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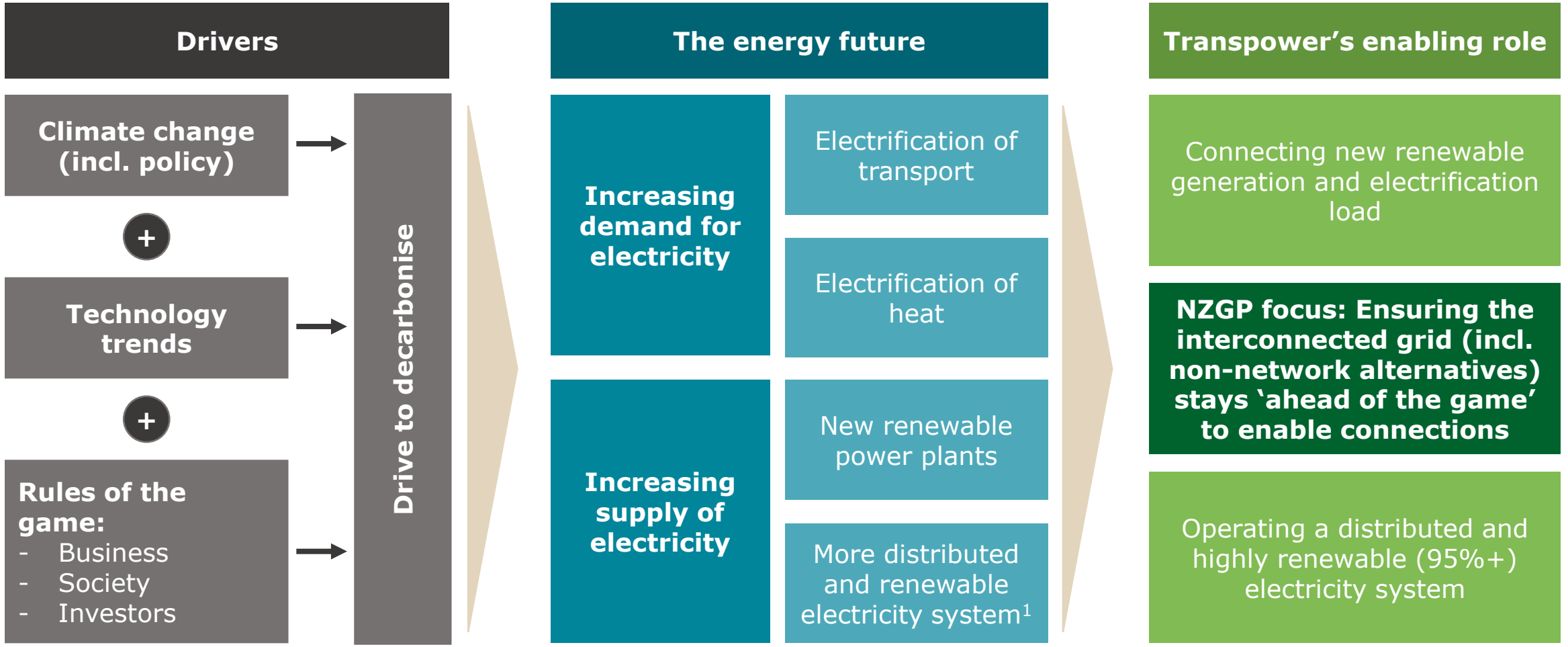
Net Zero Grid Pathways

Empowering our energy future

The energy future has implications for the grid



1. These trends are likely to result in some form of market disruption that will lead to value shifts within the energy sector. These could include value shifting from fossil fuel transport and process heat energy sources to electricity, from thermal generation to renewable generation, from poles and wires solutions to poles and wires alternatives, from local incumbents to new domestic and international entrants, from a shift 'down the value chain' to distributed energy resources, and from traditional markets to new trading platforms and modes of transacting energy

Recap: Net Zero Grid Pathways context

- Net Zero Grid Pathways takes an integrated view of future grid investments
- This is needed to facilitate *least regrets* decisions so that we do not over invest in the grid, but also so that we are an enabler for the energy future
- Our initial focus for Net Zero Grid Pathways was to identify near-term investments required in a Tiwai Exit scenario
- We are now looking at a broader scenario set. Our initial focus will be on least regrets investment required to 2035

Net Zero Grid Pathways – What we have done to date

- Commenced the Clutha Upper Waitaki Lines Project
- Commenced System Operator investigations to ensure that we can continue to operate the New Zealand power system securely
- Completed EDGS 2019 scenario workshops and have received submissions
- Conducted high-level system planning to broadly understand what investments may be required under a Tiwai Exit scenario

Today's Net Zero Grid Pathways presentation

- Part 1: Change in context since NZAS' announcement to stay until at least December 31 2024 - Richard Hobbs, GM Strategy and Customer
- Part 2: Areas of grid investigation, our initial findings and next steps for the NZGP project – John Clarke, GM Grid Development
- Part 3: Impact on the operation of the grid and system – Stephen Jay, GM Operations

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Richard Hobbs: A Change in Context

