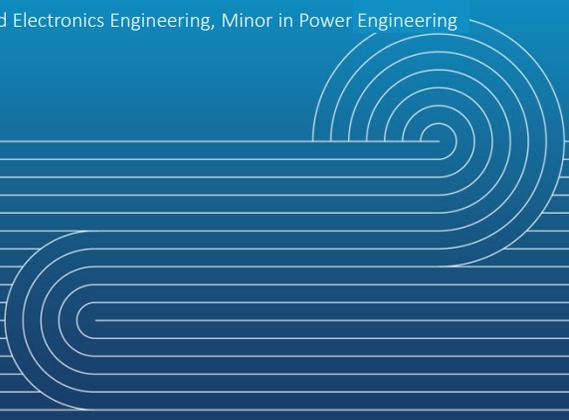


TRANSPower

The challenges with a changing generation portfolio and an introduction into grid-forming inverters



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Agenda for today's presentation

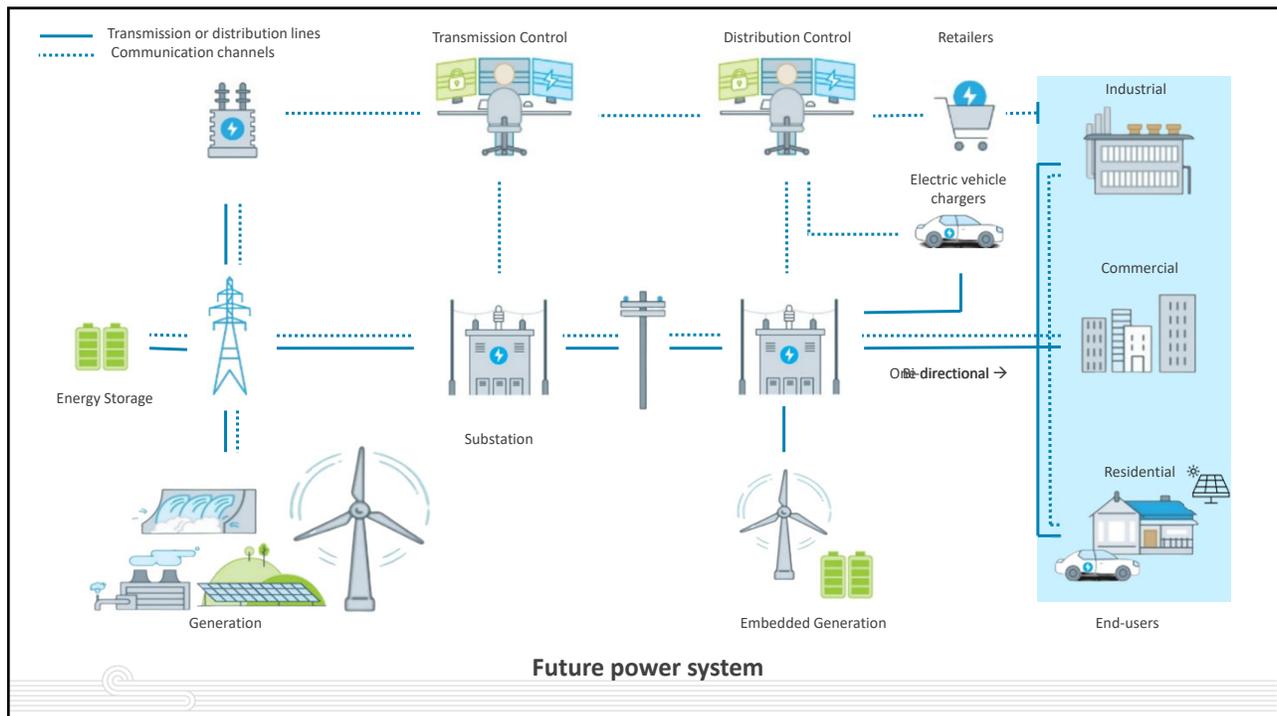
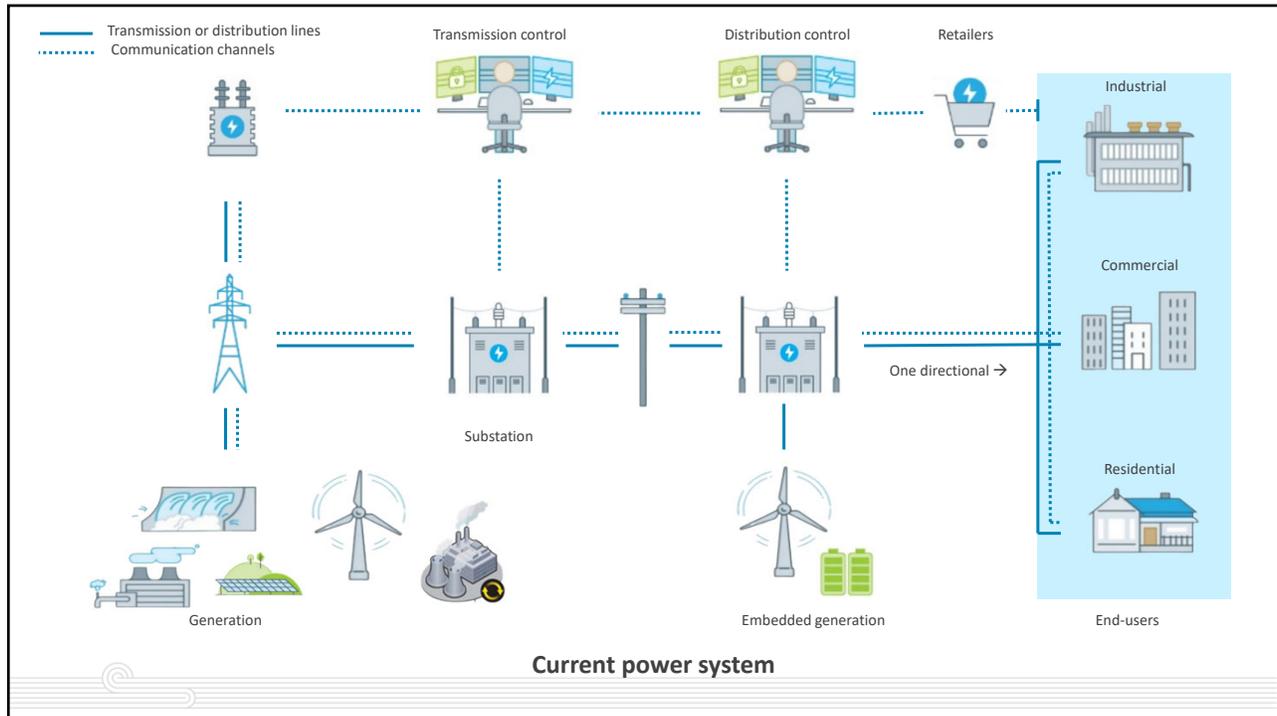
A changing generation portfolio

