Potential models for distribution system operation (DSO) in Aotearoa.

A report commissioned by the Future Networks Forum.

An introduction from the Future Networks Forum

A fast-changing world

Lines companies are imagining a future in Aotearoa with:

🟠 **Close to 100% renewable generation**
A grid powered almost entirely by centralised and de-centralised renewable energy sources like wind, hydro, and solar.

⚡ **Mass uptake of flexible consumer-owned energy resources (CER) and other distributed energy resources (collectively, DER)**
Widespread use of technologies like rooftop solar, batteries, smart hot-water heating and EV charging, and other smart appliances that can both use and supply electricity.

⚖️ **DER used for non-wires alternatives and system balancing**
Leveraging DER to avoid traditional network upgrades (non-wires solutions) and support real-time balancing of supply and demand both locally and across the national grid.

🚗 **Electric vehicles (EVs) and hot water responding to price signals**
Smart charging and heating that shifts use to cheaper, off-peak times — moving load to when it is cheaper to serve, reducing strain on the network and costs for consumers.

🔋 **Risks of 'herded' load and discharge**
Coordinated control of energy use and battery discharge across many devices, like a digital flock, can create risks to network safety and stability. This will need to be carefully managed with lines companies hosting these devices.

Potential DSO models

Electricity Networks Aotearoa (ENA) hosts a platform for collaboration called the Future Networks Forum (FNF). It's made up of representatives from lines companies and identifies opportunities where lines companies can align to help us reach our climate change goals and create value for customers.

The FNF has commissioned Baringa to review potential models for distribution system operation (DSO) in Aotearoa.

Many different technology trials and industry architectures are currently being tested in UK, Australia and the US. In Aotearoa, many organisations and groups have formed views about how DSO could work here, but there is no clear or agreed way forward.

The purpose of this report is to show 'potential' DSO models for New Zealand and to show the challenges and opportunities with each approach. The hope is that this research will help our sector to have informed two-way engagement about all the options available.

We hope this report will help to support future DSO model decisions which will unlock the use of flexibility in Aotearoa New Zealand. Getting this right as a sector will not only benefit the consumers who own DER, but all electricity consumers as they will save costs throughout the energy system.

The project team that worked with Baringa on this report was made up of reps from a number of lines companies, as well as Transpower as System Operator.

An introduction from the Future Networks Forum

More work is happening

This report is part of the FNF's broader project looking at capability, roles and functions to enable distributed flexibility. As well as this, the distribution sector has ongoing mahi in this space including:

- Working with the Electricity Authority and sector on the **ongoing evolution** of the DSO role and integration into the broader power system. .
- Building a **least-regrets capability roadmap** for enabling distributed orchestration, to feed into a refreshed **Network Transformation Roadmap**, and working with the Commerce Commission to ensure it is sufficiently funded.
- Coordinating **shared delivery** of new capability, including in-sourcing and out-sourcing. EDBs already coordinate delivery of key functionality in other areas, including cyber security, procurement of non-wire solutions, advanced distribution management systems, and grid condition monitoring. Shared delivery models will continue evolving.
- Pursuing low-cost, **ubiquitous visibility of LV networks**, in close to real-time, to support development of **dynamic capacity management**. Regardless of DER dispatch models, this is essential for enabling **safe operation of DER by third parties** within the physical and power quality limits of distribution networks.
- Developing **consistent load management protocols** for retailers and other aggregators managing flexibility resources on EDBs' networks, regardless of how these resources are being activated.
- Facilitating and stimulating **procurement of local flexibility solutions (contracts, platforms, markets)**, supported by the new innovation allowance.
- Evolving **distribution pricing** and **flexible connection arrangements** to ensure flexibility is being appropriately incentivised to deliver whole-of-system value to consumers.

Next steps

The Electricity Authority plans to release their next consultation on Future System Operation (FSO) in mid-2025, which will seek input on issues and options.

The Authority has been updated regularly as this project progressed. We hope that this report will help to inform all parties' submissions on the Authority's paper.

If you would like to discuss this paper, please reach out to the FNF at fnf@electricity.org.nz

Presented in the following pages is Baringa's report: *An exploration of potential DSO models for New Zealand.* It was commissioned by Electricity Networks Aotearoa's Future Networks Forum.

electricity networks aotearoa

Distribution System Operation (DSO) models

An exploration of potential DSO models for New Zealand

Final report

April 2025

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Executive summary

DSO models in New Zealand

It is crucial for New Zealand to ensure alignment and whole-of-system value across the sector, as the country transitions towards more distributed flexibility

Purpose of this report

- Electricity Networks Aotearoa (ENA) commissioned Baringa Partners (Baringa) to deliver an assessment of distribution system operation (DSO) models for New Zealand (NZ). Baringa's report covers three models:

DSO models for assessment

1. Total Transmission System Operation (TSO)	2. Total Distribution System Operation (DSO)	3. Hybrid between 1 & 2
• TSO's current role is expanded to include distribution network demand/generation optimisation	• EDB expands its role, with DSO dispatching all local resources and providing a residual demand or supply curve to the TSO	• TSO and DSO share capabilities and responsibilities in some way

- This report considers international case studies, as the local NZ market context. While this report's focus is on market models, there are also many DSO-enabling functions (e.g. planning & connections) that policymakers also must consider.[1]
- The report includes a qualitative assessment of the three models via a set of assessment criteria covering value, cost, regulatory issues, customer experience and decarbonisation.
- The objective is not to identify a single best model but to inform the discussion around the relative merits of each DSO model and recommendations that support unlocking whole-of-system value for the long-term benefit of consumers in NZ.
- The report is intended to support common language and encourage discussion around the options and relative advantages/disadvantages – this is needed given the complexity before a model can be recommended.

[1] As outlined in the ENA Stage 1 Discussion paper.

Current state and future state insights

NZ local factors context

It is essential to consider key local factors when developing future options for NZ. These include:

- Large number of electricity distribution businesses (EDBs) at 29, which have a diverse range of contexts and scales, and are subject to mix of price control regulation
- A material proportion of peak demand managed by ripple control hot water systems and high uptake of residential smart/interval meters
- Nodal wholesale pricing arrangement and over 85% of generation produced by renewable energy in 2023
- Clear emission reduction framework that will drive electrification and material demand growth for EDBs through electrification of heat and transport
- EDBs and others trialling initiatives to provide greater coordination of consumer devices and emerging business models among flexibility providers

Recommended near-term actions

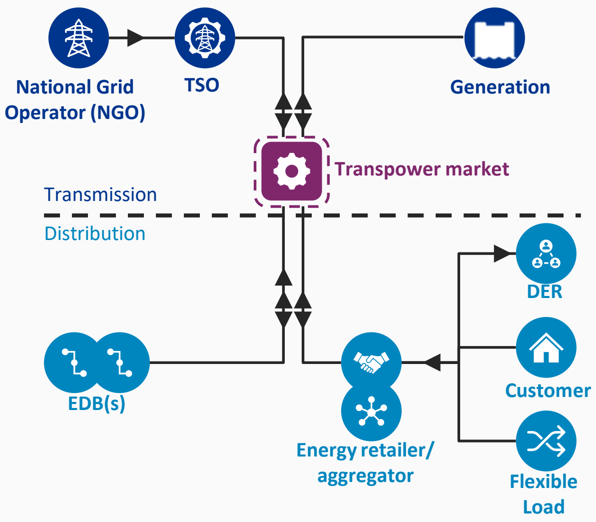
The report identifies a number of next steps including:

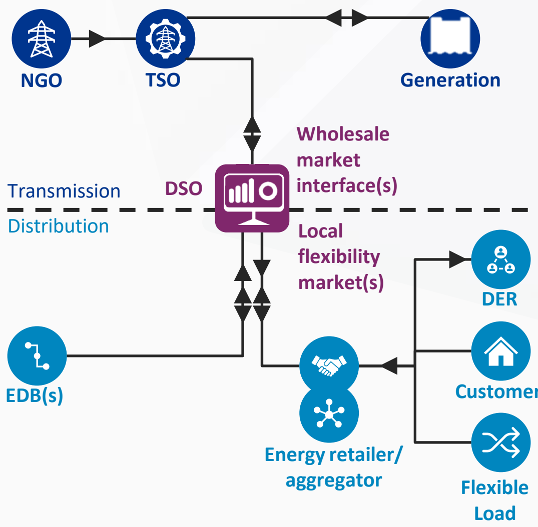
- EDBs and Transpower should continue to cooperatively develop processes to manage a system with more flexible resources in a coordinated way with flexibility service providers
- Develop good practice principles to improve data availability across the network and shared standards for data communication as data access and quality is a prerequisite for all DSO models
- Explore technology partners and consider shared services models to leverage expertise and gain scale efficiencies in the development of new functions.