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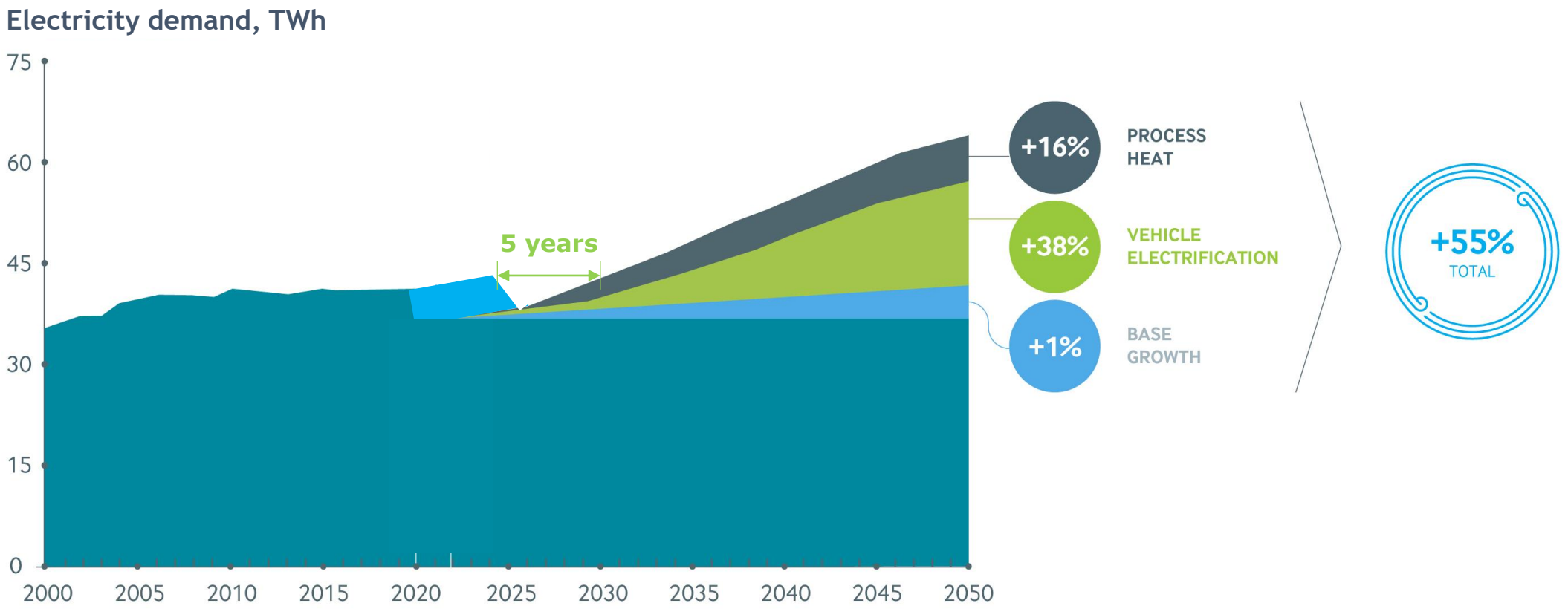
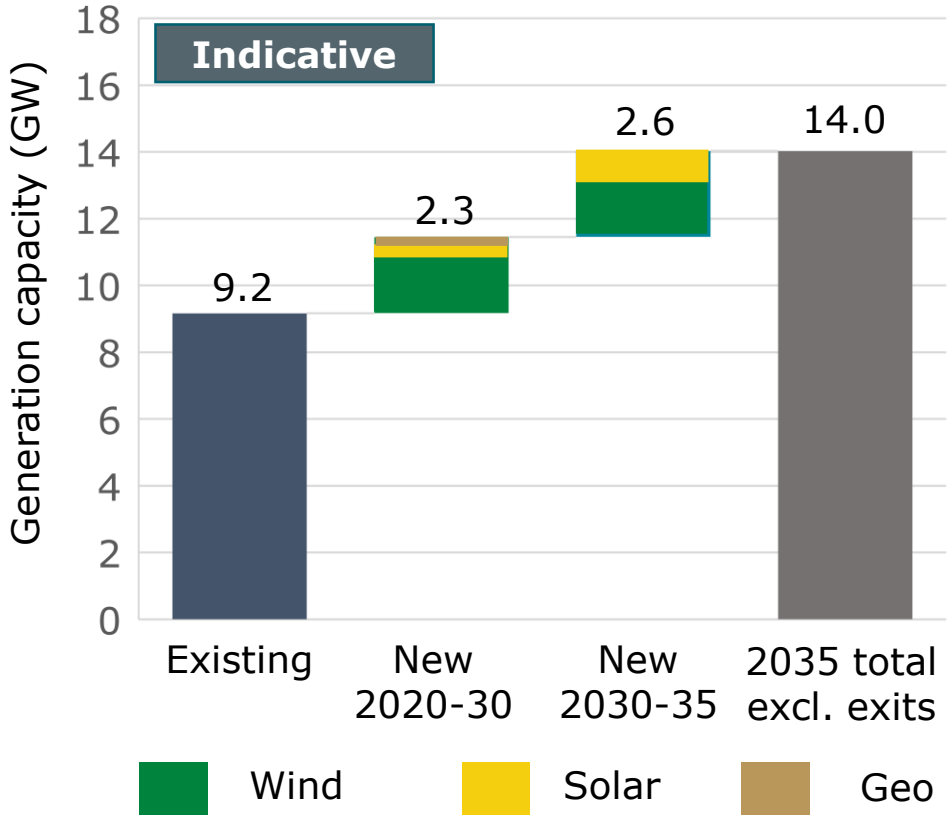
Whakamana i Te Mauri Hiko shows that short-term Tiwai uncertainty is followed by mid to long-term load growth

