Orchestrating Aotearoa's distributed energy resources to maximise whole-system value

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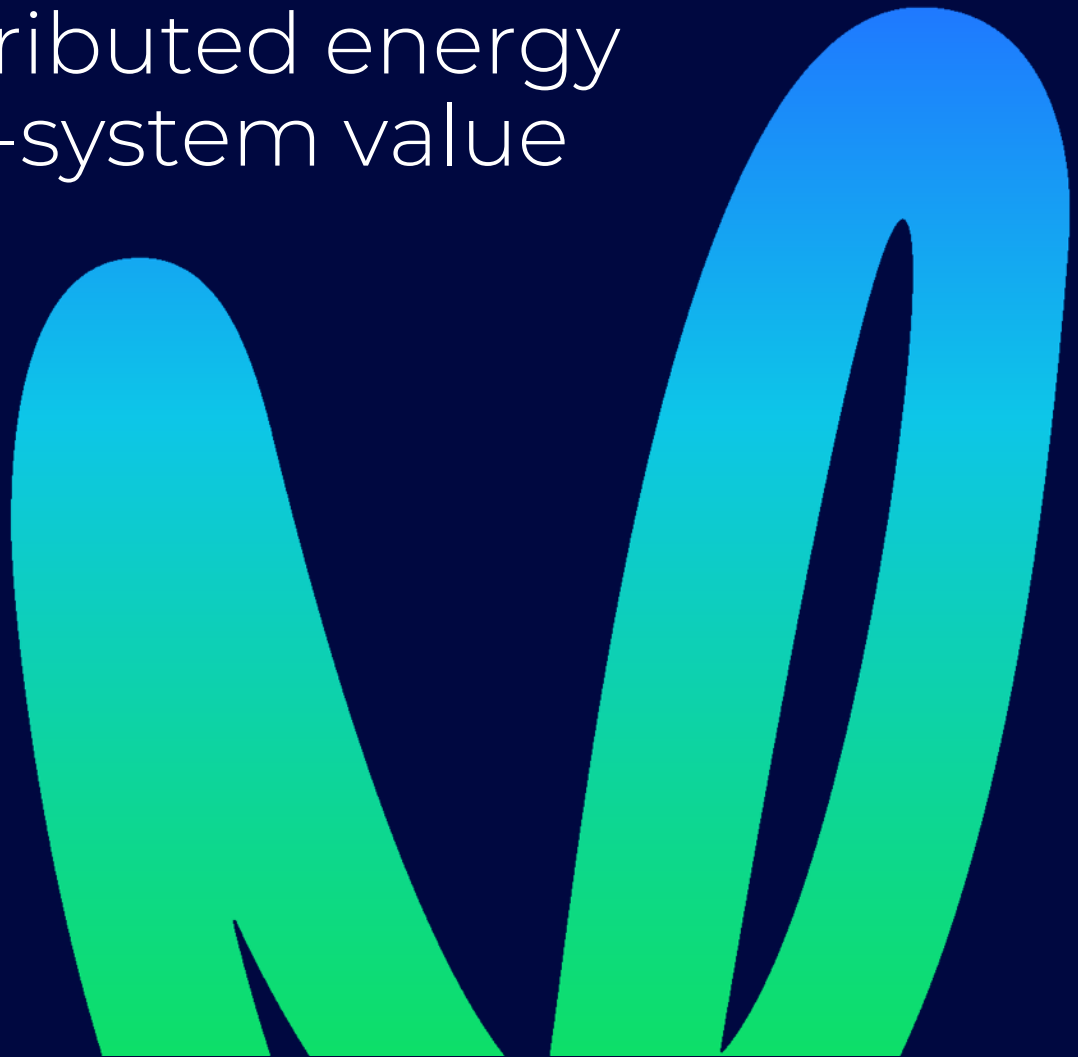
GM Market Strategy / Regulation

21 February 2024



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Agenda

- The evolving electricity system and terminology
- Different ways distributed energy resources (DER) can deliver whole-of-system value
- What's required to unlock / enable that value
- Future roles, architecture and relationships required
- Further reading

Acknowledgement: Many of the slides in this pack have been borrowed from other sources, including Electricity Networks Aotearoa and the Northern Energy Group

Who am I?

- **2022 –** **Vector: GM Market Strategy/Regulation**
  Co-chair, ENA Future Networks Forum
- 2019 – 2022 Electricity Authority: Chief Strategy Officer
- 2009 – 2019 Trustpower:
  - Corporate / organisational strategy
  - Business cases for new generation investment
  - Policy and regulation – all products/markets
  - Wholesale market trading, analytics and foresight
- 2006 – 2009 Energy market consultant (UK)
- 2002 – 2006 Energy market consultant (NZ)
- 2003 – 2006 Energy market researcher
  Part-time university lecturer

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The evolving system and terminology

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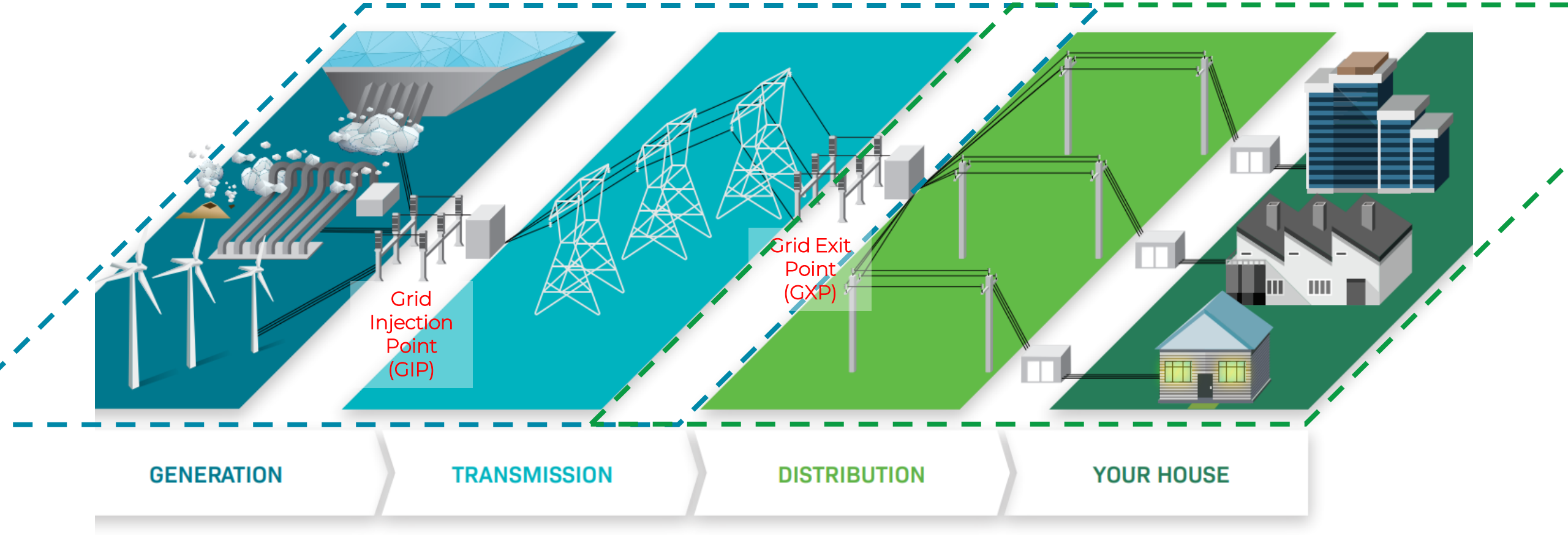
Power system components (traditional)