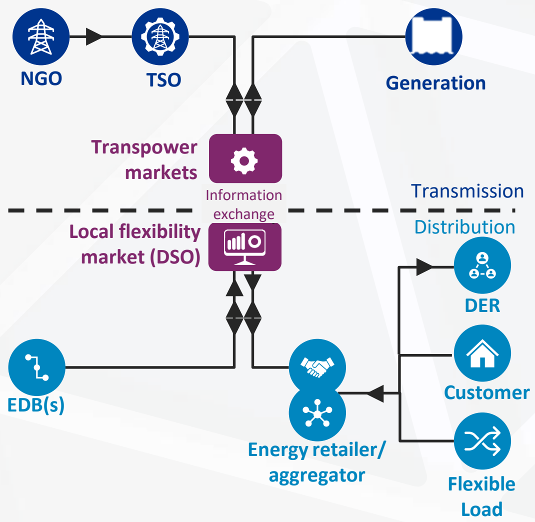
We have considered 3 DSO models that could feasibly deliver flexibility markets and services for both national and local requirements in NZ

Model name	Total Transmission System Operation (TSO)[1]	Total Distribution System Operation (DSO)	Hybrid Model[2]
Description	A centralised approach for procurement and operation of local flexibility by Transpower's TSO function, where the TSO balances all local network optimisation, system optimisation and energy market trading to deliver optimum value. Aggregators need to offer services only to the TSO.	A locally operated flexibility market, where the DSO optimises constraints within its own distribution network and provides aggregated bids to the TSO, who optimises at a market and transmission level. Aggregators need to offer services only to the DSO.	A hybrid approach, where the DSO operates local flexibility markets and optimises constraints within its own distribution network. The TSO optimises the wholesale market at transmission level. Aggregators can offer services to one or both DSO and TSO.

Simplified Diagram







[1] The concept of a 'Total TSO' and other models were originally considered by Martini and Kristov (see for example, Martini & Kristov, *Distribution systems in a high distributed energy resources future*, Berkeley Lab, 2015).

[2] There are many variants of a hybrid DSO framework – this description and model diagram represent just one way this could work, noting it is one that is already evolving in NZ.

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All 3 DSO models have a range of strengths and weaknesses, differing across both benefit and cost and practicality related assessment criteria

Type	#	Assessment criteria	**Model 1** Total TSO	**Model 2** Total DSO	**Model 3** Hybrid model
Cost/value	1	Creates whole system value			
	2	Cost to implement			
	3	Unlocks flex value stacking			
Practicality	4	Clarity of roles			
	5	Regulatory change required			
	6	Implementation timeframe			
	7	Simplicity and standardisation			
Benefit	8	Network stability			
	9	Climate change resilience			
	10	Enables customer choice			
	11	Contributes to decarbonisation			

5-point rating scale

Our findings of each of the models suggest:

- Total TSO means Transpower's existing capability would need to be expanded significantly to cover the local distribution constraints being integrated with wholesale market optimisation.
- A Total DSO Model would require the TSO/DSO interaction to be clear and transparent, however forcing Aggregators/Retailers to access all markets via the DSO, and regulatory change required to aggregate flexibility will pose challenges.
- A Hybrid Model could require the least amount of regulatory change and allows a logical expansion of existing entities' activities into the flexibility space.

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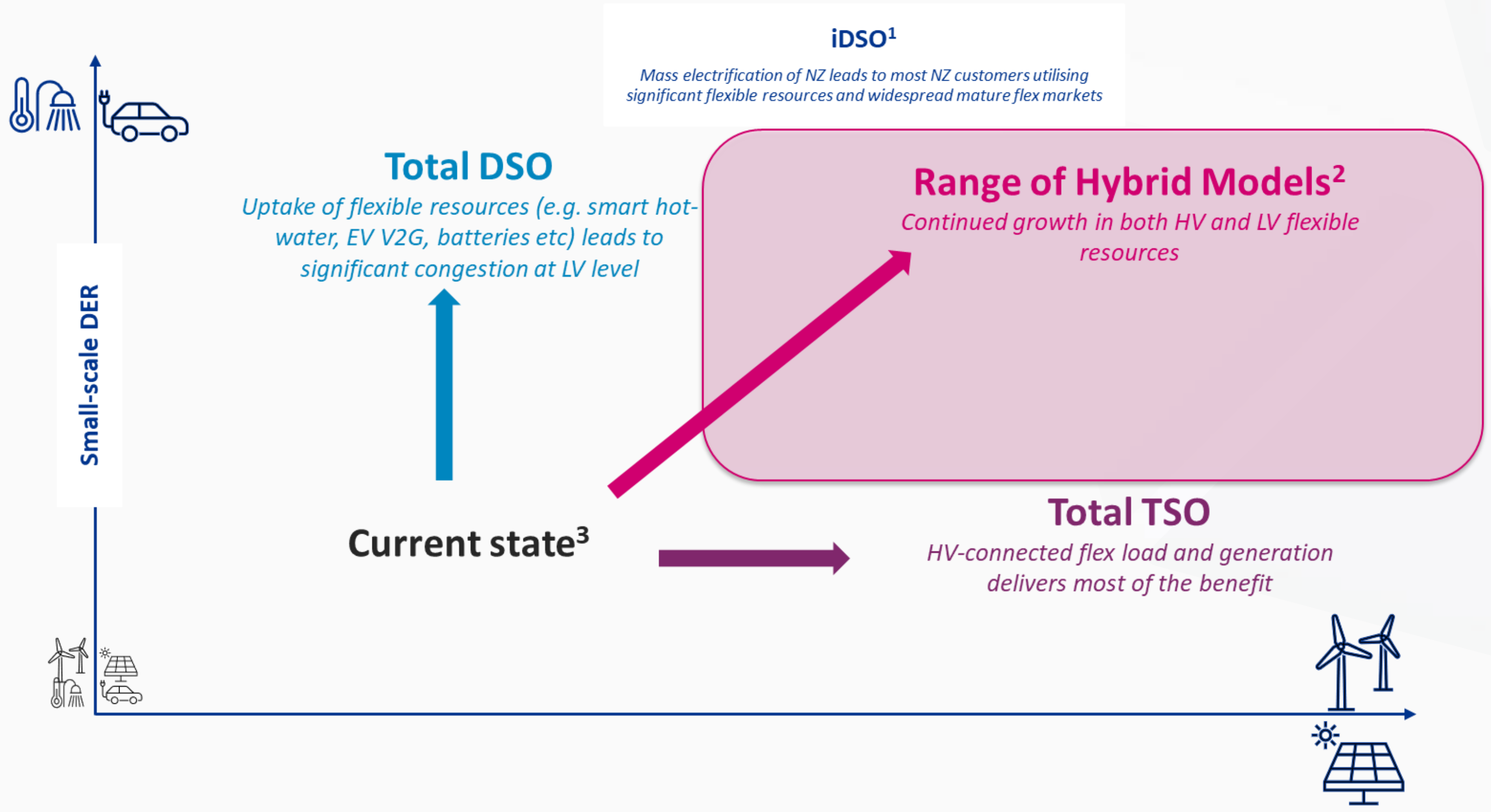
NZ has potential directions for travel for each of the industry structures, with many EDBs already observing and responding to emerging challenges and market changes



Implications for NZ

- Total TSO and Total DSO represent contrasting end points of market design and evolution. NZ should continue to closely monitor how sector developments may align with these models.
- There are many potential Hybrid Models covering the spectrum from Total DSO to Total TSO.
- Current market settings and regulation (e.g. separate operation of local flex services and wholesale markets) are a form of hybrid model similar to the one assessed in this report.
- Note this two-dimensional diagram does not capture how the best model for NZ could evolve over time.[2]

[1] See Sections 4 & 6 for an outline of issues relating to Independent DSO Model (iDSO).
[2] The initial path could trend towards Total TSO but then evolve towards Hybrid, even a Hybrid Model nearer Total DSO, over time. Conversely, if LV headroom issues are considered the priority challenge, the initial move could be towards Total DSO, with later moves towards some Hybrid Model features to improve management of HV-connected flex resources.

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Recommended near-term actions that are no/low regret

	Enabler
	Continue collaborative development of DSO-like functions, do not delay action while waiting for the exact DSO model, roles & responsibilities to be set
	Agree a robust method for valuing costs and benefits of this system-wide transformation
	Develop a **preliminary plan that maps milestones** and persist/exit decision points to avoid overspending
	Develop **good practice principles to improve data availability** across the network
	Develop **shared standards for:** • **DER control and management**, including the protocols for control signals • Passing **dynamic and static operating envelope** information • **Bid and offer structures for flexibility services**
	Explore technology partners and solutions for DSO functions/capabilities
	Consider opportunities for joint DSOs/shared services

1. Introduction

DSO models in New Zealand

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This report qualitatively assesses DSO coordinated dispatch architecture and models for NZ, drawing on international lessons learned and local NZ market context

Overarching objective

- Flexibility services can help decarbonisation, increase system resilience and utilise investments in smart technologies, managing this complexity in electricity networks is a challenge and an opportunity for New Zealand (NZ).
- In this context, Electricity Networks Aotearoa (ENA) aims to explore various distribution system operation (DSO) models that could enhance the efficiency, resilience, and sustainability of NZ energy systems.
- While this report's focus is on market models for flexible resources, there are also many DSO-linked functions that policymakers also must consider – areas such as planning and connections.
- The overarching objective of the DSO models and dispatch architecture is to **enable flexibility and whole-of-system value** in NZ and considers:
  - The NZ local market context,
  - The stated desire of the Government to have distributed flexibility play a major role in balancing an increasingly renewable generation fleet, and
  - Options for managing real/perceived conflicts of interest.