- What our future grid looks like
- Effects of a changing generation portfolio

Introduction into grid-forming inverters

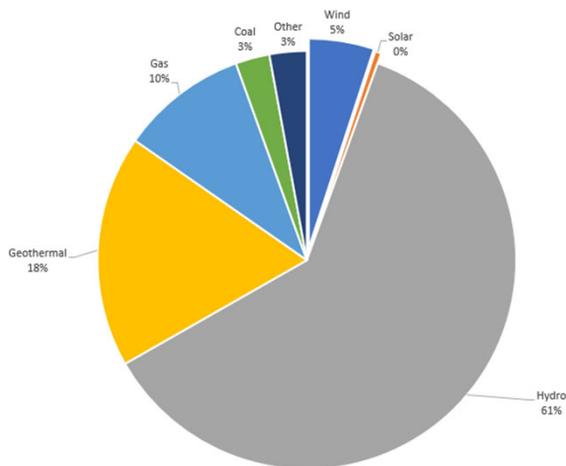
- Grid-following inverters
- Grid-forming inverters
- Droop control



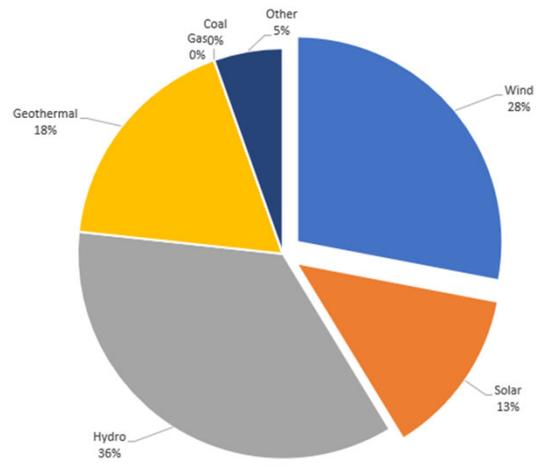


Projected generation portfolio

2020 Delivered electricity by generation type



2050 Delivered electricity by generation type



TP Whakamana | Te Māuri Hiko.pdf (transpower.co.nz)