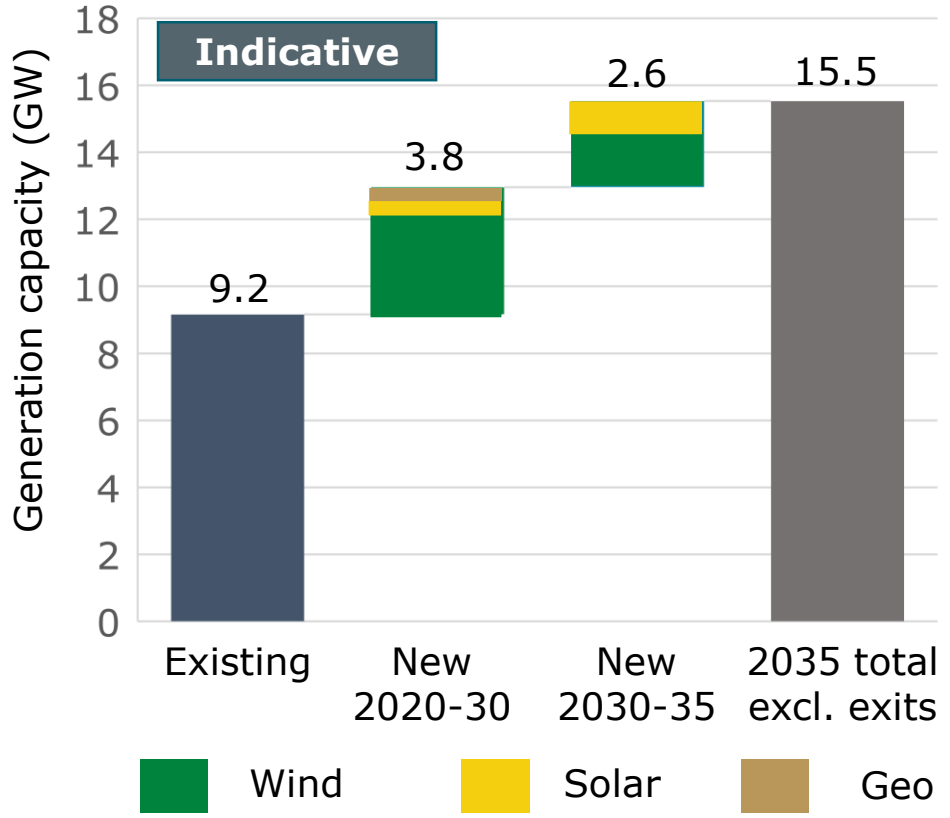


If Tiwai remains the amount of new generation needed could be significant

New renewables if Tiwai exits



New renewables if Tiwai remains



Source: Transpower analysis based on Climate Change Commission's Our Path Scenario
Note: CCC numbers converted by Transpower from energy (TWh) to capacity (GW) using capacity factors of 90% for geothermal, 40% for wind and 20% for solar. Tiwai remains graph assumes wind and solar energy covers additional 5 TWh

Different uncertainties impact our need for energy South Island to North Island transfer differently

Different uncertainties impact our interconnection investment decisions in different ways	
High need for SI to NI transfer	**Lower need for SI to NI transfer**
• Tiwai exit in 2024 (fewer connections) • Thermal generator retirements (more connections) • Urban transport electrification (more connections) • NI process heat electrification (more connections) • Hydrogen production in Taranaki (more connections) • Generation expansion far from load (neutral)	• Tiwai remains (more connections) • Datacentre in Southland (more connections) • NI industrial closures (fewer connections) • SI process heat electrification (more connections) • Hydrogen production in Southland (more connections) • Generation expansion near load (neutral)

Uncertainties (uncertain impact)	
• NZ Battery project findings • Impact of TPM on peak demand	• 100% renewables target • Gas availability

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John Clarke: Areas of investigation