DSO models for assessment

1. Total TSO	2. Total DSO	3. Hybrid between 1 & 2
• TSO's current role is expanded to include distribution network demand/generation optimisation	• EDB expands its role, with DSO dispatching all local resources and providing a residual demand or supply curve to the TSO	• TSO and DSO share capabilities and responsibilities in some way

Report structure

- This report outlines the development of appropriate options and recommendations that support unlocking whole-of-system value for the long-term benefit of NZ consumers.
- The qualitative assessment within the report focuses on 3 different DSO models. The report outlines:
  1. **The NZ local market context,** outlining the key factors that will influence the choice of a model that works best for NZ,
  2. **International case studies** from Australia and Great Britain,
  3. **Different DSO model options** and the **strengths and weaknesses** of each option in the NZ context,
  4. **Assessment criteria** for the qualitative analysis that supports the overarching objective and identified **future drivers** that may lead to each model being the preferred model
  5. **'No regret' or 'low regret' enablers** for DSO reform
  6. **Key roles for regulation and industry-led** collaboration (including retailers and aggregators) to support the ultimate identification of a preferred DSO model and its implementation
- This paper is intended to support understanding of the options and encourage discussion of their relative advantages/disadvantages. Given the complexity, further analysis and consideration is needed, including quantitative analysis, before one model can be recommended.
- Given this situation, the assessment criteria are not weighted, as the current objective is not to deliver a definitive conclusion, but to comparatively assess between DSO models. **The objective is not to identify a single best model but to inform the discussion around the relative merits of each DSO model in NZ.**

While Baringa brings global experience to the analysis of different DSO models, domestic energy factors will shape the best outcome for NZ

Our international experience

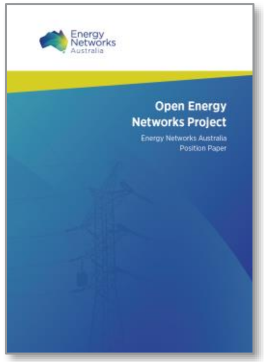
- Baringa's experience working with network peak bodies, regulators and market bodies globally have established a firm knowledge base to undertake an assessment of different DSO models.
- Baringa has been a key contributor to three major DSO market studies, shown on the right, as well as a range of DSO capability development initiatives for distribution businesses.
- Our experience has given us an appreciation of the detailed mechanics of different models, their costs and benefits, and the possible pitfalls that NZ can avoid.

Advancing the discussion about DSO in NZ

- This experience is highly relevant for NZ, but care and diligence needs to be applied when translating these global models into the NZ context.
- These DSO models need to be considered in light of the structure of the NZ market, energy system drivers, regulation, policy objectives, social license considerations and other factors in order to make a practical assessment about which DSO approach will create the best outcomes for NZ consumers.
- This piece of work, therefore, builds on international examples and work ENA has completed to-date to further the discussion about DSO models in NZ by:
  - Clarifying plausible NZ model options for NZ
  - Assessing them against a set of criteria
  - Outlining considerations for next steps

Three major global DSO studies supported by Baringa

The Energy Networks Association's (UK) DSO Future Worlds Cost-Benefit Assessment sought an independent impact assessment of the Future Worlds, including quantifying the net benefits for each and a qualitative assessment of the performance of each Future across over 30 different criteria.



The AEMO / Energy Networks Australia DSO Market Framework sought an independent quantitative and qualitative analysis of several DSO frameworks, including developing bespoke cost and benefit models to calculate net benefits of each.

Joint Utilities of New York's (JU) demand-side participation (DSP)/DSO vision and roadmap required an expert advisory team to support the development of a strategic vision for the JU's role in New York's transition to more decentralised energy sources, centred around the concept of a Distribution System Platform.

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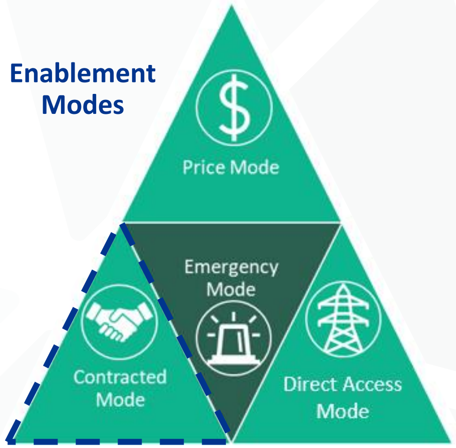
ENA completed Stage 1 analysis, the Stage 2 report builds on this to consider DSO models and their application in NZ

Multi-stage process

Stage 1 → Stage 2



Project overview

- In Dec 2023, a project was initiated to improve understanding and alignment between electricity distribution businesses (EDBs) on the **capability, enablement modes, roles, functions and industry architecture to enable distributed flexibility**
  - **Stage 1** of the project focused on defining the **roles, functions and common terminology**. The project undertook international research on emerging practices and engaged with EDBs to capture a pan-EDB view.
  - ENA has undertaken **Stage 2** of the project, which considers **coordinated dispatch and operation architecture and DSO models** to fulfil these roles and functions, and the impact of these on capability of EDBs.
- The purpose of the Stage 2 paper is to review international DSO models and apply an assessment approach to inform the discussion around the relative merits of each DSO model in NZ.

Price Mode
Uses pricing signals to encourage flexibility based on network conditions

Contracted Mode
Secures flexibility through agreements, increasing certainty of response. We have split this further into:
- **Contracted Procurement of flexibility products/services**
- **Flexible Customer Connections, where a customer is required to modify their capacity under certain conditions such as an operating envelope**

Direct Access Mode
Allows direct access or physical control of flexible resources

Emergency Mode
Mandatory response to avoid outages and protect the network in critical situations

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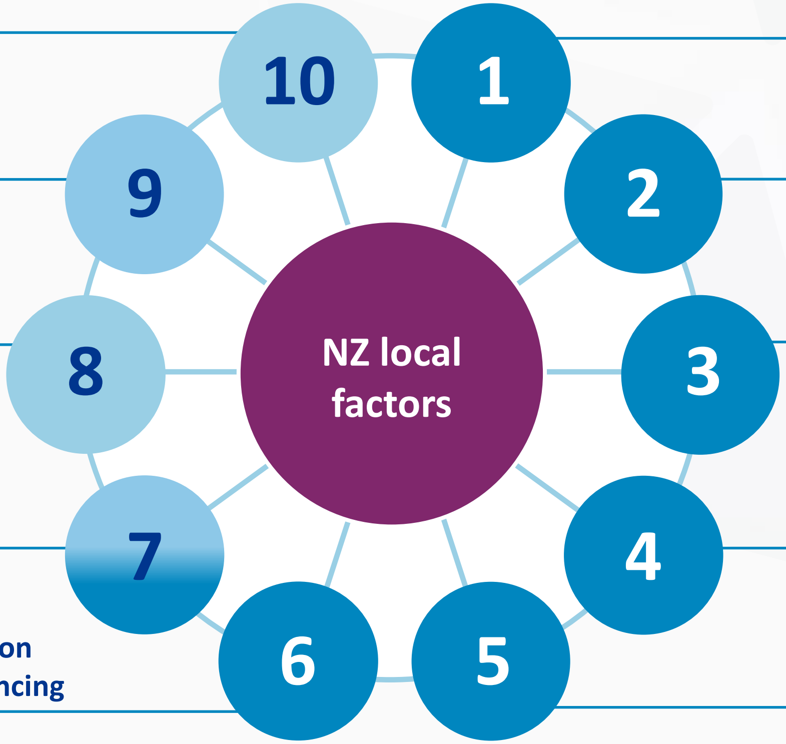
2. New Zealand context for DSO models

DSO models in New Zealand

We consider there are ten key local factors in New Zealand that DSO model enablement needs to take into account to develop a fit-for-purpose approach



1. Large number of EDBs with diverse contexts, scales and drivers
2. Mix of price-controlled and non-price controlled EDBs
3. Near universal penetration of smart metering
4. Significant levels of flexibility from (and reliance on) hot water controlled-load
5. Dynamic and nodal wholesale market pricing design
6. Current high level of renewable energy share of generation with clear aspirations for DER as a source of system balancing
7. Government target of net zero greenhouse gas emissions by 2050, other than biogenic methane
8. Emerging but fledgling flex business models among energy retailers and aggregators
9. Electrification of heat, especially domestic gas use and industrial processes
10. Electrification of transport, especially EVs