WHOLESALE MARKET
Electricity is sold and purchased on the wholesale market

RETAIL MARKET
Retailers (power companies) sell electricity to consumers

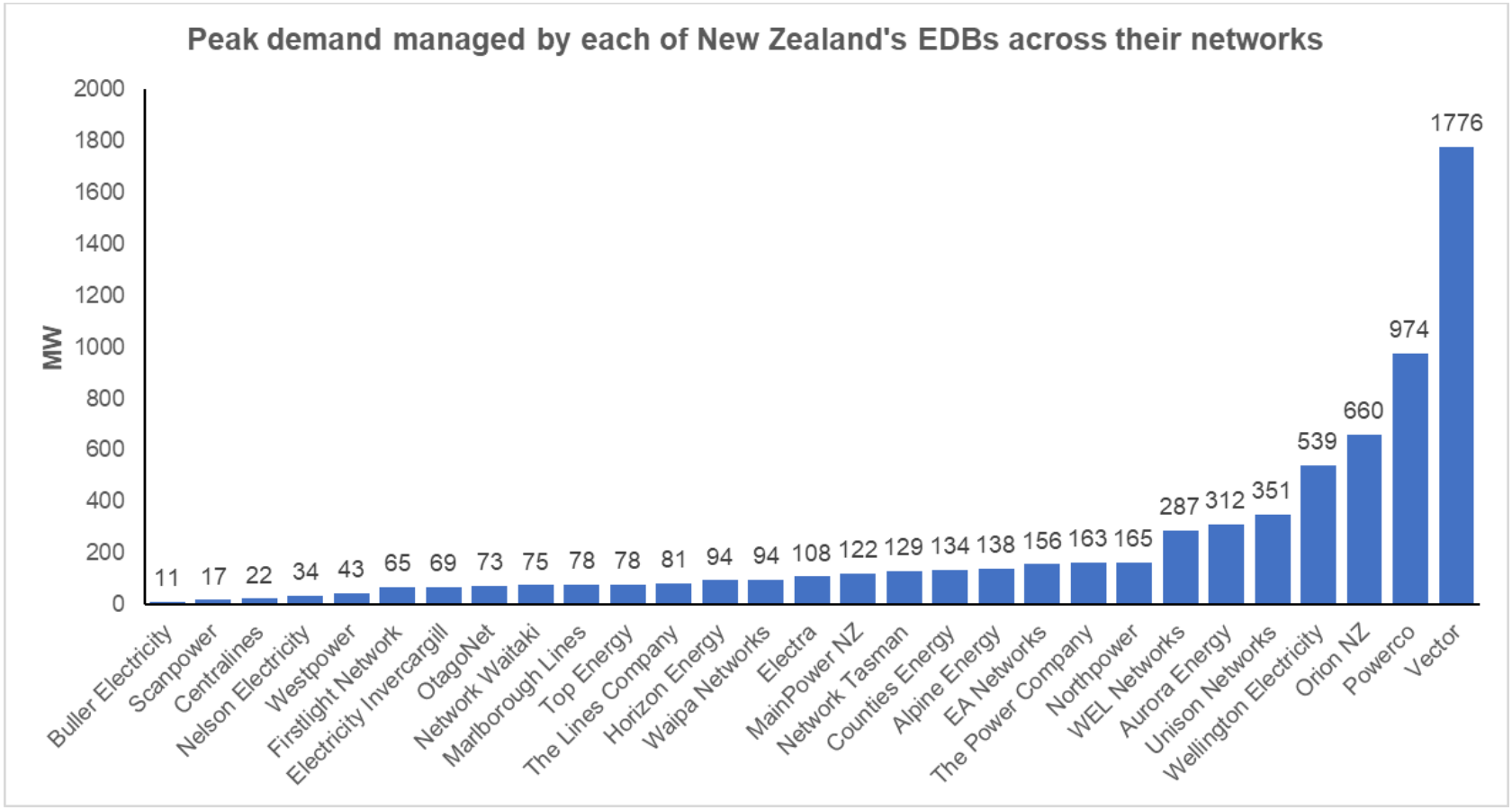
Source: EA, Electricity in NZ (2018)

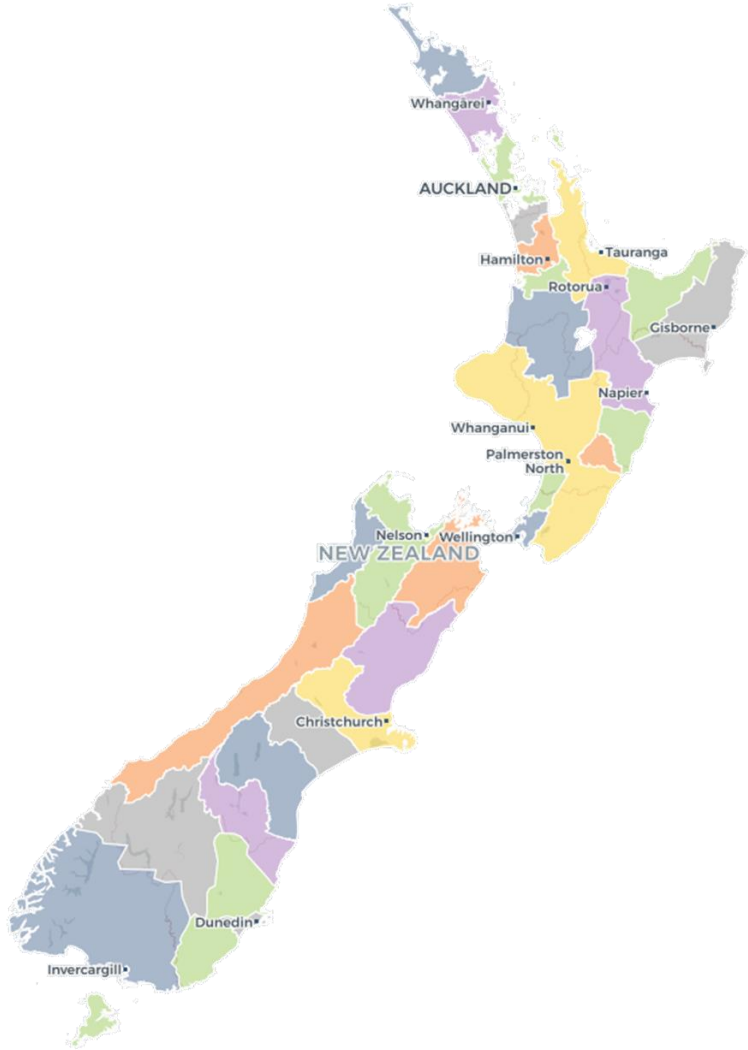
The electricity transportation companies

- Transmission:
  - Transpower is Grid Owner

- Distribution
  - NZ has 29 Electricity Distribution Businesses (EDBs)

New Zealand’s range of distribution businesses





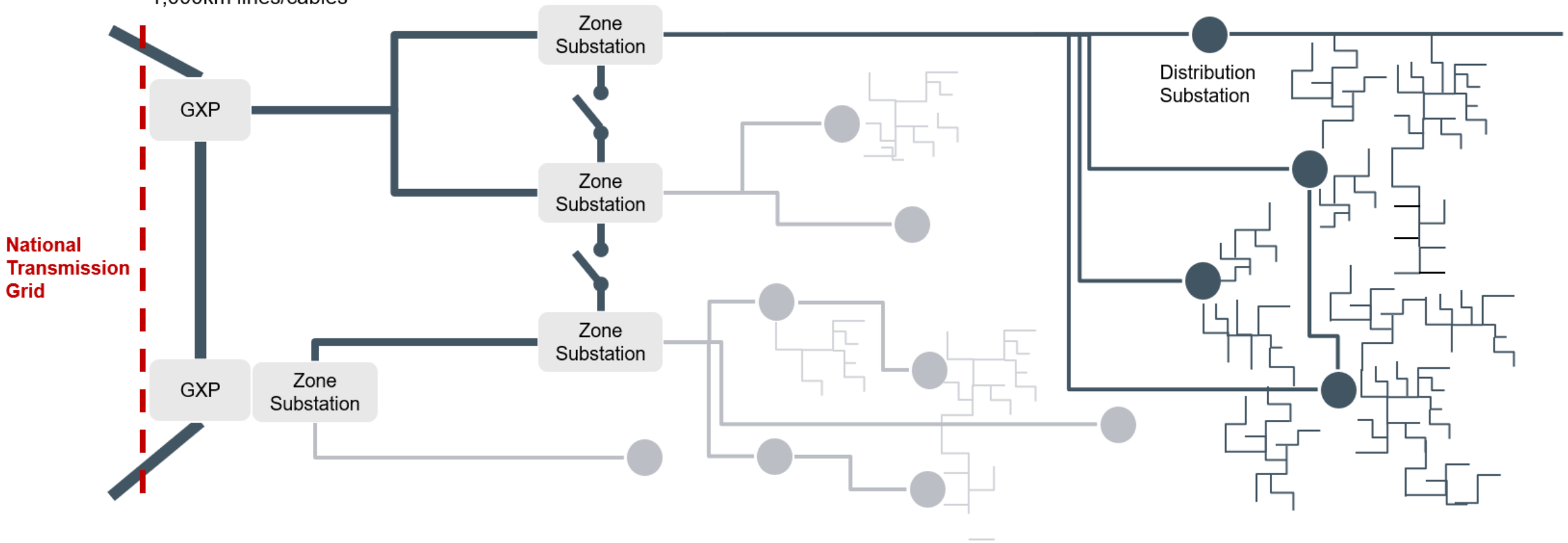
Source: https://www.ena.org.nz/lines-company-map/

Basic structure of the distribution network

Sub-Transmission
- 15 GXPs connecting Auckland's network to the national grid
- ~200 circuits
- ~1,000km lines/cables

High Voltage Distribution
- 113 Zone Substations
- ~1,000 feeders
- ~7,500km lines/cables

Low Voltage Distribution
- ~22,000 Distribution Substations
- ~35,000 feeders
- ~11,200km lines/cables



