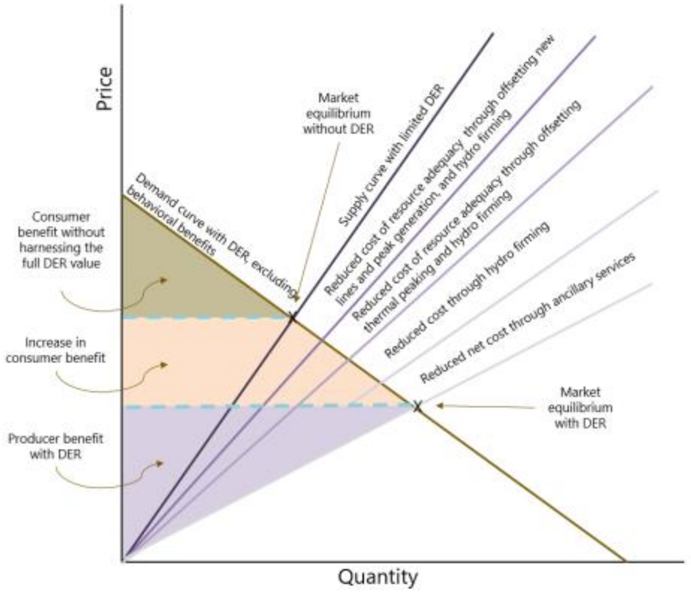
The generation mix is going to be different, requiring flexibility and demand-side management…



This example illustrates what the generation mix could look like with 4GW of PV installed on a typical winter day in NZ (duck curve). Demand-side management could reduce the need for thermal generation

Source: [Distributed BESS in NZ - Power System Operational Implications - Technical Report_2019v1.pdf (transpower.co.nz)]()

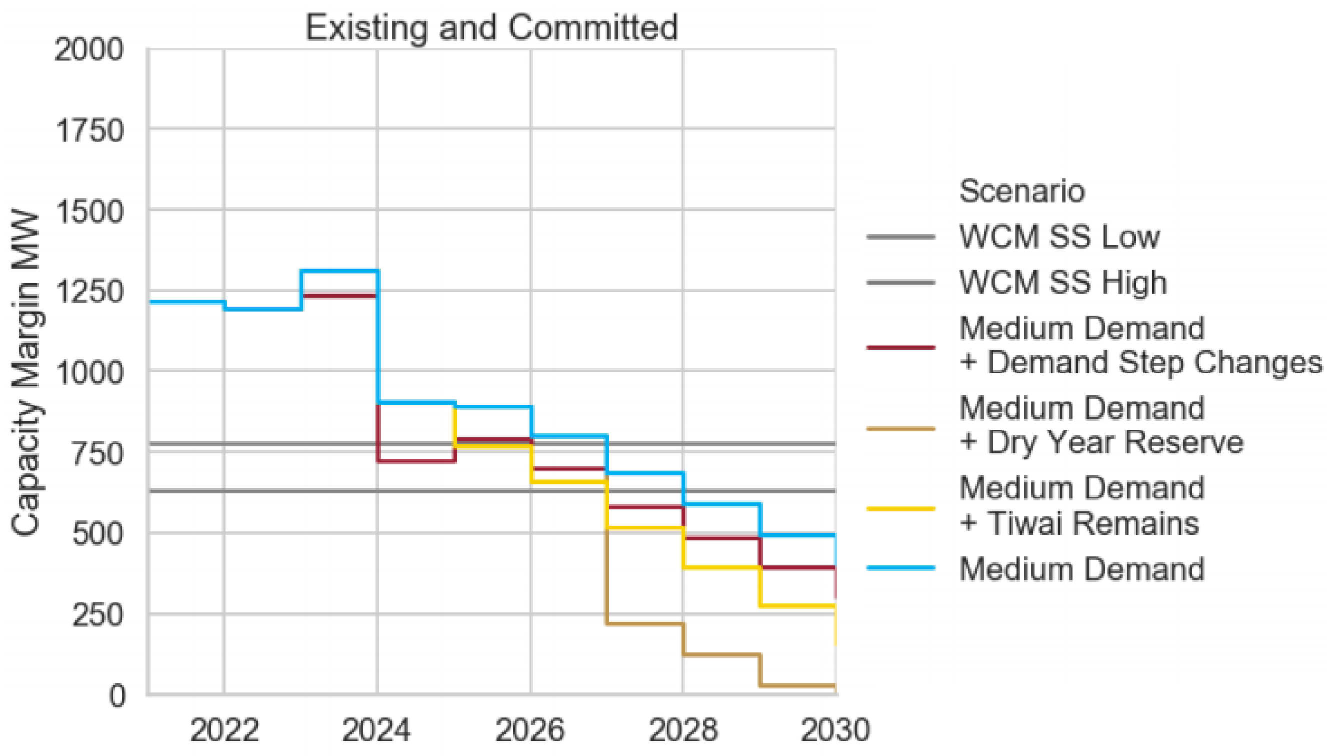
… which DERs can efficiently enable, driving price down for electricity consumers



DER can offer a range of services, including demand-side management, firming and ancillary services. Each of them can help increase consumer benefits.