Current state factor

Future state factor

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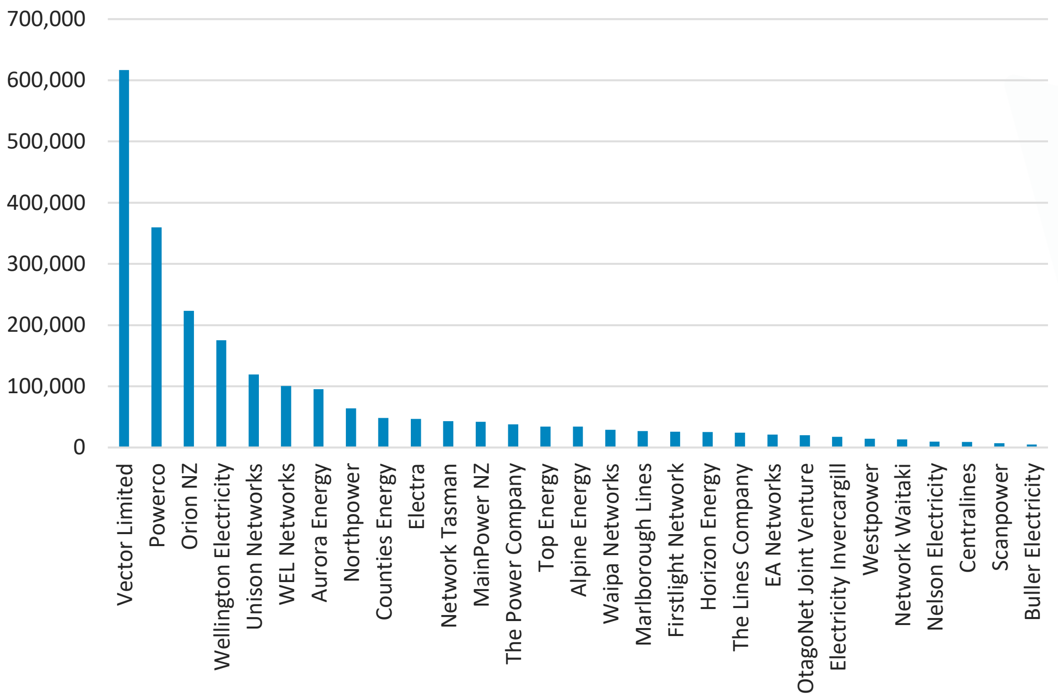
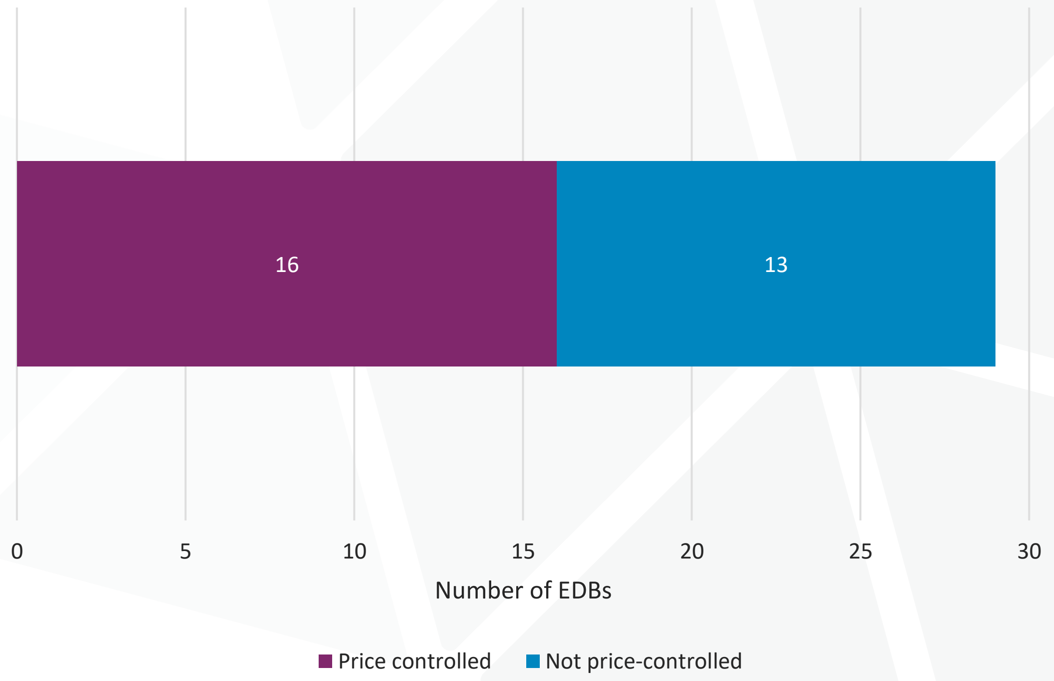
NZ has a large number of EDBs at 29, which have a diverse range of contexts and scales, and are subject to mix of price control regulation

Number of connections per EDB



Mix of EDBs subject to price control

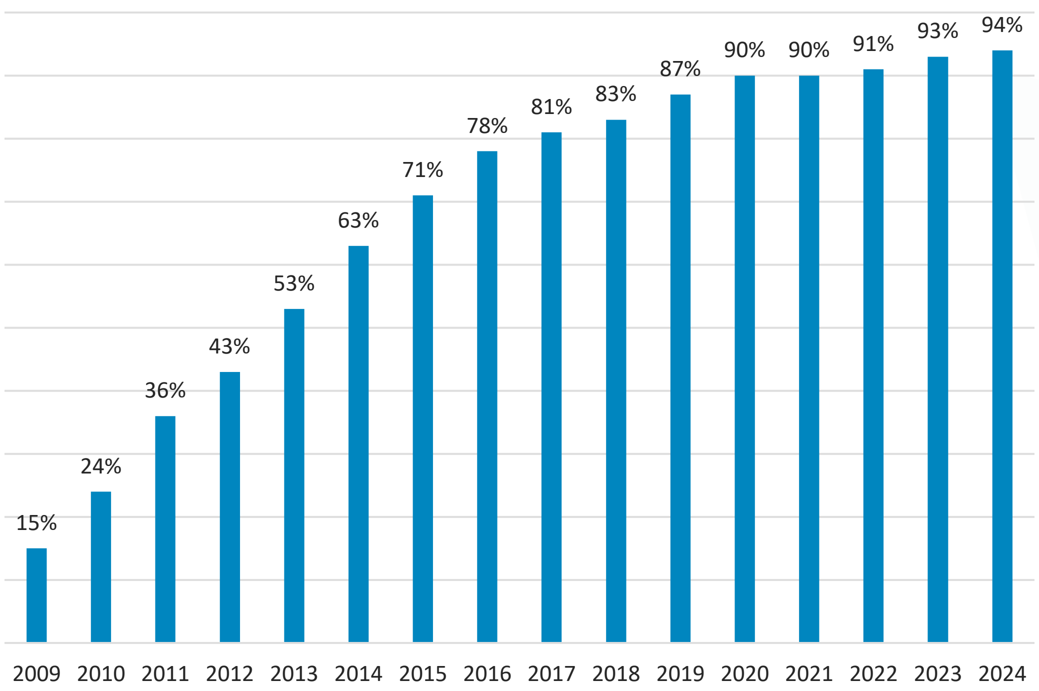


	Number of connections per EDB	Mix of EDBs subject to price control
Comment	EDBs have diverse operating environments with wide bookends. Vector has over 600,000 connections, while Buller Electricity has less than 5,000.	While most EDBs face price control regulation, including most larger EDBs, there are many EDBs that make spending decisions without regulatory approval
Significance for DSO approach	The DSO model will need to be flexible enough to accommodate diverse circumstances of EDBs	EDBs that are not subject to price control may have more flexibility in moving towards a DSO model, but they cannot be encouraged to do so by regulatory incentives like those we see in the UK

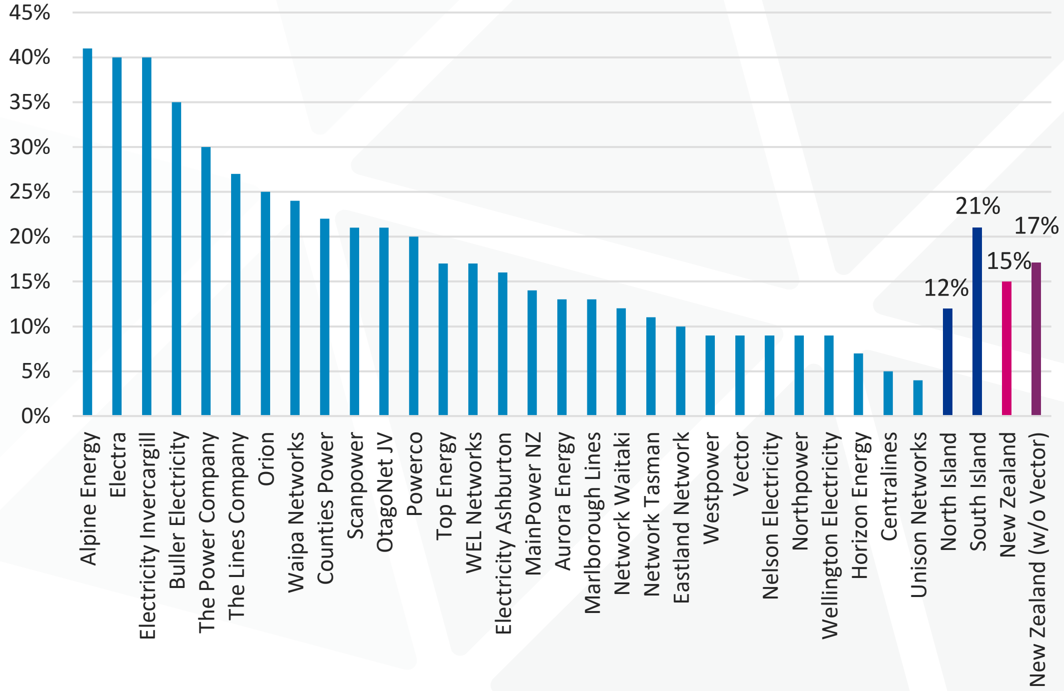
Source: Electricity Distribution Business Pricing Methodology, Mainpower, 2022 Electricity Networks Aotearoa, February 2025 (both panels)

NZ has near universal uptake of residential smart meters and a material proportion of peak demand under ripple control via hot water systems