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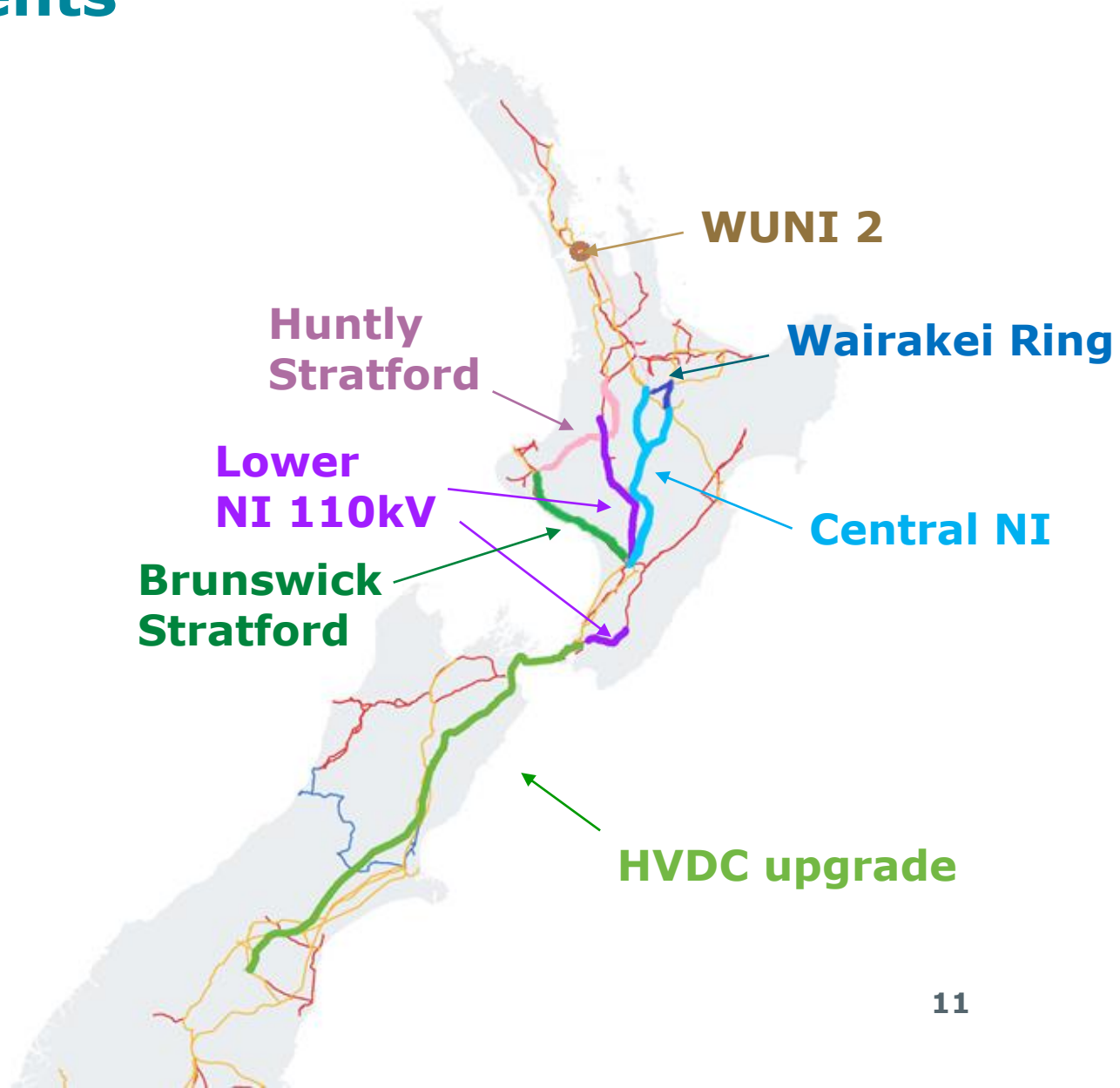
Net Zero Grid Pathways is simultaneously investigating a number of potential investments

Investing under uncertainty

- Both demand and supply are highly uncertain
- Some investments are driven by new generation connections
- Others are driven by scenarios where there is high south to north transfer required
- All areas of investigation are likely to need some kind of enhancement, but the scale is uncertain