Source: Cost-benefit-analysis-of-distributed-energy-resources-in-New-Zealand-Sapere-Research-Group-v2.pdf

North Island margin, a measure of peaking resource adequacy, is tight by 2025 in absence of new peaking investment and/or demand flexibility



- Transpower (as System Operator) consults on, and publishes an Annual Security of Supply Assessment
- The North Island winter capacity margin is likely to trend down as demand increases

Source: Security of Supply Annual Assessment 2021 (transpower.co.nz) – v1.0 under consultation at the time of writing

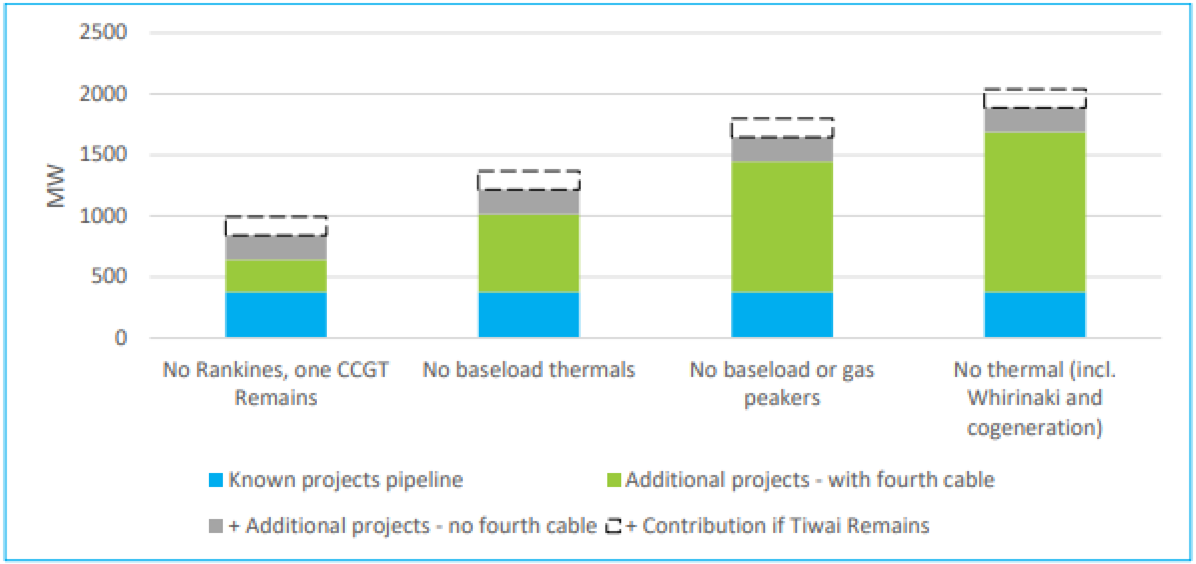
NB: Assumes Tiwai exits in 2025, HDVC remains at current capacity, the TCC is decommissioned in 2023, and one Huntly rankine unit is available. The full set of assumptions is included in the document

Context

Transition to 100% renewables

Additional capacity will be required

Figure 6: Additional capacity contribution from NI projects required in 2030 to meet the 780 MW security standard



Source: Security of Supply Annual Assessment 2021 (transpower.co.nz) – v1.0 under consultation at the time of writing

- The removal of thermal generation from the system requires additional dispatchable generation projects to be built above what is required to sustain demand from electrification
- In 2030, all scenarios considered show that additional capacity is required (green bar) on top of the known projects under consideration (blue bars) to meet North Island peak capacity margins