Share of residential connections with a smart meter, 2009-2024



Share of maximum demand under ripple control, 2018

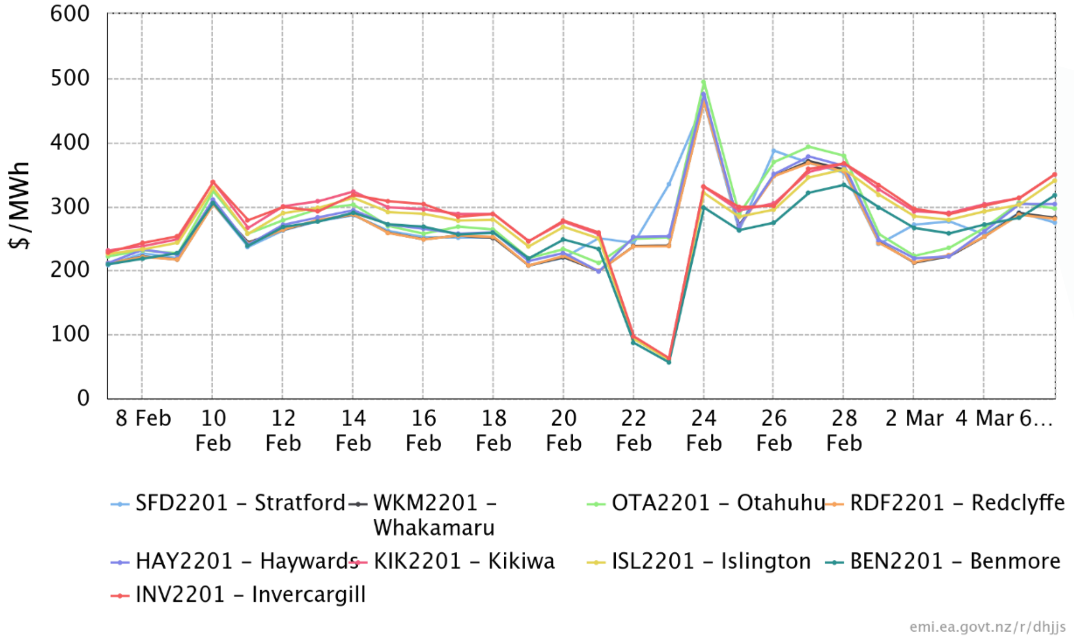


	Share of residential connections with a smart meter	Share of maximum demand under ripple control
Comment	The NZ market has very high smart meter uptake by international standards and therefore broad-based consumer operational data availability	EDBs, through ripple control of hot water systems, have influence over a material proportional of peak demand
Significance for DSO approach	High smart meter uptake is a key enabler for the DSO transition as it provides critical visibility of consumer usage, LV network utilisation and activity. However, many NZ smart meters may not have the functionality to enable these services.	Hot water provides a significant source of demand response flexibility. A key consideration is how operation will be coordinated between parties managing this resource through ripple and smart meter technology for different purposes.

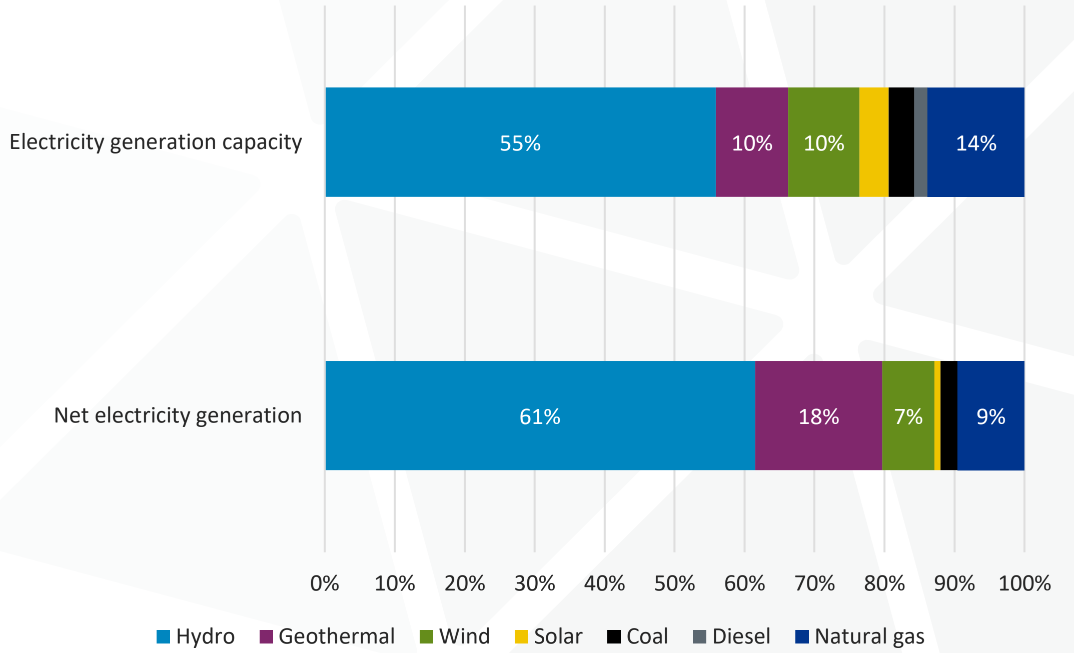
Source LHS: Electricity Authority, Retail Market Snapshot, 2024. **Source RHS:** Energy Efficiency & Conservation Authority, Ripple Control of Hot Water in New Zealand, 2020

NZ has a nodal wholesale pricing arrangement and over 85% of generation was produced by renewable energy in 2023

Wholesale price at key nodes, 8 February - 6 March 2025



Share of electricity generation use and capacity by source, 2023



	Wholesale price at key nodes	Share of electricity generation use and capacity by source
Comment	Market participants trade at over 200 nodes within the wholesale electricity market providing robust price signals across the transmission network	In 2023, renewable energy represented around 85% of electricity generation use and almost 80% of electricity generation capacity, with most of this coming from hydro and geothermal sources
Significance for DSO approach	While the many nodes could mean wholesale prices will correlate well with local network constraints, as wholesale prices become more influenced by variable supply (solar & wind) issues rather than demand levels, correlation is expected to weaken.	While the DSO may initially focus on providing flexibility to manage local constraints, the Govt Policy Statement is explicit in wanting to see DER flexibility as a source of balancing for intermittent grid demand and supply

Source LHS: Electricity Authority, Wholesale price trends, 2025. **Source RHS:** MBIE, Electricity Demand and Generation Scenarios, 2024 (RHS), excludes biogas, waste heat and wood.

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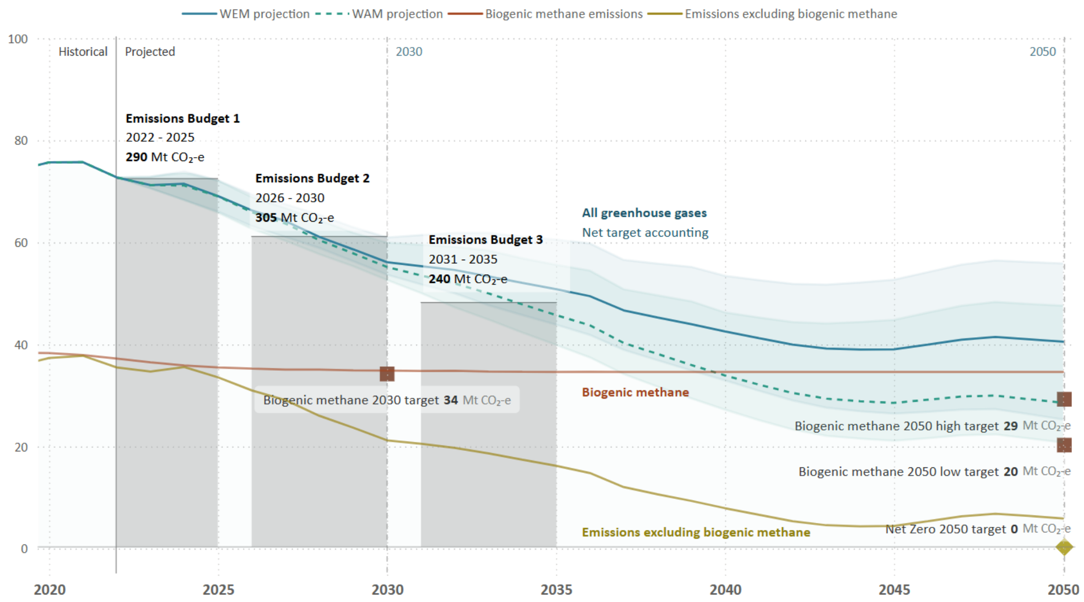
NZ has a clear emission reduction framework that is expected to drive electrification and EDBs are trialling initiatives to provide greater coordination of consumer devices

Overview of targets, budgets and projections for emission, 2020-2050



Examples of flexibility trials and calls for non-network solutions

Powerco hot water trial

Octopus Energy hot water trial

Calls for non-network solutions

mainpower
Aurora ENERGY
POWERCO
vector
networktasman
Your consumer-owned electricity distributor

Comment

The NZ *Climate Change Response (Zero Carbon) Amendment Act 2019* targets net zero emissions by 2050 (except biogenic methane)

EDBs and others are trialing the use of consumer resources to provide greater flexibility in their networks as well as making calls to the market (ROIs/EOIs) to determine if specific network needs can be met with flexibility

Significance for DSO approach

Driving down emissions will require deeper decarbonisation of the electricity system and fuel switching, which is expected to drive electrification at the consumer-level, proliferating resources that need to be efficiently coordinated

These early trials and calls to market are building EDB capability and knowledge that would be applicable for transitioning into a DSO arrangement and stimulating local flexibility markets

Source LHS: NZ Ministry for the Environment, 2024. WEM (with existing measures), WAM (with additional measures).