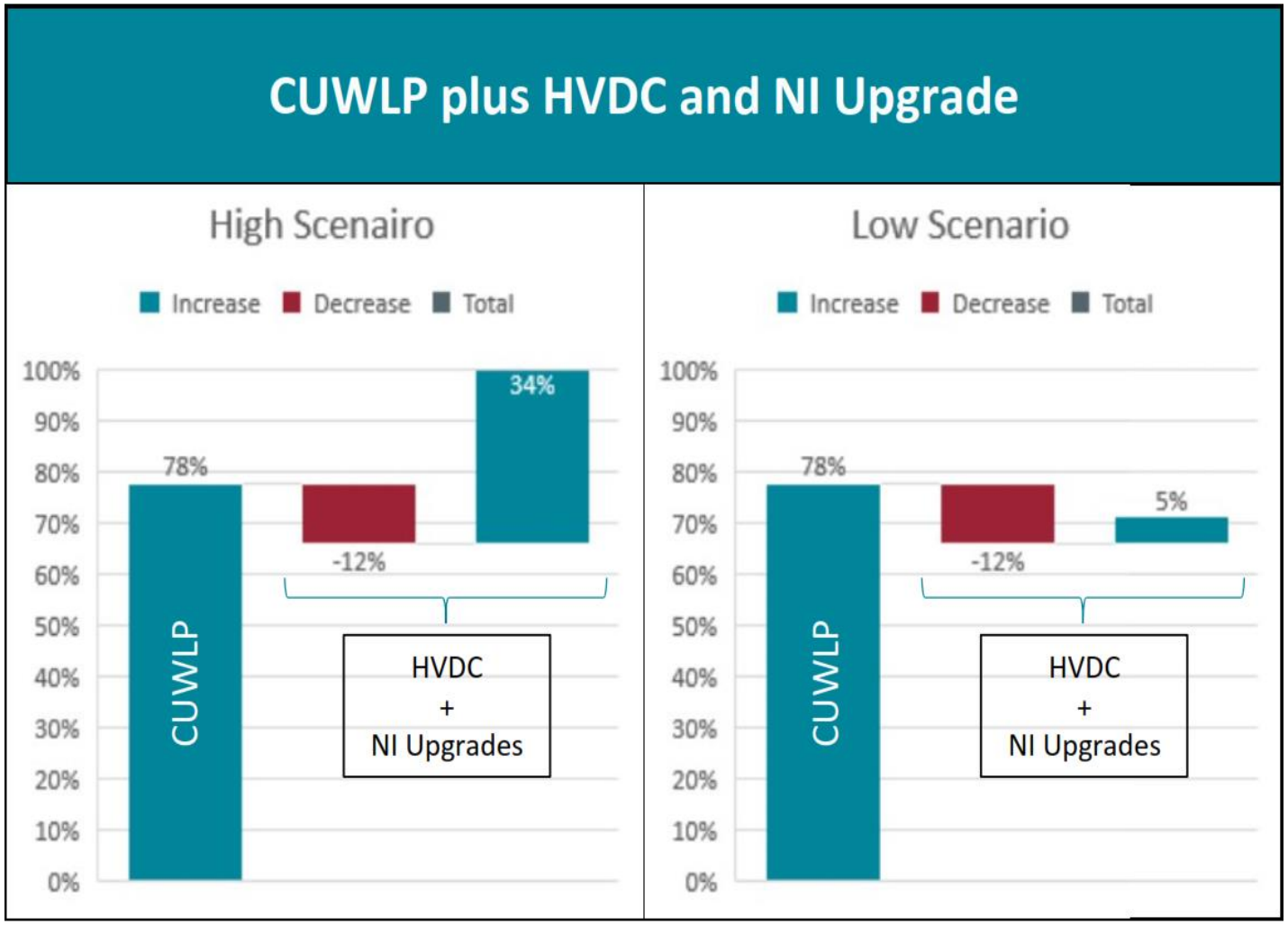


Industry support and engagement – demand and supply scenarios for NZGP work

Variations to EGDS to align with current context

- Identifying variations to MBIE EDGS to support portfolio approach for MCP's
- Demand scenarios – Industry working group and consultation on results. Valuable input, thank you
- Generation scenarios – many options for wind and solar build. Need industry input on build timing to inform investment test scenarios
- Questionnaire next month, finalise scenarios June.

Investments are more valuable as a portfolio than if assessed individually



Decision to progress Wairakei Ring series reactor

Least Regrets – Wairakei Ring Constraints

- Series reactor provides up to 600MW added capacity into upper North Island through the "Wairakei Ring"
- High benefit low cost project. Cost ~ $12m
- Commitment of new wind and geothermal generation makes the case as a least regrets investment
- Investigation underway, planned commissioning in 2023
- Subsequent investment in line upgrades possible in early 2030's

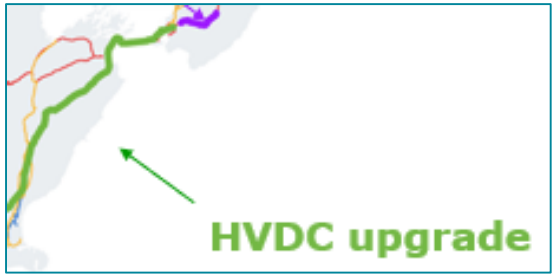
HVDC options – added capacity across Cook Strait

Replace cables in early 2030s

- If added transfer need is low
- End of life cable replacement
- No extra capacity – 1200MW
- Cost ~$500- $600M

Enhanced STATCOM

- Increased transfer need early
- Install before 2030's upgrade
- Extra capacity mid 2020's
- Cost $>100M



Lower Transfer → Higher Transfer

Replace & upgrade cables in 2030s

- Increased transfer need later
- Upgrade and replace
- 1400MW capacity
- Cost ~$650-800M

4th cable 2028

- Increased transfer need large and immediate
- 1400MW capacity
- Cost $~150M

Benefits in high transfer scenario

- Increases access to low cost South Island generation
- Increases ability for North Island generation to displace South Island water in dry years

Benefits in high connection scenario

- Increases ability of SI hydro to provide peaking and firm North Island intermittent renewables
- Increases ability for North Island generation to displace South Island hydro in dry years

Central North Island upgrade options

Less added capacity required

More added capacity required

110kV reconfiguration

- CNI additional grid capacity need low
- Increase transfer on 220kV backbone
- Limited physical works ~$10-20M

Upgrades to 220kV lines

- CNI capacity need for limited added connection or transfer
- Low physical works, deliver mid-late 2020's, ~$50-80M

Reconductor/Duplex 220kV Lines

- CNI capacity need for moderate added connection and transfer
- Deliver before 2030
- Cost ~$250-350M

Parallel new line

- CNI capacity need for high transfer and connection
- Longer lead time, tactical upgrades in interim?
- Cost ~$700-900M??