Multiple pathways for power to flow across the grid
High Load Diversity

Single pathway for power to flow across the grid
Low Load Diversity

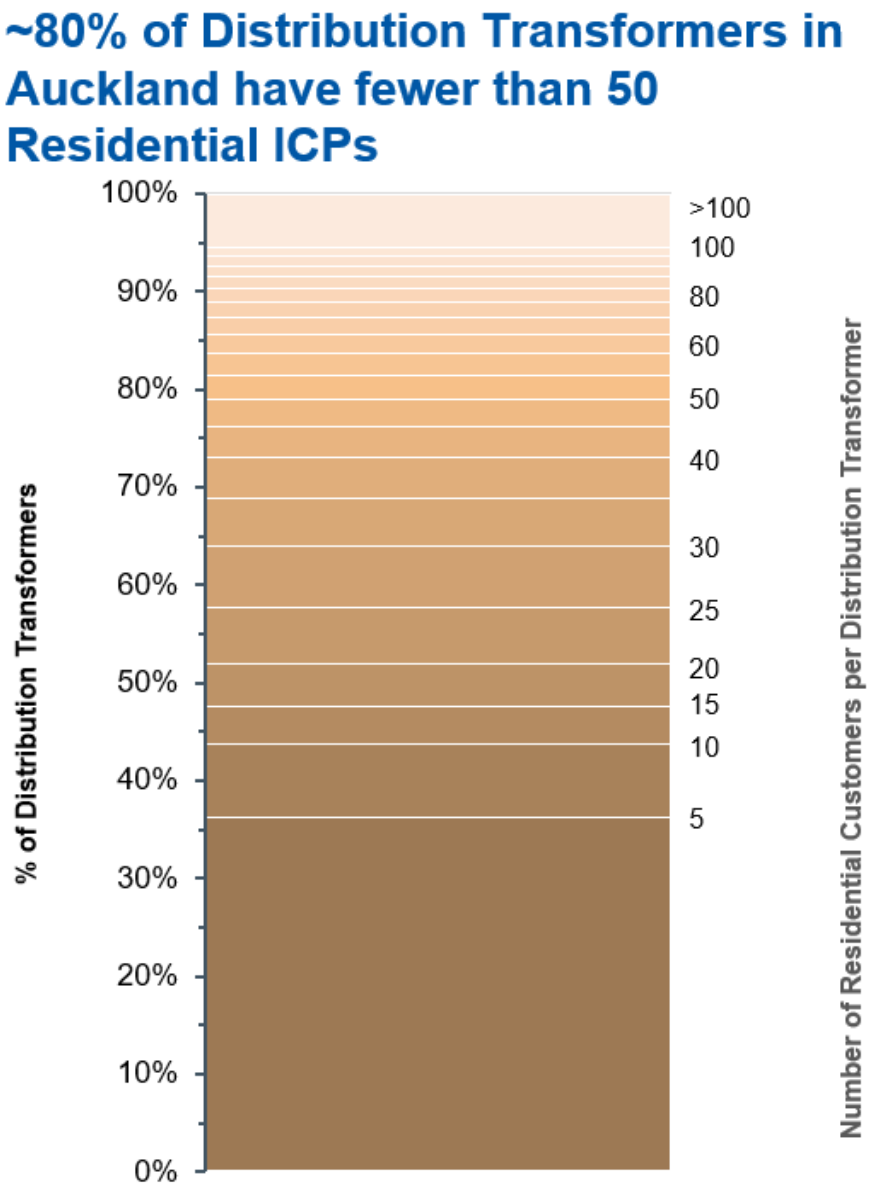
Orders of magnitude

Transpower:

- 25,000 transmission towers
- 11,000 km of lines
- 170 substations (multiple GXP voltages)
- Most substations serve many thousands of consumers (except for direct-connect consumers or GIPs)

Vector:

- 20,000 km of lines
- 15 GXPs, 113 zone substations, 22,000 distribution substations!!
- 80% of Vector's distribution transformers serve fewer than 50 residential connections (but some also have larger commercial connections)



Lots of different generation technologies (1) …

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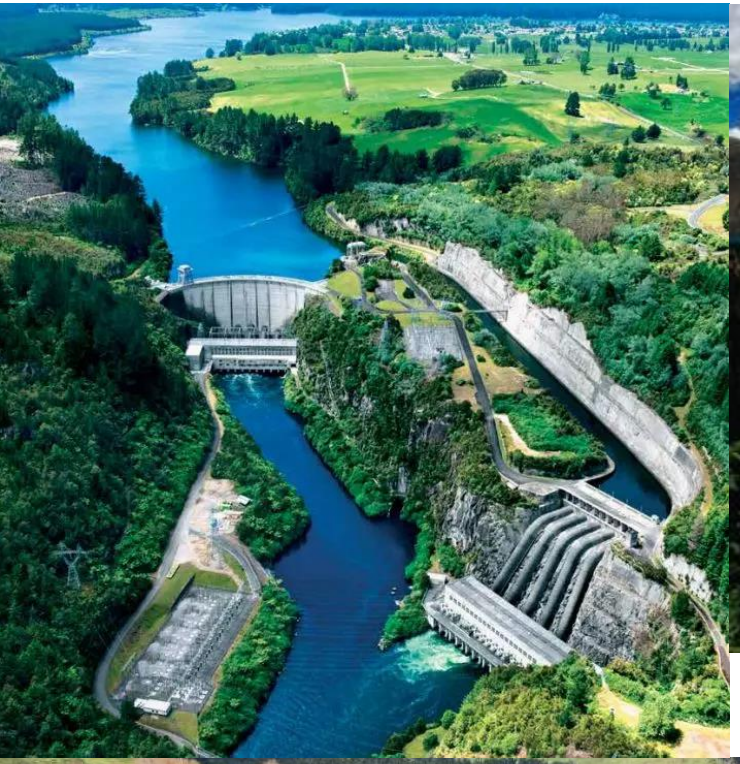
Sources: Wikipedia, NZ Herald, Watercare, Stuff, BusinessDesk, MTL

Lots of different generation technologies (2) …

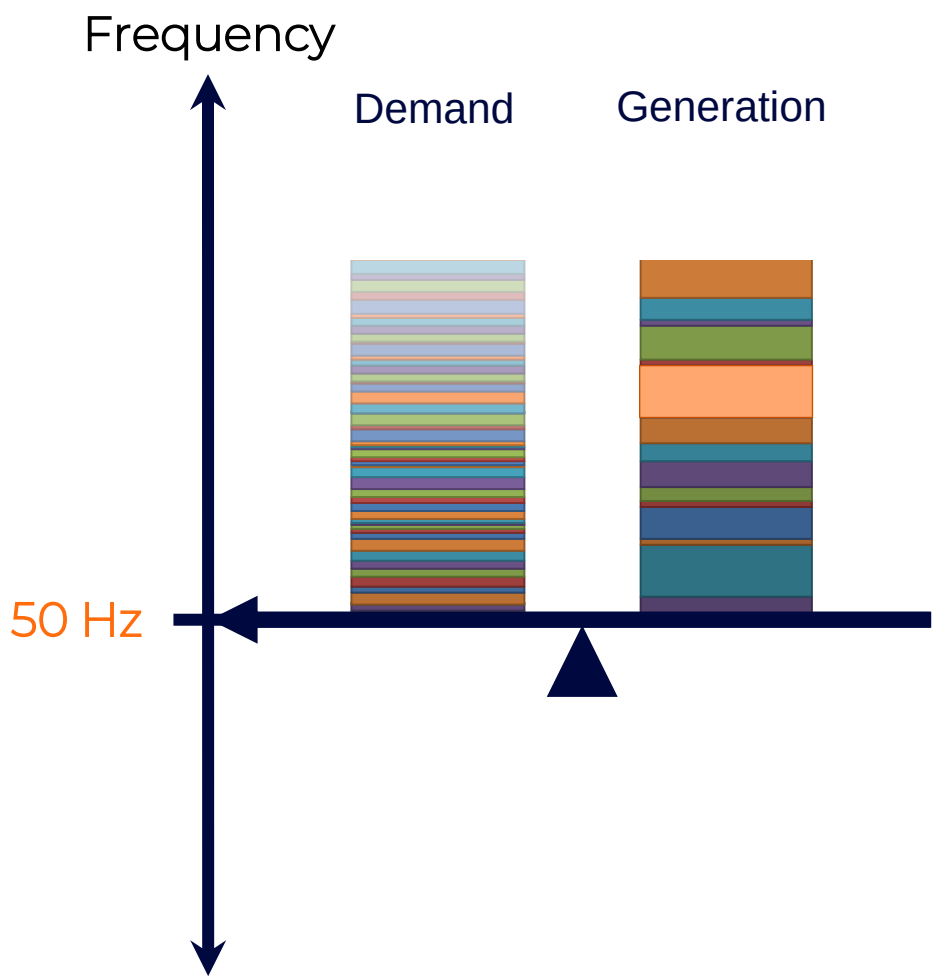


Sources: Wikipedia, NZ Herald, Stuff, BusinessDesk, MTL, MachineryLine, Meridian

… lots of different kinds of consumers …

Sources: NZAS, Vector, Eurotec, Release Wanaka, Healthpoint, Interest.co.nz, PanPac

Supply and demand need to be kept in balance



There is a significant sea change occurring:

1. Traditionally:
   - Consumers consume power across myriad devices
   - Generation flexes up or down to match demand and keep system in balance
2. Evolving world:

- Generation operates when fuel is available (e.g. the wind is blowing or sun shining)
- Consumer devices (consumption, storage, generation) flex in line with supply