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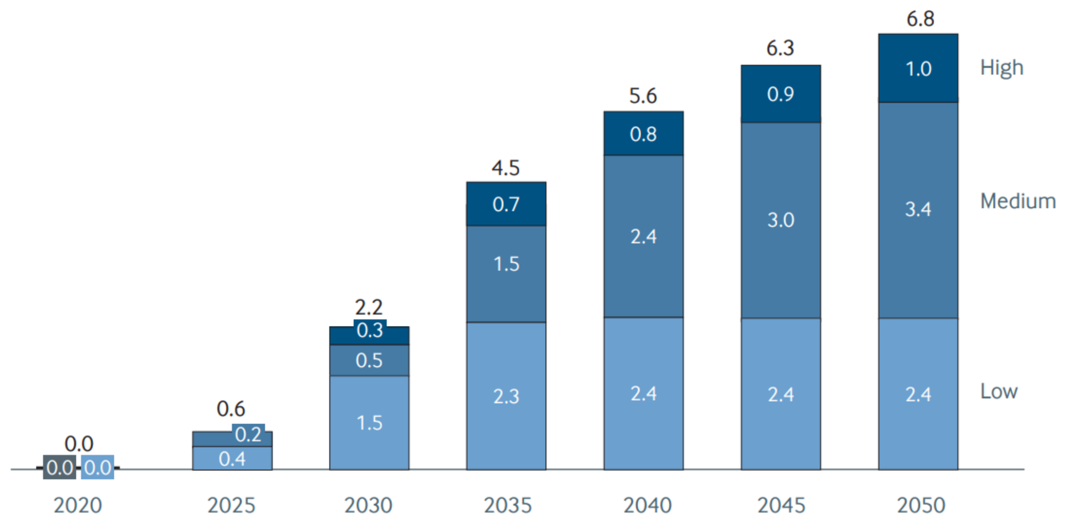
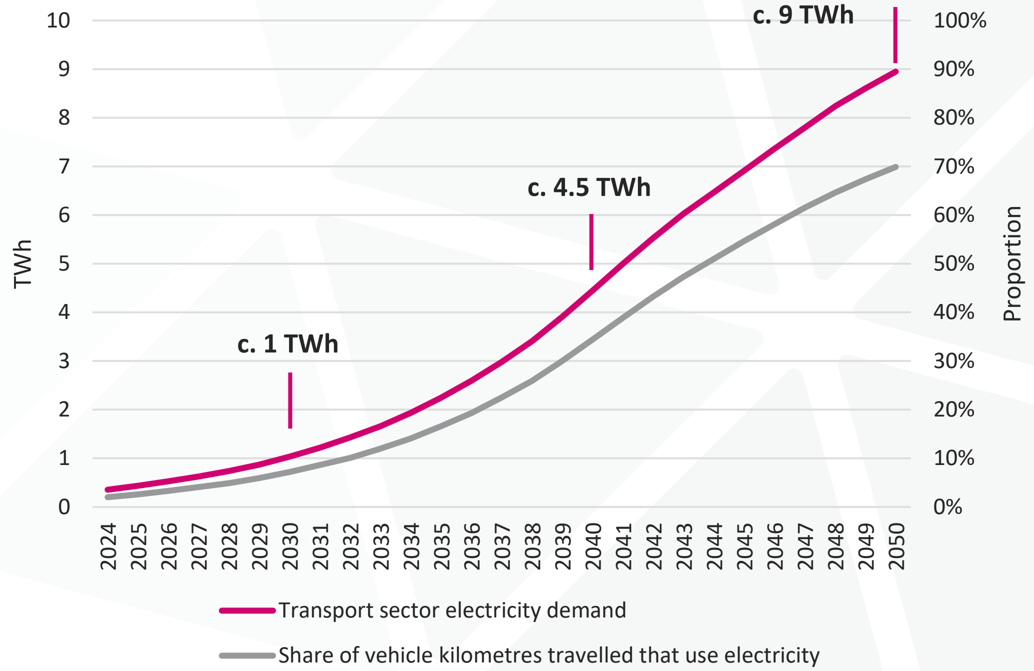
NZ is expected to see material electricity demand growth at the distribution level through electrification of process heat and transport, creating capacity challenges

Projected process heat electricity demand by temp. (TWh), 2020-50



Projected transport electricity demand and EV uptake, 2024-2050



Comment

Electrification of process heat could add 6.8 TWh of electricity demand by 2050, including 2.4 TWh at low temperatures (100 C of less), such as space and water heating. The South Island industry is expected to lead the country in the adoption of electrified process heat due to its lack of a reticulated gas network.

MBIE projects that EVs will contribute around 1 TWh, 4.5 TWh and 9 TWh of annual electricity demand, in 2030, 2040, 2050, respectively

Significance for DSO approach

Electrification of transport is expected to not only provide a material contribution to electricity demand at the LV level in New Zealand, but has the potential to be coordinated via load shifting and interruptibility to deliver benefits to the network. We also note that while current battery penetration is very low at the residential level, V2G will be a game-changer for LV networks. As parts of NZ have low kW/customer capacity levels, these factors may cause headroom congestion at LV in the near term.
At the HV level, electrification of heat is expected to be a significant driver.

Source LHS: Transpower, Whakamana i Te Mauri Hiko, 2020 **Source RHS:** MBIE, Electricity Demand and Generation Scenarios, 2024 and Ministry of Transport, Vehicle Fleet Model, 2024.

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3. Summary of international case studies

DSO models in New Zealand

The importance of different drivers varies by geography and can be a function of technology uptake, network topology, ownership structures and policy priorities

Different drivers and regulatory frameworks lead to different outcomes

GB	DG increase	Reducing fossil fuels	Lower bills	EV uptake	Grid modernisation	Heat electrification	Changing reg incentives
AUS	DG increase	Reducing fossil fuels	Lower bills	EV uptake	Grid modernisation	Heat electrification	Changing reg incentives

	Key policy driver	Regulatory model	Wholesale market model	Separation	DSO market model	DSO transition lead
GB	Net zero by 2050	Single national regulator - Ofgem	Bilateral Single price	Full unbundling	Hybrid – co-ordinated	ESO/DSO joint
AUS	Integrated System Plan	National regulators – AER/AEMC	Pool based Zonal	Full unbundling	Emerging Hybrid approach	Emerging joint approach

- Through our work on related projects internationally, we have identified a range of drivers for a more active DSO role, and the need for flexibility on the distribution network.
- These include increases in the connection of renewables and batteries to the distribution network, increases in electrification (e.g. data centres, EVs, heat pumps), and reductions in flexible assets (e.g. thermal) on the transmission network.
- The importance of different drivers varies by geography (see heat map, left), and can be a function of technology uptake, network topology, ownership structures and vertical integration, and national policy priorities.

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GB and Australia both have vertically separated industry structures with relatively large EDBs, key differences are wholesale market structure and network conditions

Market structure overview

	Great Britain	Australia (NEM)
High level market overview	• Bi-lateral wholesale market • Full unbundling of retail and networks • Retail competition exists • Live BAU flexibility markets at the distribution level	• The wholesale market is an energy only central pool • Vertically integrated 'gentailer' model • Full retail competition • AEMO as market operator across NEM
Primary DSO driver	• Congestion forecast on the transmission and distribution networks in coming years	• Uptake of residential solar on long stringy networks

Network overview

Characteristic	Great Britain	Australia (NEM)
Level of industry disaggregation	Industry vertically disaggregated between contestable segments (generation, retail) and monopoly segments subject to economic regulation (transmission, distribution)	Similar to GB, plus strong presence of 'gentailers'
Number of electricity distributors	14 licenced distributors One standalone distributor (Spanish owned), all other distributors are part of five corporate groups that each own more than one British energy network	13 licenced distributors Some standalone distributors, a total of nine corporate groups owning licenced Australian electricity distribution networks (some also own transmission and/or gas networks).
Network ownership	Privately owned	Government or privately owned depending on Australian state
Network conditions	Predominantly winter peaking grid	Predominantly summer peaking grid – for now
Economic regulation	Revenue cap reset by regulator every 5 years. Timing of 5 year cycle aligned across all electricity distributors Potentially wide set of annual adjustments to revenue cap including for incentive rewards/penalties for delivery of outputs, and uncertainty mechanism adjustments for previously uncertain expenditure.	Revenue cap reset by regulator every 5 years. Timing of 5 year cycle aligned for distributors within the same Australian state, but differs between states. Limited number of annual adjustments to revenue cap focused on service performance rewards/penalties, interest rate and inflation movements, historical under/over recoveries of revenue cap, and adjustments for previously uncertain expenditure once a trigger has been met.
Network users who pay network tariffs	Demand and generation users both contribute to upfront connection tariffs and ongoing use-of-system network tariffs or credits	Demand users pay both upfront connection tariffs and ongoing use-of-system network tariffs Generation users only pay for connection costs

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4. DSO model options for New Zealand