Benefits in high transfer scenario

- Increases access to low cost south island generation
- Increases ability for North Island generation to displace South Island water in dry years

Benefits in high connection scenario

- Increases capacity for new Wellington / Wairarapa / Manawatu / Taranaki renewables
- Increases ability of South Island hydro to firm North Island intermittent renewables

Taranaki Import and Export Capacity Brunswick-Stratford MCP

Future options for Taranaki Region
• Plan to rationalise two existing parallel lines into one single line • Can upgrade remaining line to match current capacity of two existing lines • Presently no need to match capacity with forecast reduced baseload generation in Taranaki region • MCP at short list stage with four possible outcomes ($0-120M) • Transfer - depends on extent and timing of renewable development or major new loads – Hydrogen? • Connections – capacity required to balance renewables and new load

Waikato and Upper North Island

Implications of 100% renewables by 2030 on Upper North Island Supply

- Potential reduction and possible closure of thermal generation in upper NI addressed by our WUNI 1 and 2 investigations
- WUNI stage 1 approved $140m – installing one STATCOM on hold for 2nd STATCOM
- WUNI stage 2 under investigation
- Battery solutions offered as non-transmission solutions for stage 1
- Will seek interest in such alternatives for both balance of WUNI 1 and for WUNI 2

Role of Batteries and Transmission Alternatives

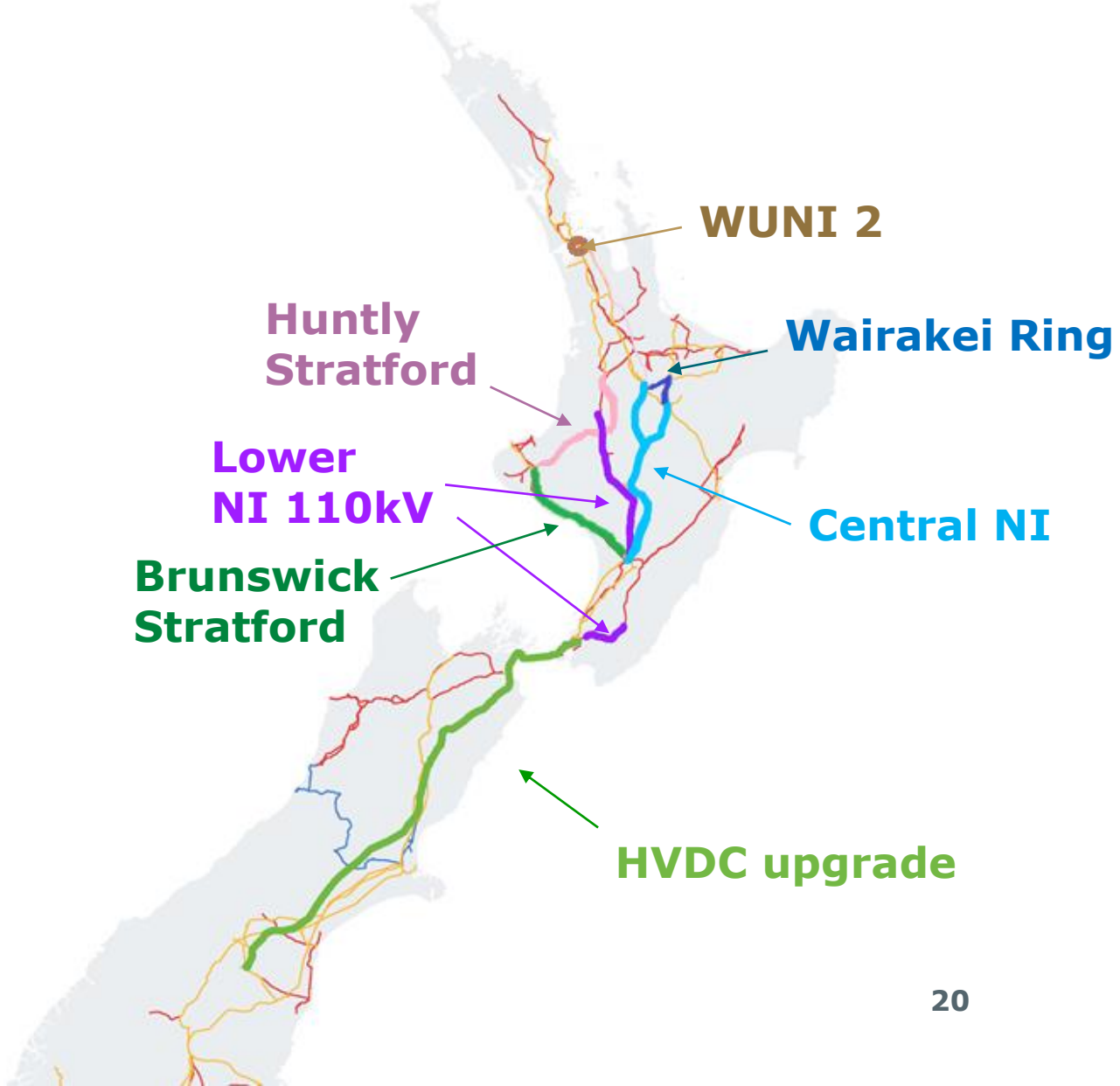
Batteries offer Non-Transmission Solutions