Supply and demand **also has to fit within the limits** of Aotearoa's transmission and distribution networks

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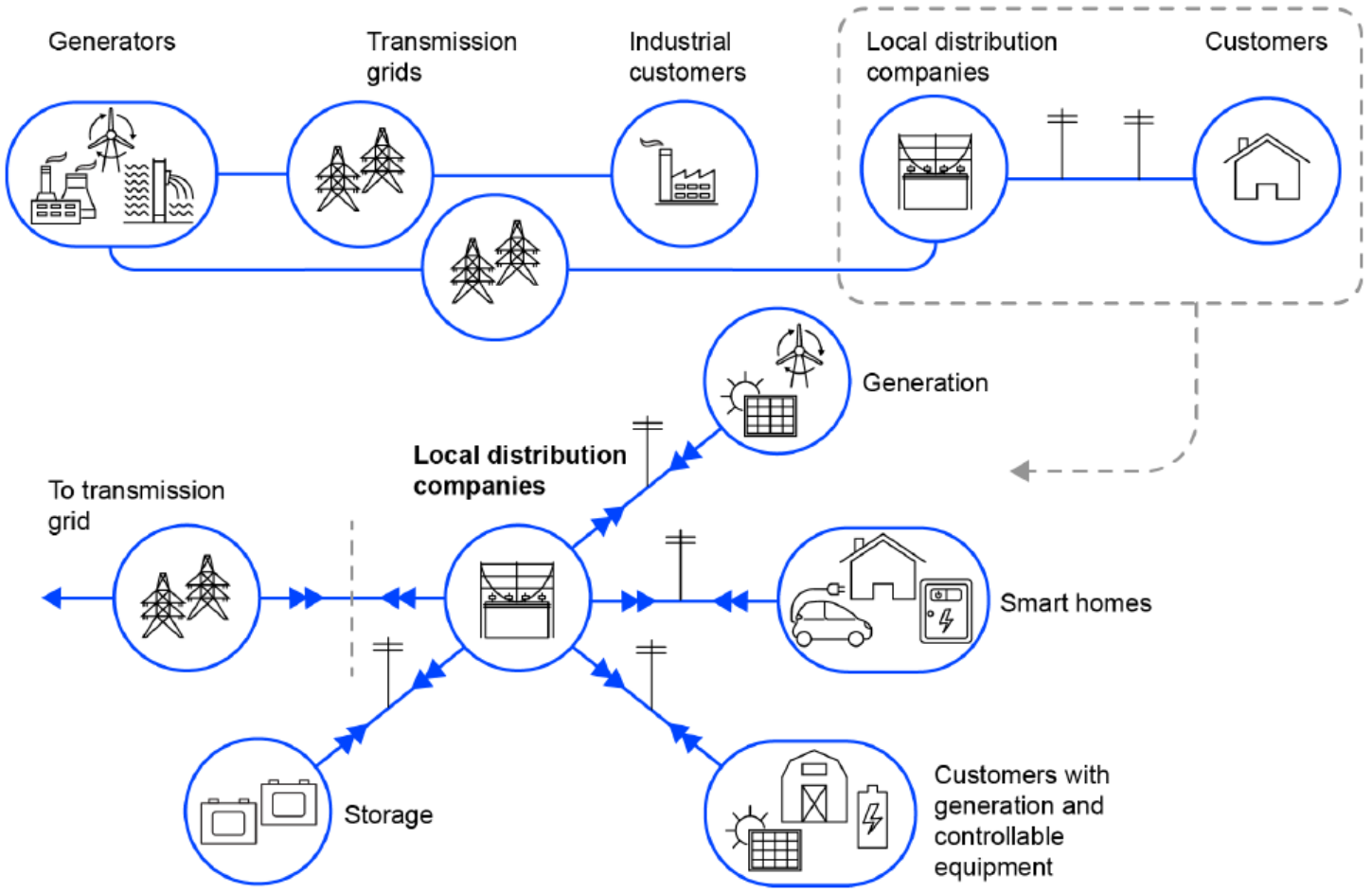
A new way of doing things is emerging

The power system of the past and future



Source: Adapted from IESO (2019), Exploring Expanded DER Participation in the IESO-Administered Markets.

Source: IEA (2022)

The “Virtual power plant” (VPP) concept

- Several definitions exist, but most commonly refers to an aggregation of DER at **more than one location**
  - Typically hundreds or thousands of devices, across a large number of locations
- Devices include batteries or manageable loads, but could include other manageable distributed generation (DG)
- These devices can be operated in sync to provide services to national-level wholesale markets, or provide more local “flexibility” services
- En masse, these devices can provide much the same service to these markets as actual power plants
- However, this can create issues at the very local level, if all the devices on a street or suburb do the same thing at the same time – a phenomenon referred to as “herding”

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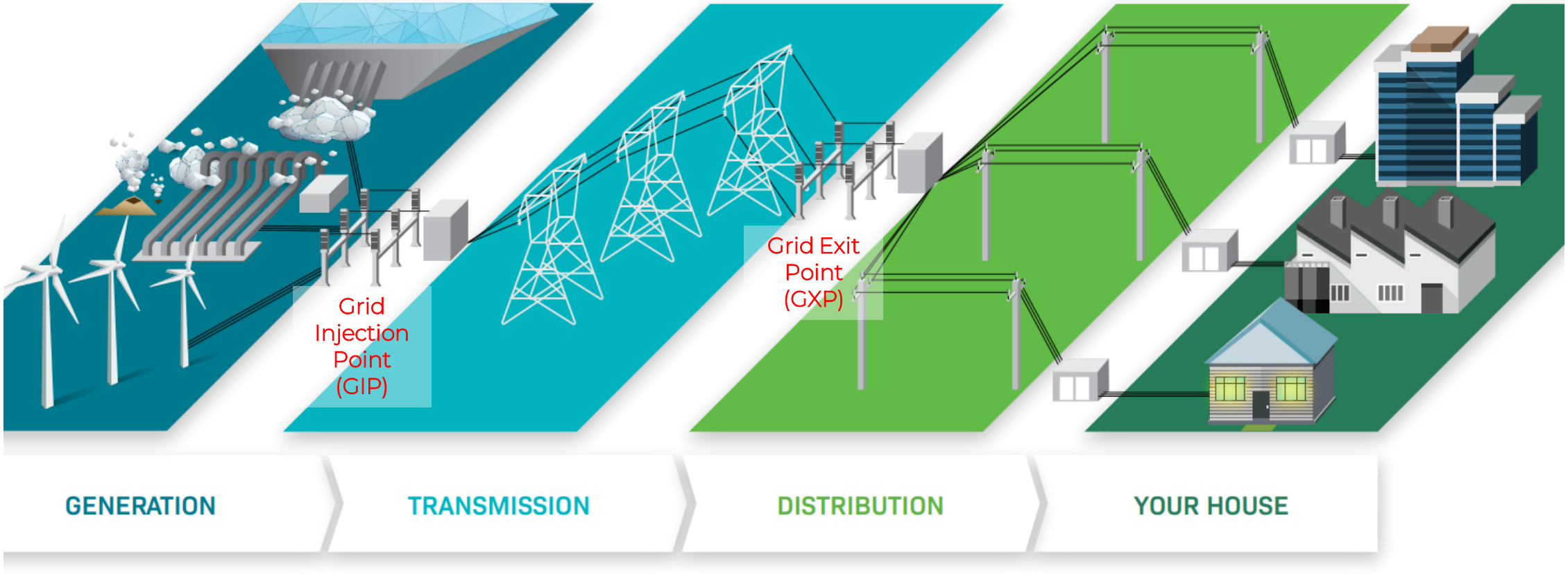
Different sources of value from DER

(aka the “value stack”)

Flexing DER can save costs throughout the system



WHOLESALE MARKET
Electricity is sold and purchased on the wholesale market

RETAIL MARKET
Retailers (power companies) sell electricity to consumers

Source: EA, Electricity in NZ (2018)

Different applications for (or “buyers” of) flexible DER

- The national electricity wholesale market:
  - Helps New Zealand keep overall supply and demand in balance
- The national ancillary services markets:
  - Provides fast response if something unexpected happens
- Transpower, as Grid Owner:
  - Helps to keep peak demand down, and avoid upgrading networks
- Distributors:
  - Helps to keep peak demand down, and avoid upgrading networks – potentially across more than one layer of the network
- Consumers:
  - Helps to store excess solar generation
  - Helps to reduce energy and/or network costs through load shifting

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DER / flexibility can help minimise costs across the value chain

An average household power bill contributes to the following costs

32%
GENERATION
Producing the electricity you use.

27%
DISTRIBUTION
Building and maintaining the power lines that transport electricity from the grid to your home.

13%
RETAIL
Your power company's operating costs.

10.5%
TRANSMISSION
Building and maintaining the national grid.

13%
GST
The GST-inclusive amount of tax we all pay.

3.5%
METERING
Reading and maintaining your electricity meter.

0.5%
MARKET GOVERNANCE
Energy efficiency programmes and the organisations that regulate the electricity industry.

0.5%
MARKET SERVICES
Organisations who operate the electricity market.