DSO models in New Zealand

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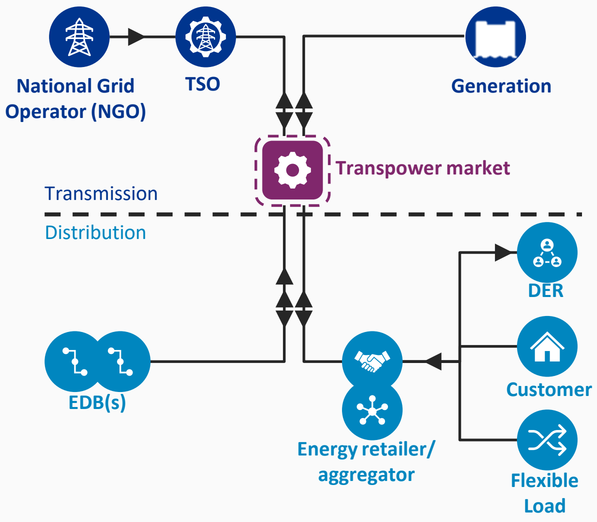
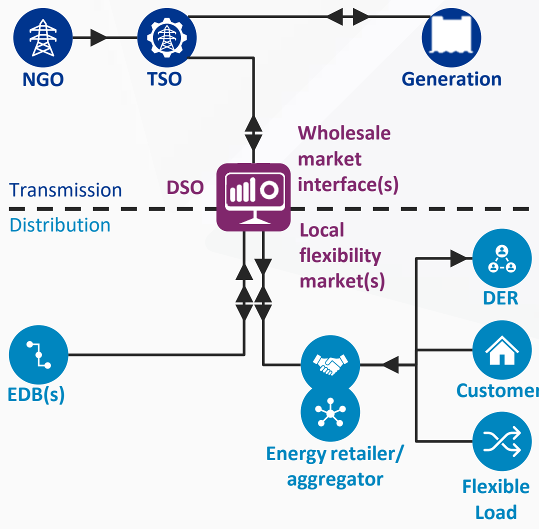
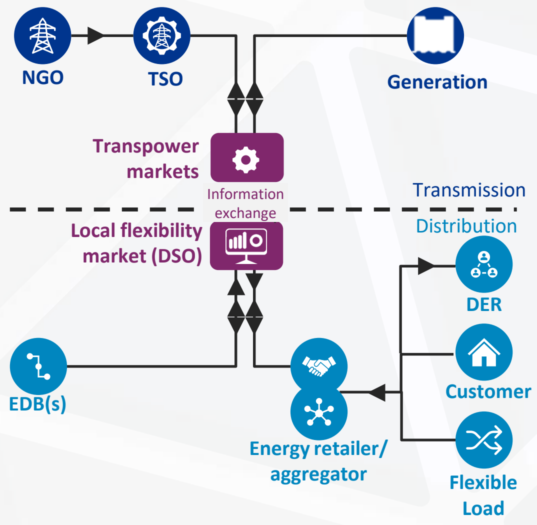
We have considered 3 DSO models that could feasibly deliver flexibility markets and services for both national and local requirements in NZ[1]

Model name	Total Transmission System Operation (TSO)	Total Distribution System Operation (DSO)	Hybrid Model[1]
Description	A centralised approach for procurement and operation of local flexibility by Transpower's TSO function, where the TSO balances all local network optimisation, system optimisation and energy market trading to deliver optimum value. Aggregators need to offer services only to the TSO.	A locally operated flexibility market, where the DSO optimises constraints within its own distribution network and provides aggregated bids to the TSO, who optimises at a market and transmission level. Aggregators need to offer services only to the DSO.	A hybrid approach, where the DSO operates local flexibility markets and optimises constraints within its own distribution network. The TSO optimises the wholesale market at transmission level. Aggregators can offer services to one or both DSO and TSO.

Simplified Diagram







[1] There is a fourth model, known as an Independent DSO or iDSO, where the DSO function is a completely separate entity, independent from both the EDB and Transpower. While models 1, 2 and 3 could all evolve into an iDSO model over the longer term, there is no logical step from the status quo to an iDSO model over the short to medium term and hence this model has not been outlined in more detail or assessed against the criteria at this stage. See section 6 for more information on governance and independence issues.

[2] Total TSO and Total TSO models can be considered ends of a spectrum of possible DSO models and the term "Hybrid Model" covers all possible model designs in between. From this spectrum, one fairly midpoint Hybrid Model has been chosen for this assessment.

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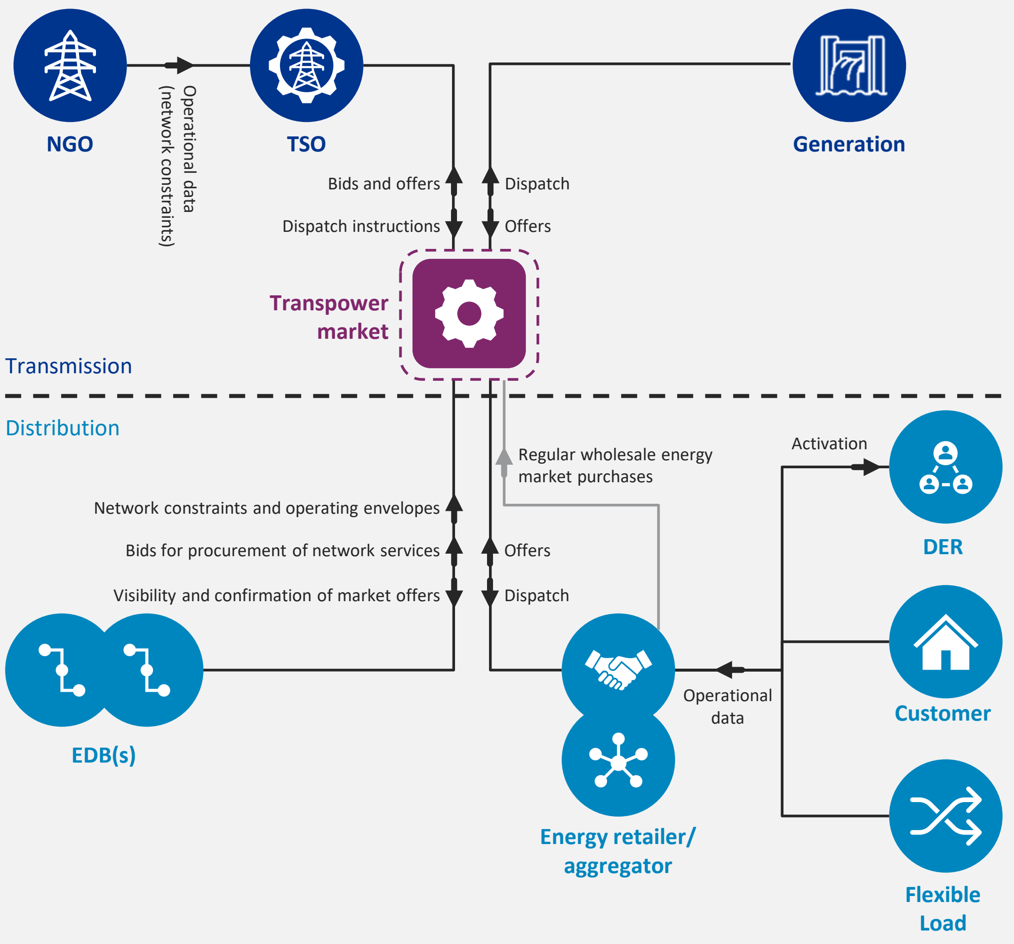
The Total TSO model has Transpower operate a single centralised market via NZX/WITS, including DER dispatch and local network constraints

Model diagram



Summary model description

- **A single centralised and integrated market**, operated by Transpower, manages all distribution and transmission-connected generation, storage and related services.
- **EDBs provide real-time network visibility and constraints** to Transpower to indicate limits to providing services
- **EDBs provide bids** (probably automated) for services from local flex/DER markets.
- **Aggregators and energy retailers develop portfolios of DER customers** to provide services to local and central markets. They offer these services to the Total TSO for both wholesale and local markets and would activate DER assets based on dispatch instructions provided by the TSO.
- **The centralised TSO**, manages all transmission and distribution network constraints and co-optimises both wholesale and local/flex markets.

Example case study:
Aggregator with a total 1MW flex load from 200 customers (5kW each).

1. *The Aggregator submits that flexibility profile to the TSO per connected GXP/per connected distribution asset level/per DER*
2. *The EDB has a local network constraint which requires, 2MW at peak times at different network levels , and submit the constraints per connected GXP and distribution asset level along with the timings to the TSO*
3. *The TSO is required to understand #1 and #2, and deliver an optimised energy profile to the Aggregator for execution so that the DNO constraints are mitigated, while the Aggregator can extract maximum practical value from the energy markets*
4. *Aggregator dispatches flex in accordance with the profile issued by the TSO*