The challenges of maintaining capacity resource adequacy

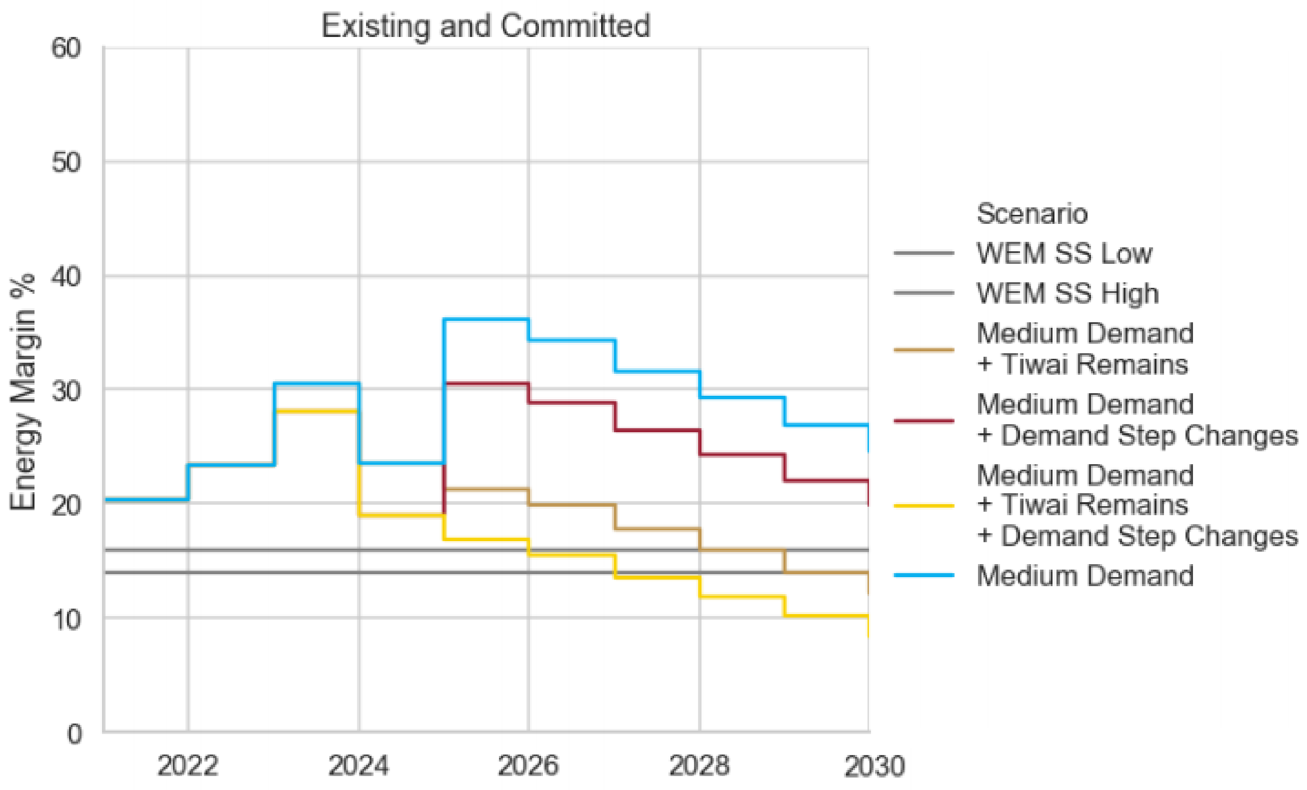
- As we transition into a system with more Variable Renewable Energy (VRE a.k.a. wind and/or solar), non-VRE generation will have to accommodate variability in demand and VRE output
- Greater system flexibility is needed from other controllable resources (e.g. demand response, hydro peaking, BESS, thermal peaking)
- Inflexible resources (e.g. slow-start thermals) will have a greater difficulty operating in this environment
- Increased need for fast-start, flexible resources to maintain short-term supply-demand balance

Two challenges for the current energy-only market design:

Can it provide adequate price signals for investment in new fast start peaking capacity?

Can it provide adequate price signals for less flexible thermal plant which we rely on to for longer term energy variability (dry-years)?

Energy margin, a measure of energy resource adequacy, is tight by 2028 in absence of new investment