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What’s required to unlock value and keep the network secure and stable

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Different ways to monetise the value of flexibility

- The national electricity wholesale market:
  - Half-hourly spot electricity prices; “active” (offered) or “passive” (non-offered) participation
- The national ancillary services markets:
  - Half-hourly reserves and frequency-keeping prices (only active participation possible)
- Transpower, as Grid Owner:
  - Commercial contracts for grid alternatives
- Distributors:
  - Time-varying distribution prices (e.g. peak / off-peak)
  - Commercial contracts for specific network support services
  - Flexible connection contracts (keep load within time-varying limits)
- Consumers:
  - Shift solar from day to evening, shift EV charging or HW load from day to night
  - Take up a time-varying retail package which rewards load shifting and/or injection

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Taking advantage of time-varying electricity prices

Spot wholesale prices

Time-of-use distribution prices

Time-varying retail packages

octopus energy

Free power from 9pm to midnight on the Good Nights plan

ONLINE OFFER

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New mechanisms are emerging

Launch of New Zealand's first fully electric bus depot with the capacity to charge 20 - 30 buses each. Charging at this depot occurs within a 'dynamic operating envelope', where Vector forecasts optimal charging times each day and provides this through to the depot, reducing peak demand for a more affordable charging solution.

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The size of the prize is massive

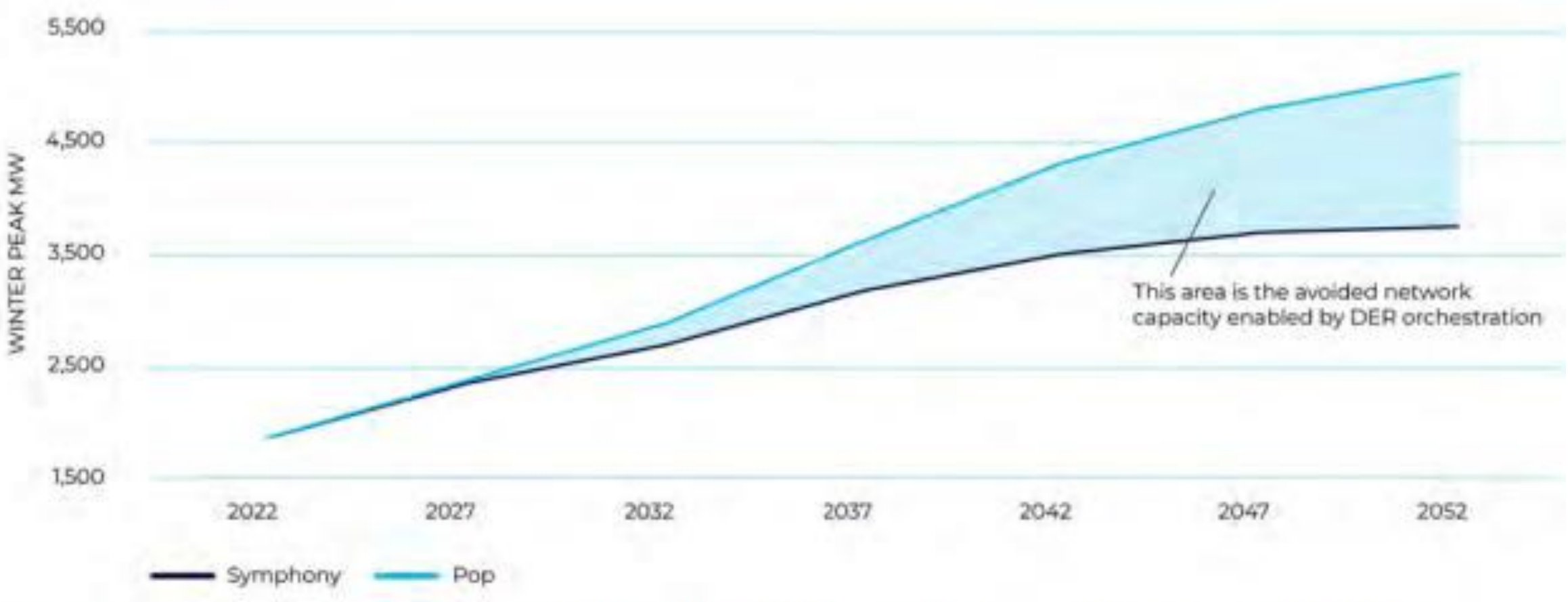
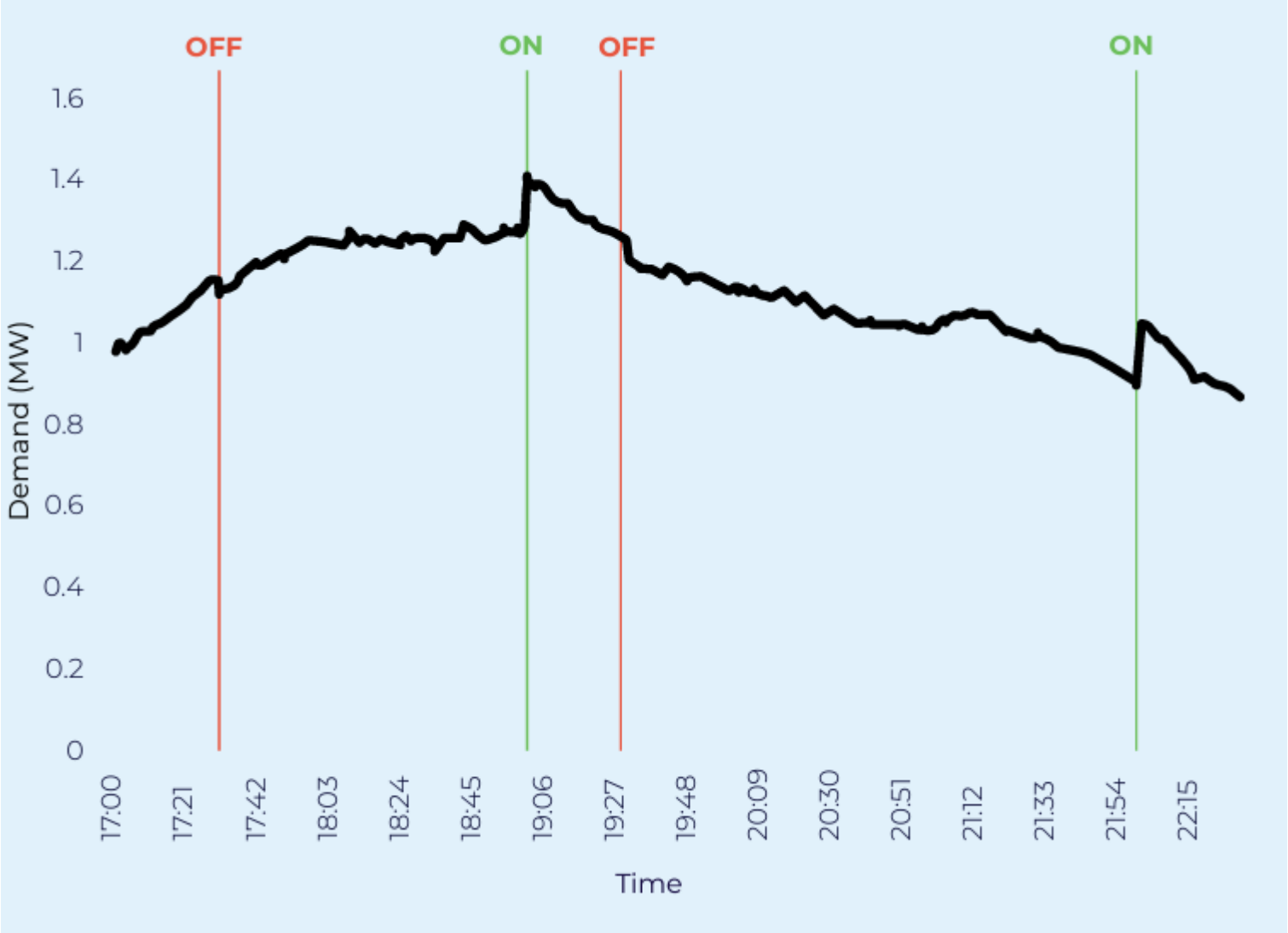


FIGURE 1.1: LOAD FORECAST FOR THE VECTOR NETWORK, WITH AND WITHOUT EFFECTIVE DER ORCHESTRATION

The “forgotten side of load management”