Synchronous generation vs inverter-based generation

Synchronous Generation

- Rotate a turbine to generate electricity
- Connects directly to the grid
- Inherently provides inertia due to the rotating mass
- Provides up to 6 pu fault current
- Black-start capability

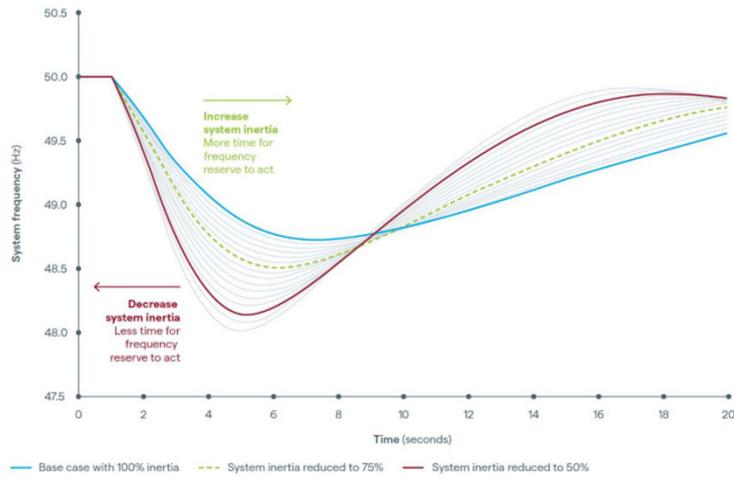


Inverter-based Generation

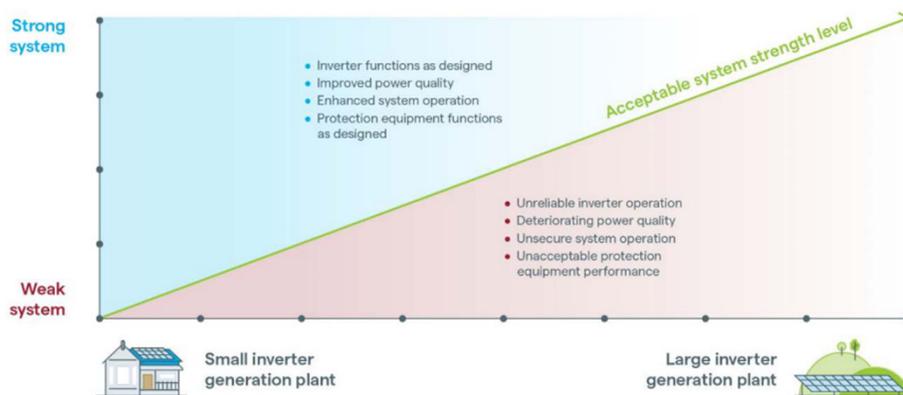
- Requires an inverter to connect to the grid
- Does not naturally provide inertia
- Limited to 1.2 pu fault current
- No black-start capability



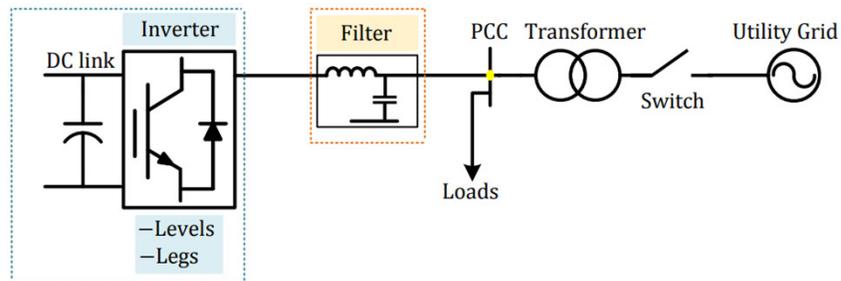
Impacts of inertia to the power system



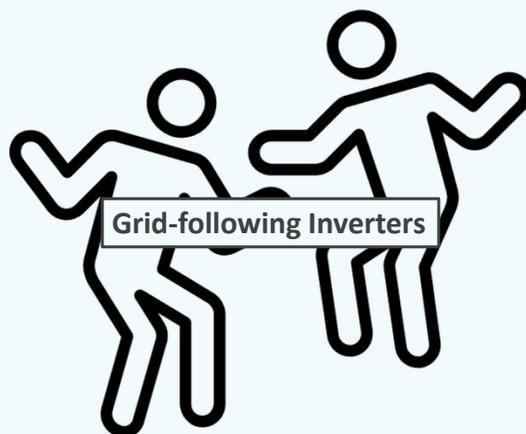
Impact of increasing inverter-based generation on system strength