- Following the announcement of the smelter closure, interest in a grid connected battery to increase North Island reserves and HVDC transfer
- Grid connected batteries located in the upper and central NI could offer other optionality, deferral and efficiency benefits e.g.:
- Address remaining WUNI 1 and the WUNI 2 voltage needs in part/full
- Optimise sizing of CNI upgrades
- We will invite interest in non-transmission solutions for CNI, balance of WUNI 1 and as we investigate WUNI 2

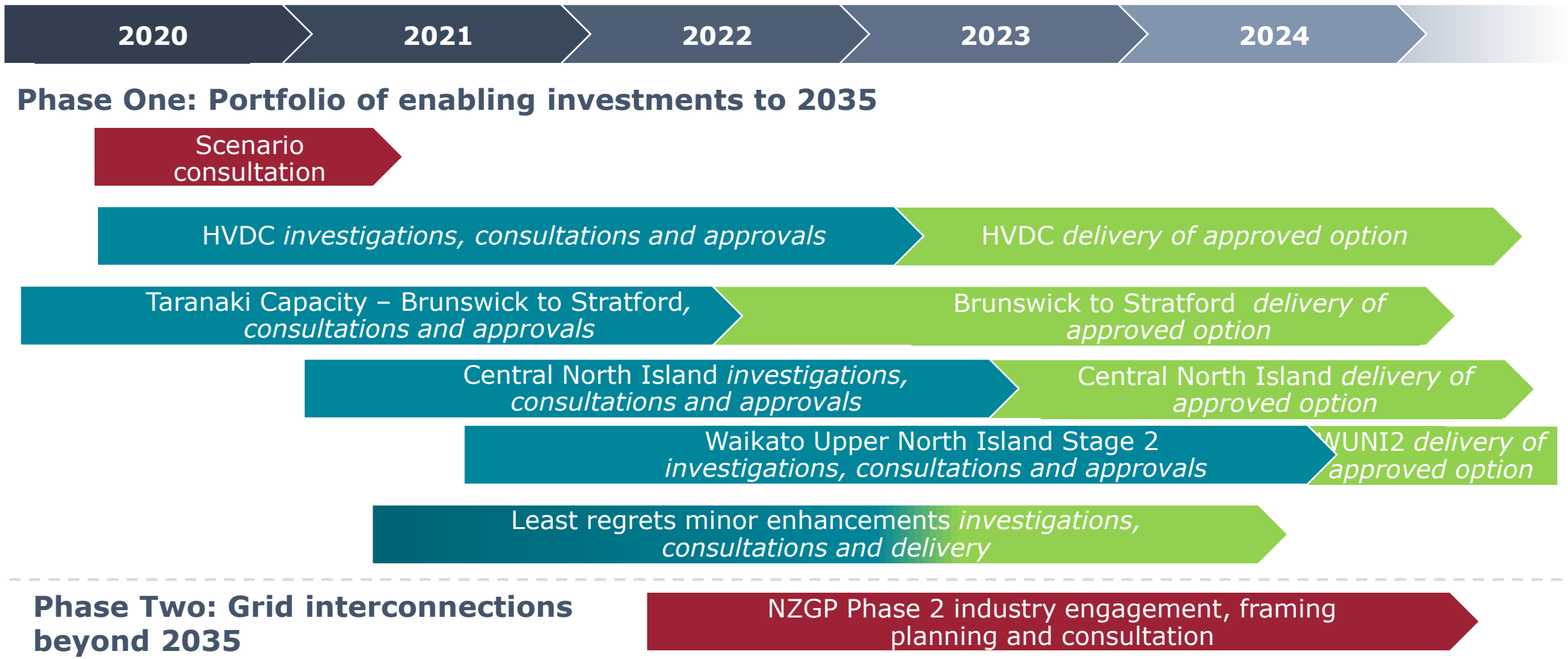
Progressing our investigations and MCPs

What we are doing - next 6 months

- Engagement on likely generation build sequence – questionnaire in April. Scenarios confirmed end June
- Progressing Wairakei Series Reactor for delivery in 2023 as low cost high benefit initiative
- Progressing MCP development for Brunswick-Stratford as well as HVDC and CNI, plus WUNI 2
- Issue an expression of interest in non-transmission solutions such as grid scale batteries assess wider benefits as part of our MCP development.