See https://www.esig.energy/the-forgotten-side-of-load-management/

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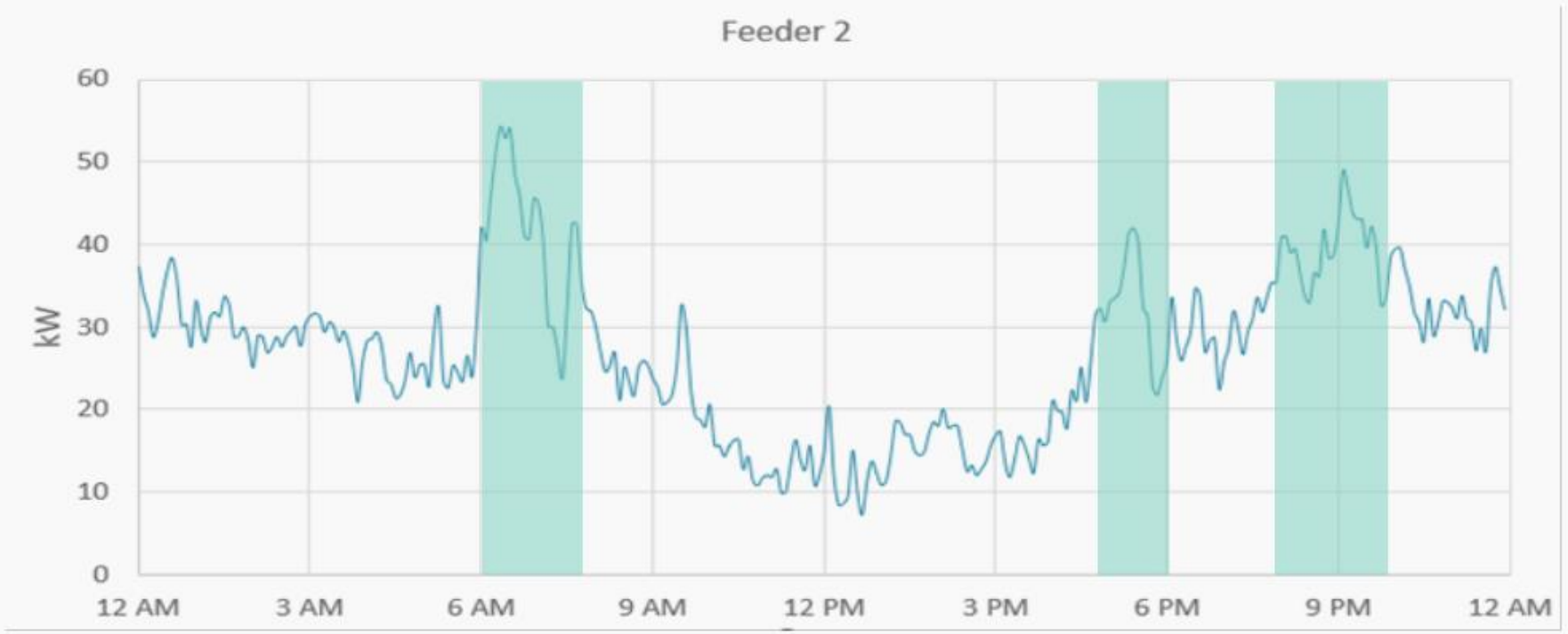
“Diversity destruction” is a real risk
Synchronisation (“herding”)
Diversity

Context – Challenges and opportunities

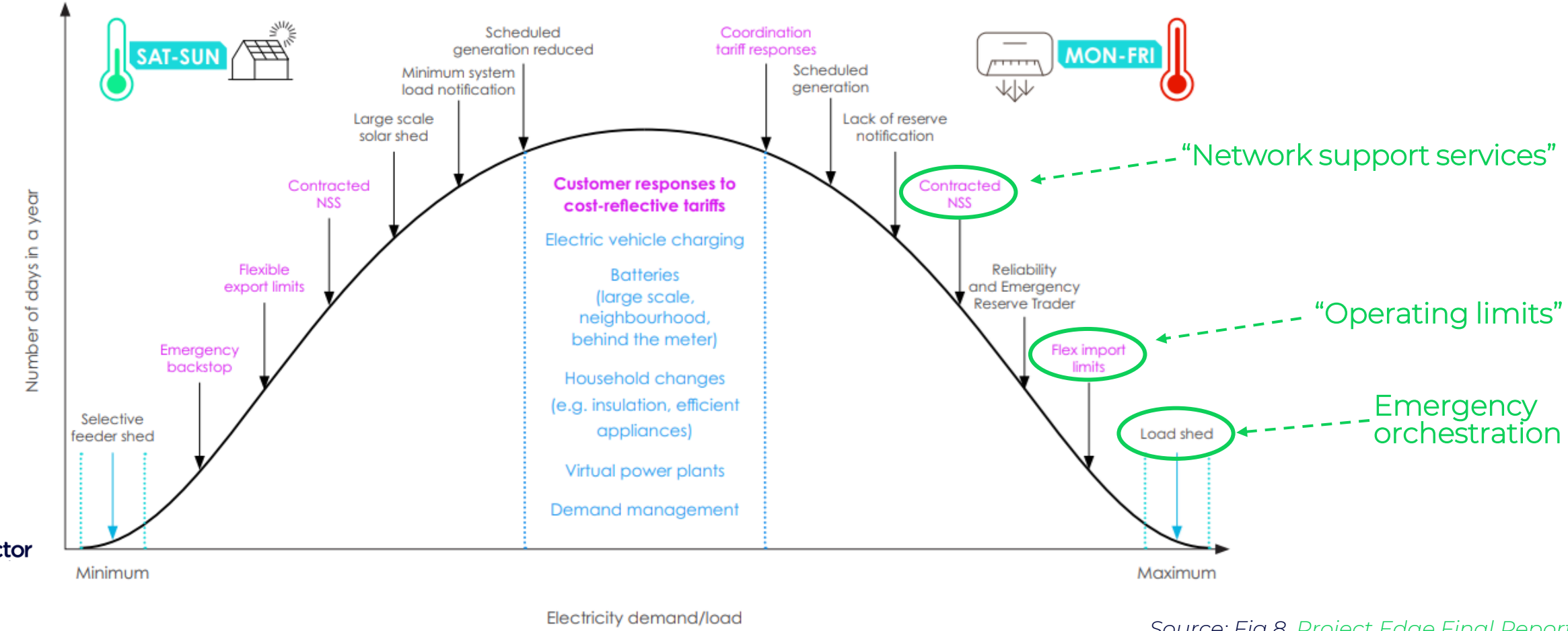
New peaks are emerging



Orion Low Voltage Feeder currently peaking before 7am and after 9pm

Several different “orchestration” mechanisms are needed

Figure 8 | Range of available measures for managing minimum demand from peak PV exports, and maximum demand event[59]



Source: Fig 8, Project Edge Final Report

Future roles, architecture and relationships required

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Evolving System Inter-relationships

The DSO will safely unlock and enable whole-of-system value from de-centralised resources

	Status Quo	Phase 1 – Enabling	Phase 2 – Procurement
Phase of DER market development	**Limited relationship** and **interaction** between DER Managers and EDB	DSO **enables** safe DER management and 'value stacking' by emerging DER Managers	DSO begins to **procure** dedicated services and solutions from DER Managers
Active DER Managers in this phase	• EDBs (hot water, network batteries, other DER) • C&I consumer process managers • DG owners (e.g. hydro, wind, solar)	• As per status quo, plus: • Retailers and other aggregators (smart hot water, smart EV charging, e-buses, home batteries, etc)	• As per phase 1, but in even greater numbers and with a wider range of business models
Main DER management activities	• EDBs utilising DER for network management (i.e. *utility-led* mode) • DG owners optimising wholesale market revenues – either *passive* response to spot prices, or *active* participation in the market ('active' = offered to, and dispatched by, the TSO)	• As per status quo, plus: • New DER Managers responding to wholesale prices and TOU distribution prices (i.e. *price-led* mode). Either active (offered) and/or passive (non-offered). • New DER Managers managing 'flexible' network connections (e.g. bus charging)	• As per phase 1, plus: • DER Managers operating under market-procured contract to the DSO (EDB) for specific services, including investment deferral (i.e. *market-led / contract-led* mode)
Main DSO activities: • local capacity management • DER orchestration	• EDB and non-EDB DER Managers operate independently of each other • Limited active relationship between DSOs and DER Managers; EDBs may have little awareness of DER Manager presence • DER Managers have little, if any, awareness of network capacity constraints	• DSO will enable safe DER Management and value-stacking by providing static or dynamic operating envelopes to DER Managers • DSO will orchestrate DER response to network and grid emergencies • Over time, more sophisticated time-varying distribution pricing could emerge	• As per phase 1, plus: • The DSO will procure (via contract) specific services and specific responses from DER Managers, including investment deferral (non-wired alternatives) and ancillary (network support) services. • Over time, more sophisticated market and pricing mechanisms for networks could emerge

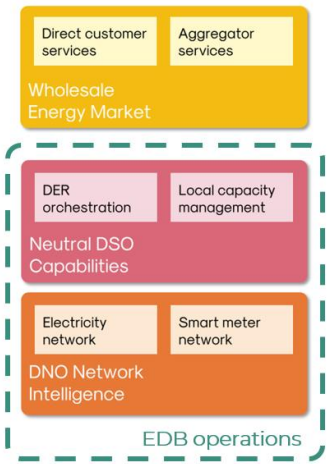
Appendix: Phase 2 – Procurement: DSO procures from DER Managers