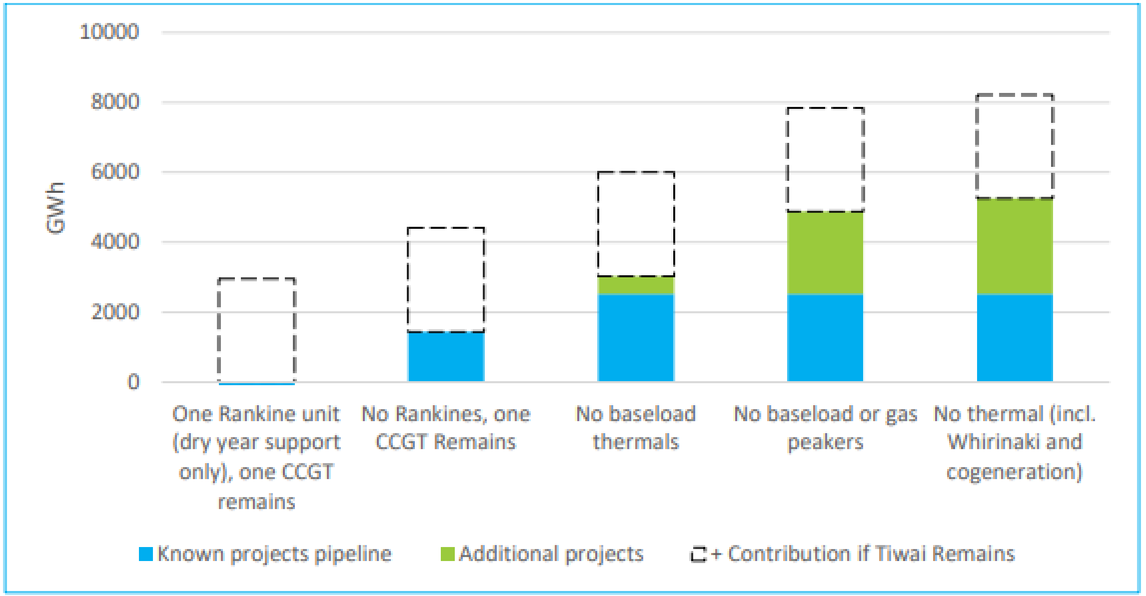
- Transpower (as System Operator) consults on, and publishes an Annual Security of Supply Assessment
- New Zealand's winter energy margin is likely to trend down as demand increases

Source: Security of Supply Annual Assessment 2021 (transpower.co.nz) – v1.0 under consultation at the time of writing

NB: Assumes Tiwai exits in 2025, HDVC remains at current capacity, the TCC is decommissioned in 2023, and one Huntly rankine unit is available. The full set of assumptions is included in the document

Energy security in dry year tumbles without thermal plants

Figure 26: Additional energy contribution required in 2030 to meet the 16% security standard



Source: Security of Supply Annual Assessment 2021 (transpower.co.nz) – v1.0 under consultation at the time of writing

- Thermal plants are contributing to the dry-year security
- The retirement of thermal plants will reduce the energy margins
- Additional projects are required to maintain security

The challenges of maintaining dry year resource adequacy

- Without thermal, we would need about ~9TWh to cover dry-year challenges in 2050
- Even if thermal generation stays, challenges remain:
  - Keeping slow-start thermal plants available to operate in a dry year has a significant cost
  - Some thermal plants require a guaranteed minimum run time and can take 3 to 12 hours to be operational
  - Access to fuel can add significant challenges
  - They might also require to be used on a regular basis to remain operationally ready
  - How to do this without dampening price signal for new dry year capacity?

Three challenges for the current energy-only market design:

Will new dry year cover be built?

Will the market signals be there to encourage building?