NZGP Phase 1 & 2: Implementation roadmap



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Stephen Jay: Operating the future grid

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Context: Main role of Operations

Ensure security of supply (System Operator)	• Ensuring there is enough generation and transmission to meet peaks and dry years • Operations assesses security of supply in the short-term (up to 18 months ahead) and the longer term (up to 10 years) and manages security of supply emergencies
Maintain power system stability (System Operator)	• Ensure the power system is able to manage disturbances and return to stable conditions if disturbances occur. • Operations coordinates the power system, procures contracts for essential ancillary services and ensure participants meet Code requirements for system reliability
Efficiently manage the market (System Operator)	• Operations coordinates the market in real-time and manage market events when they occur • We must dispatch the market in a way that maintains power system stability and the efficient allocation of resources
Operate the Grid (Grid Operator)	• Operations plans and co-ordinates outages of generation and transmission assets, operates grid assets in real-time and manages unplanned events • Planning and safely coordinating grid asset switching and operations and dealing with unexpected Grid events

Key trends will lead to a very different system in 2030

Key trends	Current	2030
Decarbonised: Transition to 100% renewables	• 80-85% renewable electricity • Mostly synchronous generation	• 100% renewable electricity • More asynchronous and inverter based generation
Decarbonised: More electrified economy	• High reliance on electricity in the economy • Flat demand growth	• Very high reliance on electricity • Many different demand growth sources
Distributed: More distributed electricity grid	• Small distributed resource penetration • Limited use of demand-side technology to manage peaks	• More consumer participation & more players • Multi-directional power flows
Digitised: Increasing digitisation and use of digital tech	• Increasing data requirements • Increasing use of automation for control and switching	• Increased complexity and volume of data • Expectation that controls, and communications will be automated

Key trends impacting Operations

Key trends

Decarbonised: Transition to 100% renewables

Decarbonised: More electrified economy

Distributed: More distributed electricity grid

Digitised: Increasing digitisation

Resulting in challenges and opportunities for Operations' ability to…

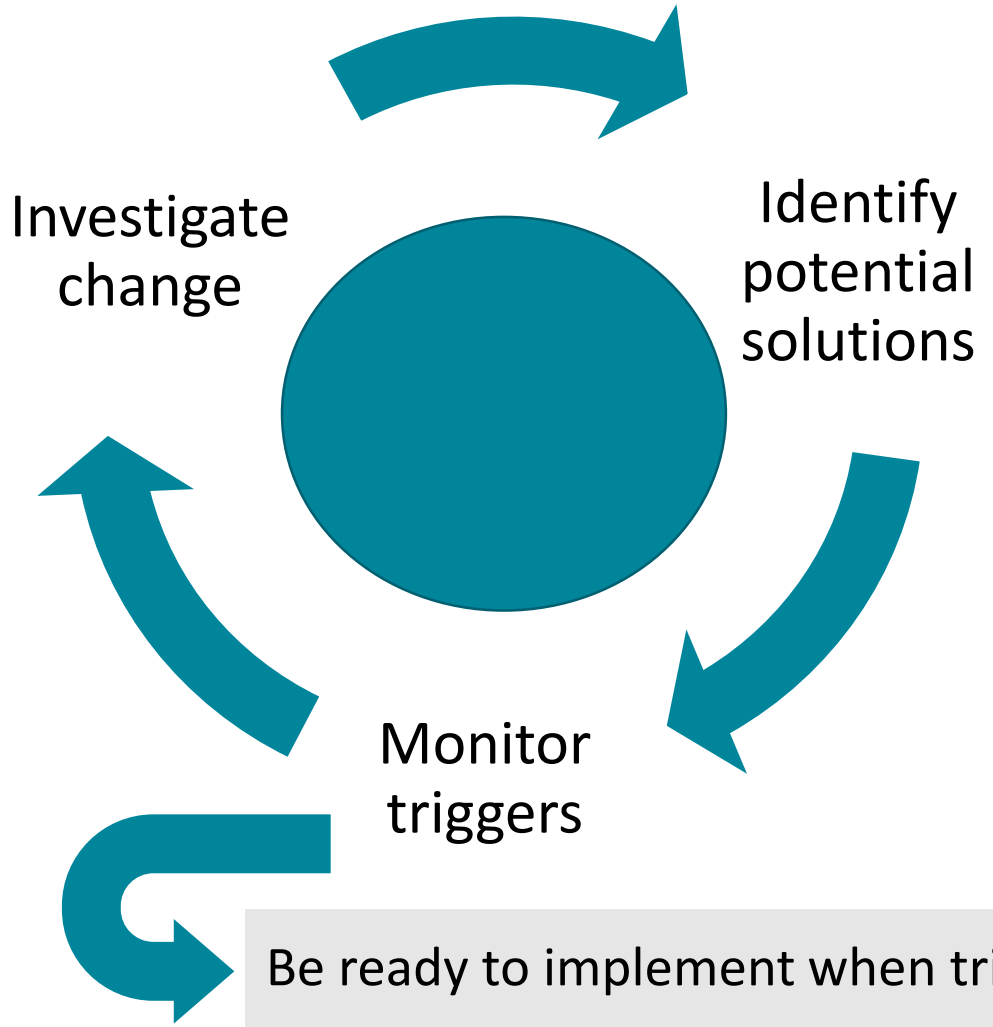
Ensure security of supply

Efficiently manage the market

Maintain power system stability

Operate the Grid

Operations is investigating a range of topics to ensure we are prepared to adapt as required



Be ready to implement when triggered

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Questions

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