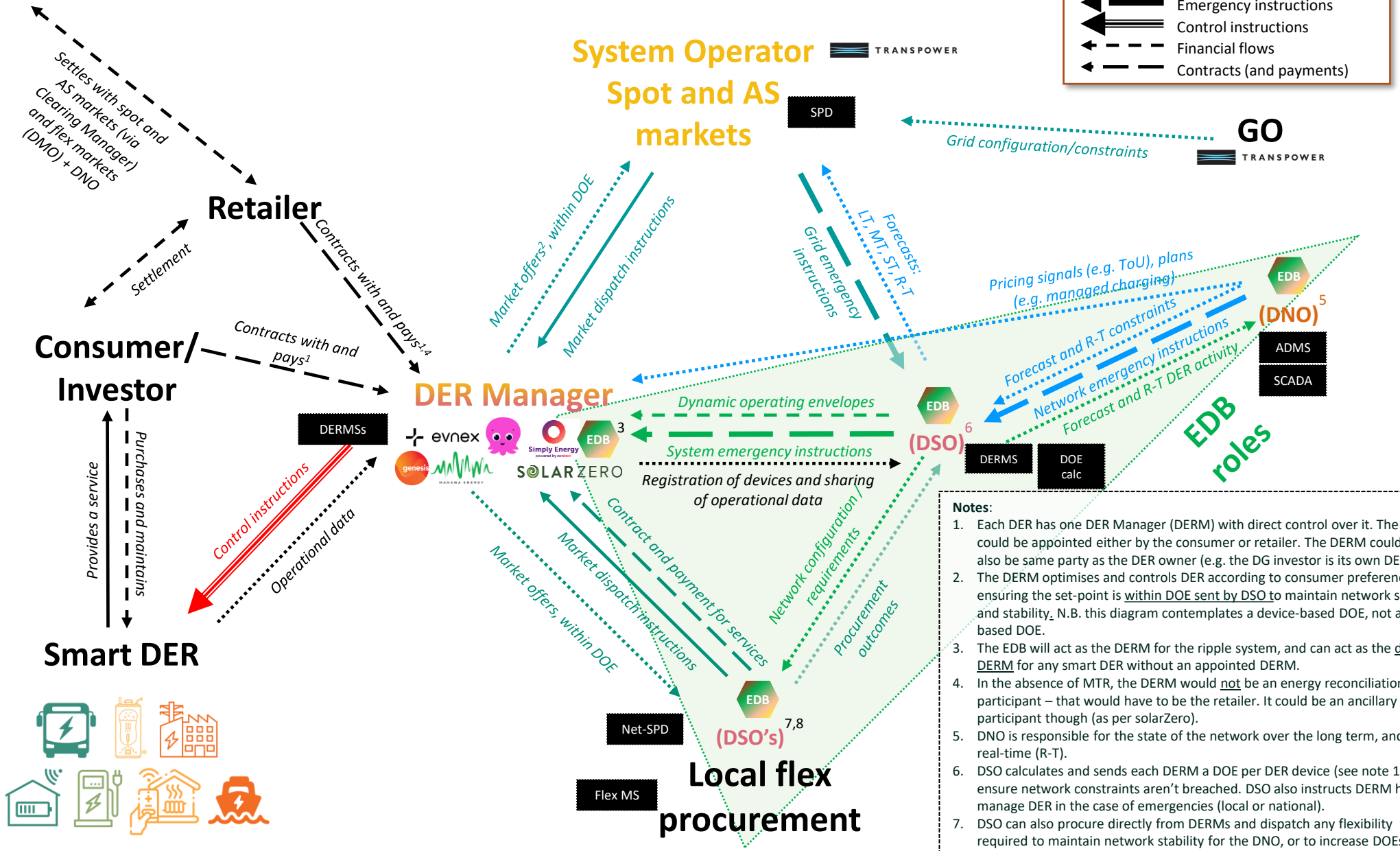
The colours from the DSO Operating Model (slide 9 and below) have been used as a key.

DNO is orange

DSO is pink

Wholesale market is yellow





Notes:

1. Each DER has one DER Manager (DERM) with direct control over it. The DERM could be appointed either by the consumer or retailer. The DERM could also be same party as the DER owner (e.g. the DG investor is its own DERM)
2. The DERM optimises and controls DER according to consumer preferences – ensuring the set-point is within DOE sent by DSO to maintain network safety and stability. N.B. this diagram contemplates a device-based DOE, not an ICP-based DOE.
3. The EDB will act as the DERM for the ripple system, and can act as the default DERM for any smart DER without an appointed DERM.
4. In the absence of MTR, the DERM would not be an energy reconciliation participant – that would have to be the retailer. It could be an ancillary service participant though (as per solarZero).
5. DNO is responsible for the state of the network over the long term, and in real-time (R-T).
6. DSO calculates and sends each DERM a DOE per DER device (see note 1), to ensure network constraints aren't breached. DSO also instructs DERM how to manage DER in the case of emergencies (local or national).
7. DSO can also procure directly from DERMs and dispatch any flexibility required to maintain network stability for the DNO, or to increase DOEs for other parties. It requires a Flex Management System (FMS)
8. This local flex procurement could evolve from bespoke, targeted procurement (e.g. Warkworth ROI, Upper Clutha, Whangamata) to something more standardised and dynamic.

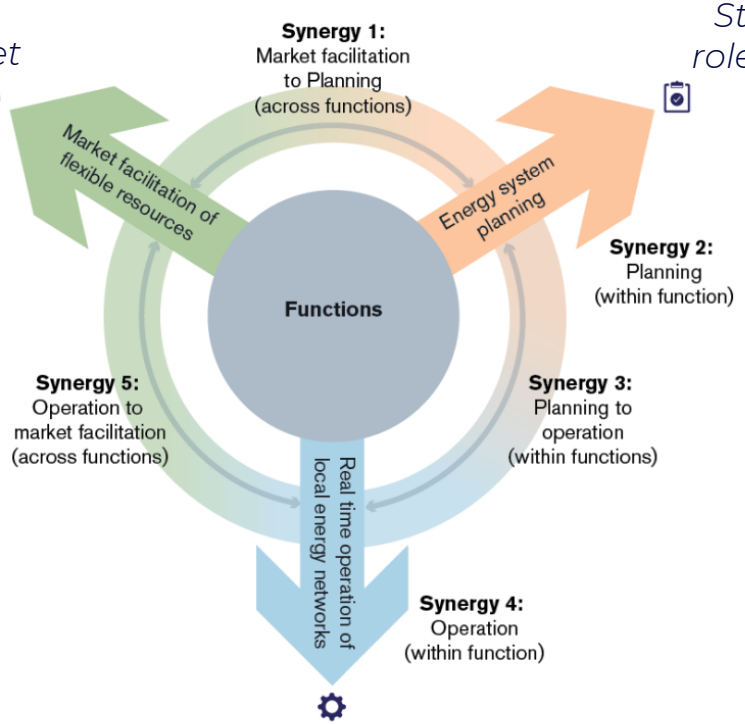
WIP version as at 1 Feb 2024

Distribution System Operation roles (global)

Great Britain

Develop a market facilitator to align national and regional flexibility market arrangements.

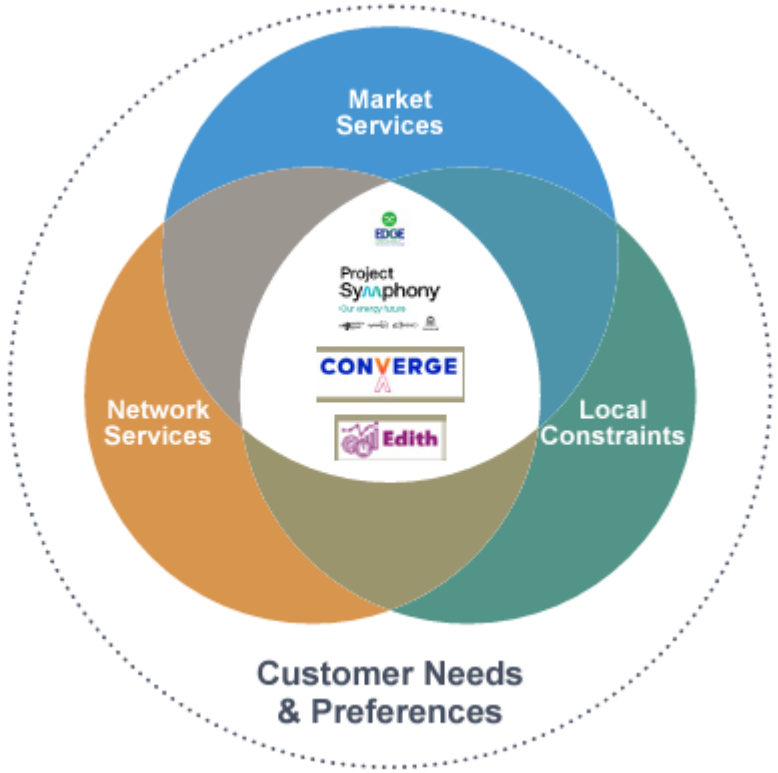
Creating Regional Energy Strategic Planner (RESP role delivered by the Futu System Operator.