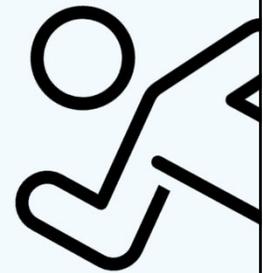
Inverter-based generation topology



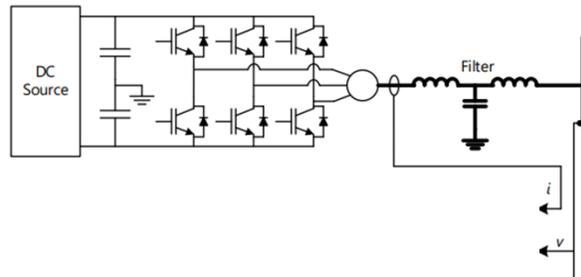
Two types of inverters



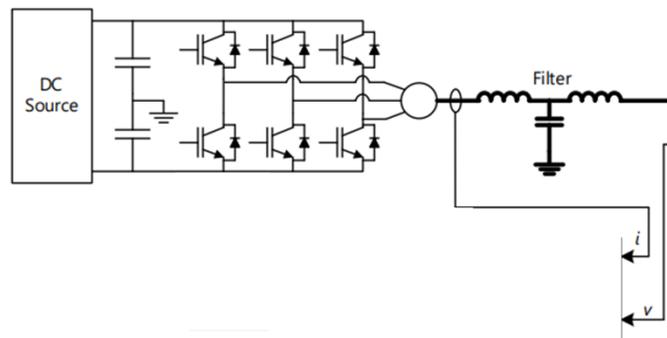
Grid-forming Inverters



Existing grid-following inverter control



Grid-forming inverter control



Droop control – cruise control analogy

Uphill represents a decrease in frequency

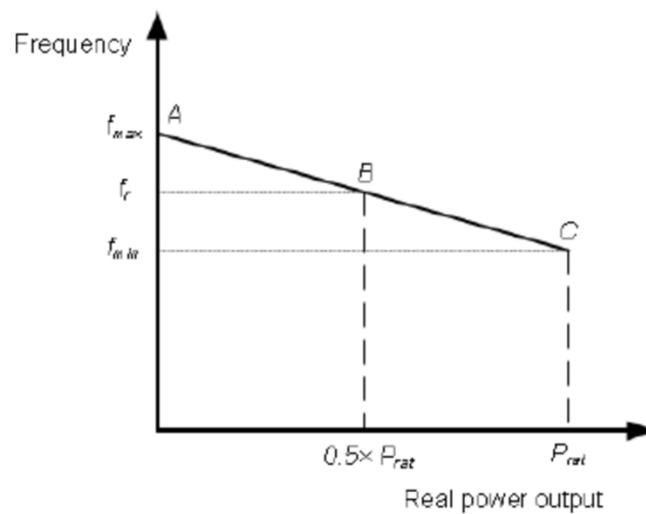
Car needs to put in more power to maintain the same speed

Downhill represents an increase in frequency

Car needs to put in less power/brake to maintain the same speed



Droop curve



Grid Following Inverters vs Grid Forming Inverters

Grid-following inverters (GFL)	Grid-forming inverters (GFM)
<ul style="list-style-type: none"> • Controls inverter terminal current • Current source • Requires phase-locked loop • Reliant on an external voltage signal • Cannot operate with 100% GFL inverters • Unstable in weak grids • No black-start capability 	<ul style="list-style-type: none"> • Controls inverter terminal voltage • Voltage source • Does NOT need a phase-locked loop • Standalone operation possible • Stable in relatively weak grids • Can maintain grid stability with 100% inverter-based generation • Black-start capability

Key takeaway

The power system is changing

We will see far more inverter-based and less synchronous generation as New Zealand electrifies its economy to decarbonise for the future