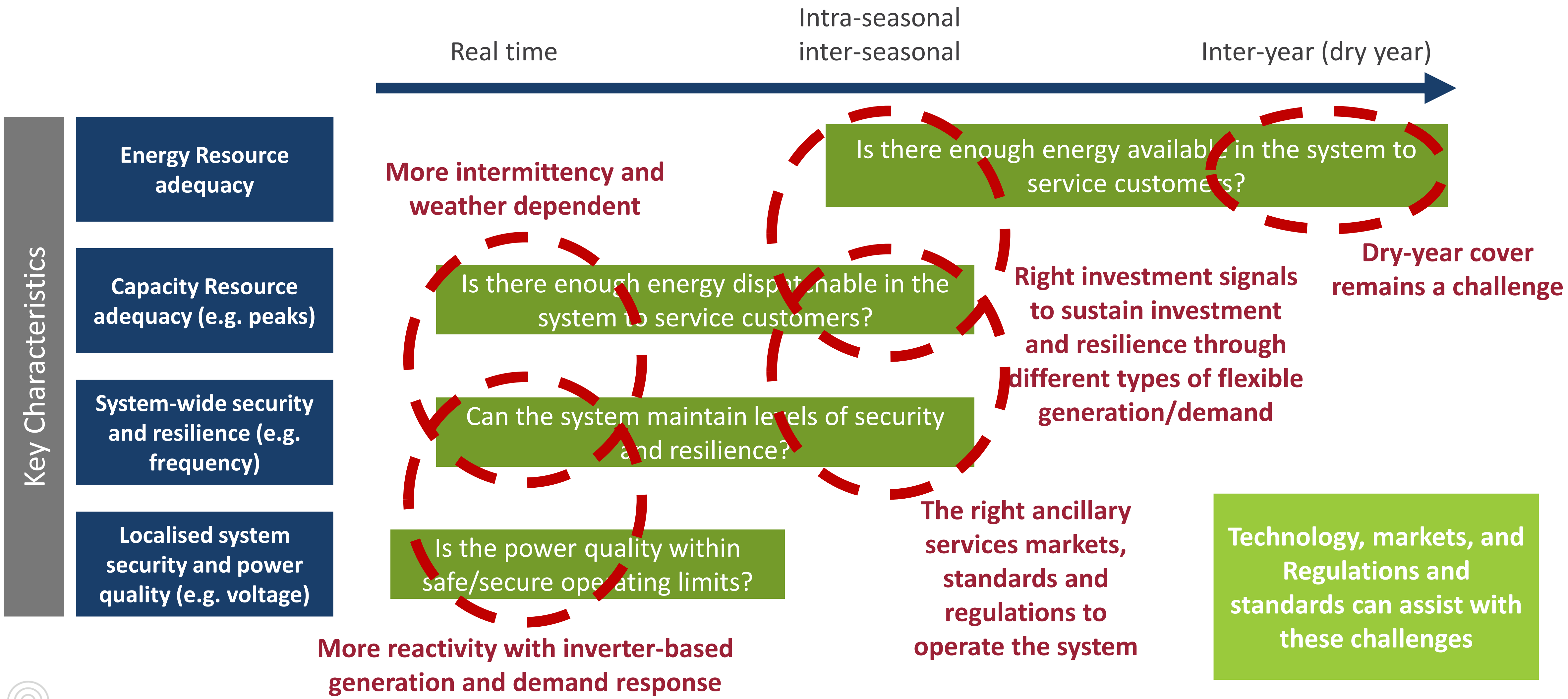
Are penalties an appropriate mechanism (e.g. costs to retailers if we have to run a campaign)?

Two main challenges need to be navigated

1. The market and regulatory settings required to transition to 100% renewables

2. **The market and regulatory settings required to operate and remain at 100% renewables**

At 100% renewable, intermittency and generation diversity is a challenge



Operating at 100% renewables

Possible solutions - technology

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
Hydrogen electrolyser	●	●	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	●	●	Environmental 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

Key

- ● Full ability to contribute
- ◐ Partial ability to contribute
- ○ No ability to contribute

Possible solutions - markets

Market option	Primarily targets peaks	Primarily targets dry year	Comments
Increase Customer Compensation Scheme payments		✓	Mechanism that exists today which could be scaled up – requires retailers to pay a weekly charge if their customers need to reduce energy use
Firm energy market		✓	Procures additional 'firm energy' to cover dry years – it is the dry year equivalent of a capacity market
Increase lake level requirements leading into winter		✓	Would allow for more energy cover entering winter – may still require additional firm energy in a dry summer to reach higher lake levels
Strategic reserve mechanism		✓	Designed to protect thermal baseload capacity for energy shortages. Possibly better designed as a market-based mechanism to provide other options
Retailer reliability obligation (RRO)		✓	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
Changes to reserves	✓		Greater intermittency might require more Fast Instantaneous Reserves (FIR) or the development of a Very Fast Instantaneous Reserve (VFIR) market
Procurer of last resort capacity	✓		This is back up reserve that is held for significant power events. An example is AEMO's RERT programme in Australia. This reserves some capacity for emergency events.
Flexibility Markets	✓		Could also provide additional ancillary services to the grid
Capacity market	✓		Procures the availability of peaking plant and/or demand response
Ensuring market settings allow batteries to realise true economic value	✓		Requires batteries to access multiple value streams (e.g. network deferral, energy, ancillary markets) simultaneously.
Balancing market	✓		A balancing market that operates between one and five minutes could provide a stronger price signal for flexible generation

Possible solutions – standards and regulations

Description	Upsides	Downsides
Standards on connected generation plants are especially useful to mitigate the risks to system stability and security	• Reduces the risk to system security and stability	• Can be a barrier for the uptake of technology
Regulations are in place to underwrite the investment required to cover resource adequacy	• Brings certainty to resource adequacy	• Not economically efficient • Distorts the market