DNOs maintain responsibility for real time operation of a safe, resilient and reliable network

Source: Ofgem Future of local energy institutions and governance

Australia



Source: ARENA Market Integration Trials Summary Report 2023

Wrap-up

1. The electricity system is evolving rapidly, and traditional roles are being flipped on their heads
2. Flexible, distributed resources like EV charging, home batteries and hot-water cylinders can provide value right across the system
3. A range of commercial mechanisms is already available for flexible resources to access, but more are needed
4. Importantly, this creates new challenges and opportunities for the networks hosting these resources – such as “herding” or “diversity destruction”
5. New system roles and relationships will be required, underpinned by new safeguards for the network (e.g. operating envelopes, emergency powers)
6. We’re all up for the challenge! It’s a very exciting time to be in the sector.

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Recommended further reading

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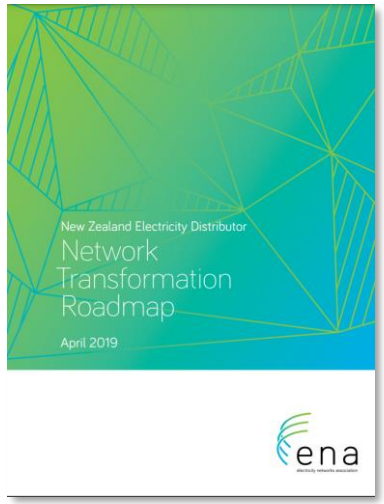
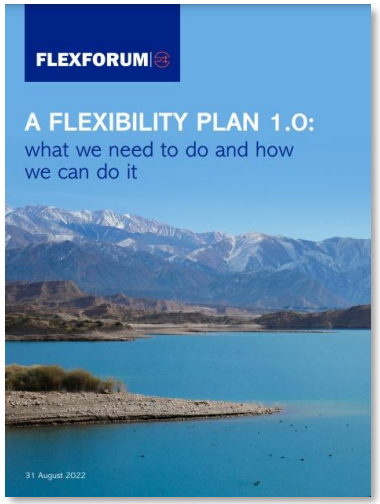
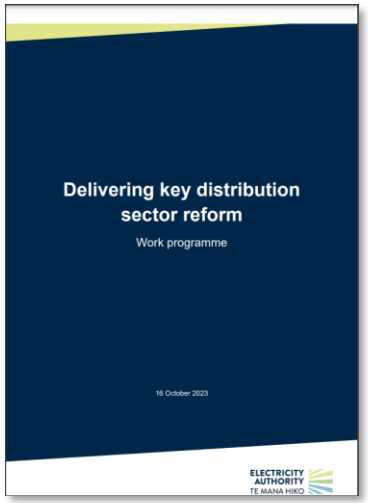
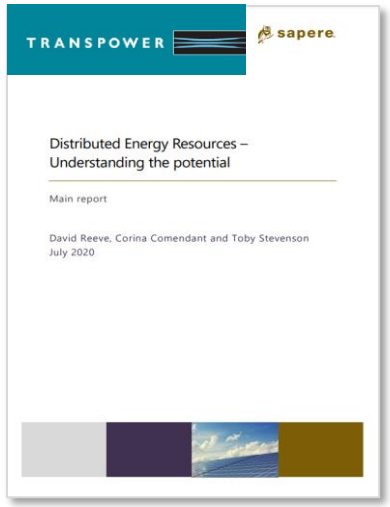
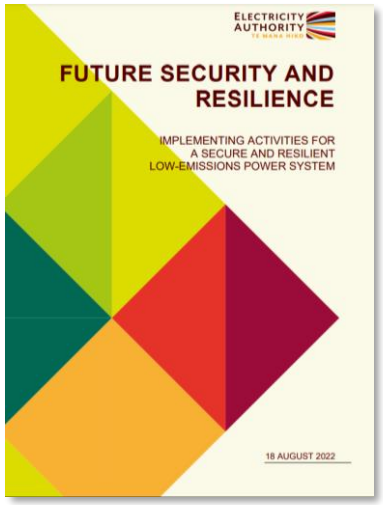
Further reading on the New Zealand context

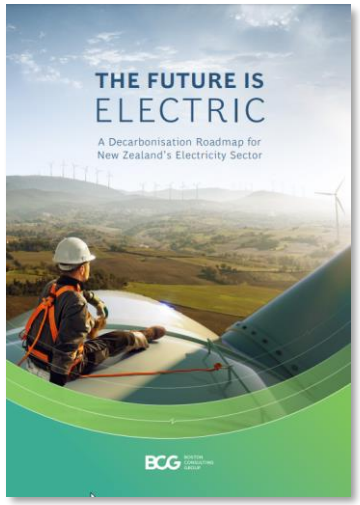


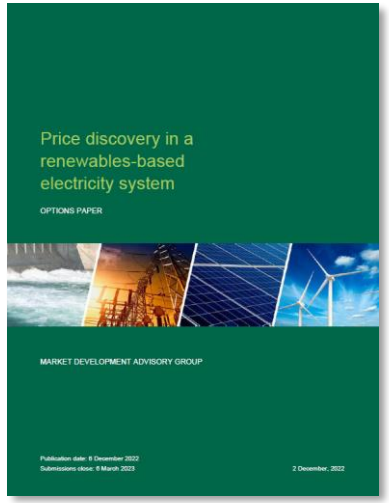












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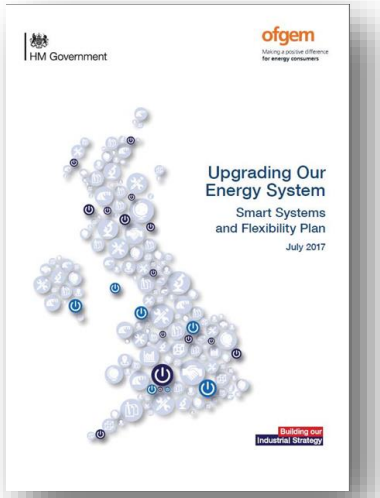
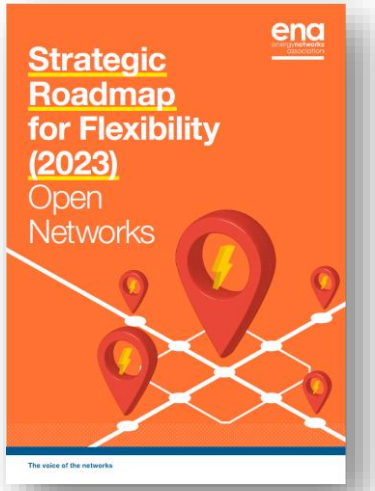
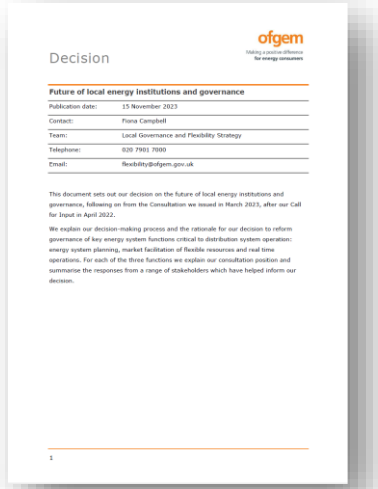
International precedents

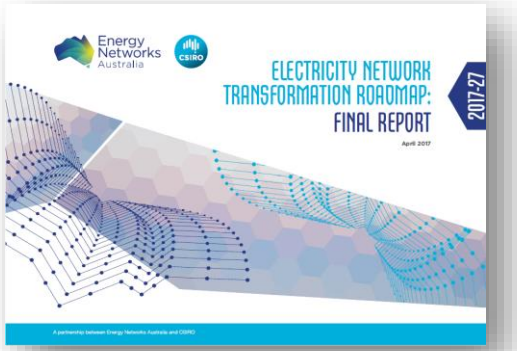
Great Britain (GB)

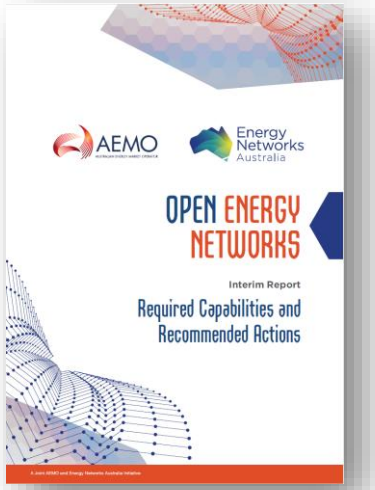


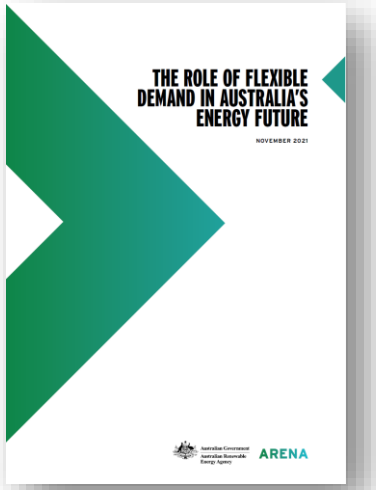




Australia







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Q&A

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