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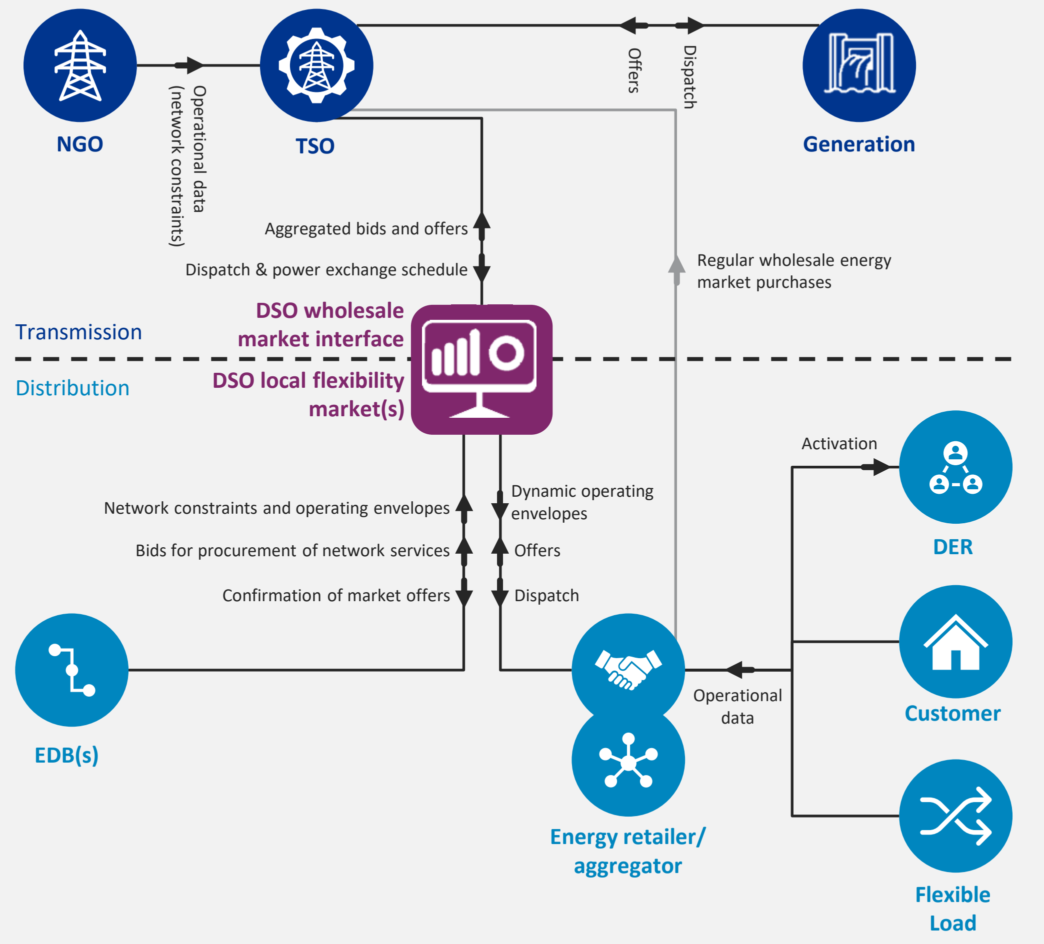
The Total DSO model has a DSO-operated interface that manages the local DER market

Model diagram



Summary model description

- **A DSO-operated market is the single interface** with the wholesale market that manages the local DER/flexibility market and distribution network constraints.
- **Aggregators and energy retailers provide offers** to the DSO that represent their dispatch preferences.
- **The Total DSO assesses offers and network constraints,** perhaps generating dynamic operating envelope (DOEs) for DER. If there are binding network constraints, some/all of an aggregator's offer to the DSO will not be offered into the wholesale market. Everything connected to the EDB must come through the DSO; the DSO effectively clears the market behind each GXP.
- **Transpower dispatches aggregated wholesale offers** but it is the DSO that advises aggregators and retailers of their combined dispatch.
- Under this model, **t**he DSO and TSO **systems communicate and interface at an aggregated level only**. Any signal from TSO to an aggregator asking to adjust an offer or from an aggregator to the TSO wanting to adjust an offer must go through the DSO.

Example case study:

Aggregator with a total 1MW flex load from 200 customers (5kW each).

1. *The Aggregator submits the flexibility profile to the local DSO per DER/per aggregated network level*
2. *The EDB has a local network constraint which requires, 2MW at peak times at different network levels , and submit the constraints per distribution asset level along with the timings to the DSO*
3. *To optimise across markets, the DSO needs some understanding from the TSO of the per GXP wholesale market pricing and any TNO level events*
4. *The DSO is required to understand #1, #2 and #3, and deliver an optimised energy profile to the Aggregator for execution*
5. *Aggregator dispatches flex in accordance with the profile issued by the DSO*

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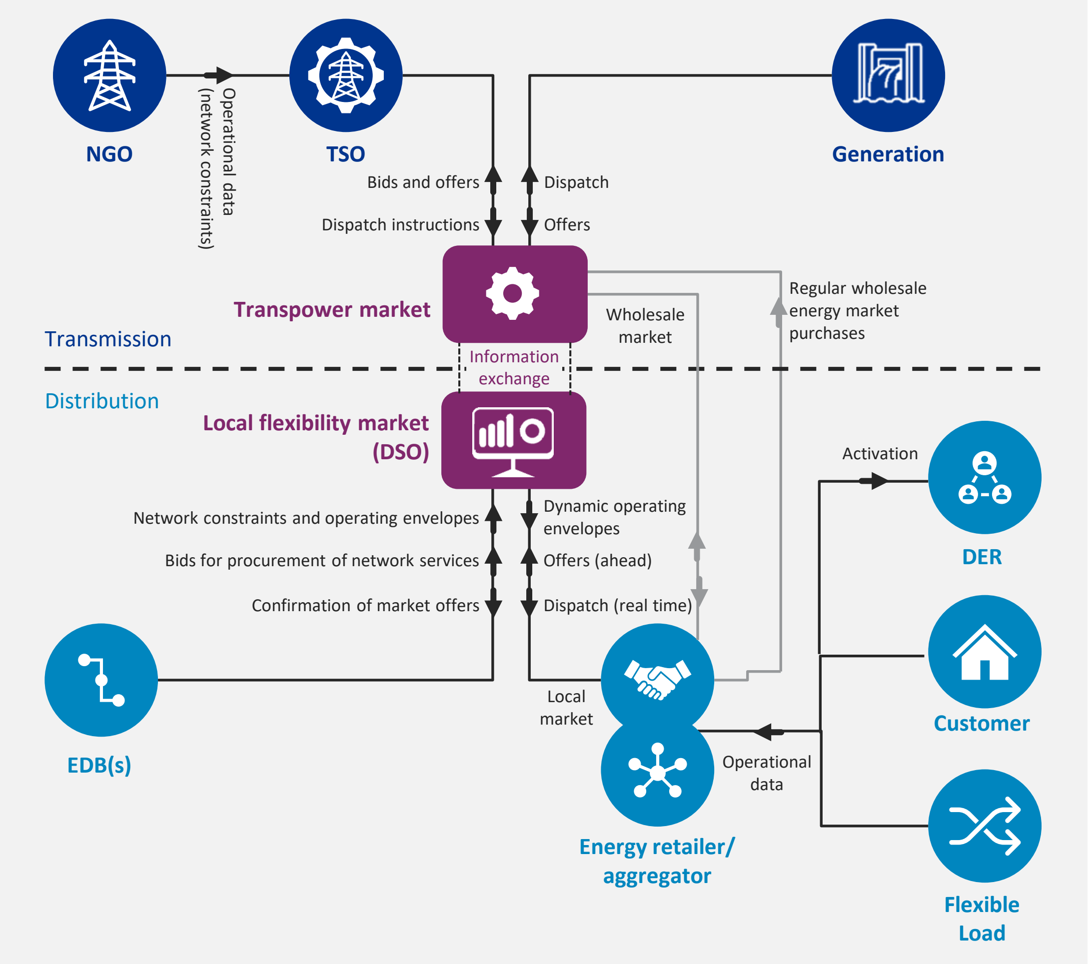
A Hybrid model involves a two-sided joint function that enables local network management while enabling Transpower to dispatch DER centrally

Model diagram



Summary model description

- **Note that there are many variants of a hybrid DSO framework** – this description and model diagram represent just one way this could work, noting it is one that is already evolving in NZ.
- **EDBs communicate network constraints** to DER participants via the DSO and, separately, may also bid for network services.
- **Aggregators and energy retailers** provide local flexibility offers to the DSO.
- **Aggregators and energy retailers** provide energy market offers to the wholesale market.
- **The DSO assesses offers against network constraints,** perhaps generating dynamic operating envelopes for DER. The DSO then optimisies and dispatches local flex markets.
- **Transpower manages the wholesale market** to optimise and dispatch all DER bids for wholesale electricity and system support services.
- **The DSO and Transpower must communicate** effectively to share information on real-time network constraints and coordinate on service procurement and dispatch activities.

Example case study:

Aggregator with a total 1MW flex load from 200 customers (5kW each).

1. *The Aggregator submits the flexibility profile to one or both of the local DSO and TSO per DER/per aggregated network level*
2. *The EDB has a local network constraint and submits it per distribution asset level along with the timings to the DSO*
3. *The DSO is required to deliver an optimised profile to the Aggregator for execution*
4. *The DSO communicates the net load result at an aggregated GXP level to the TSO*
5. *The TSO delivers optimised energy profile to the Aggregator for execution*
6. *The Aggregator dispatches appropriate flexibility to deliver the profiles provided by both the DSO and TSO*

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Functions under each of the three models

	Total TSO	Total DSO	Hybrid
Responsibility for ensuring constraints on transmission network are met	TSO	TSO	TSO
Responsibility for ensuring constraints on distribution network are met	TSO	DSO	DSO
Responsibility for receiving offers from, and dispatching to Aggregators	Only TSO talks to Aggregators	Only DSO talks to Aggregators	Both – TSO for wholesale services, DSO for local flex services. Potential DSO/TSO 'duelling'.
Achieves overall system-wide co-optimisation of dispatch?	Yes (as long as TSO is able to effectively account for all dx constraints)	No; two-step: local prioritised over global (local solved first), so slightly sub-optimal	Perhaps, dependent on offers from Aggregators and DSO/TSO coordination.
Aggregators participate directly in national wholesale markets?	Yes – send offers to TSO	No – the DSO aggregates all DER offers and passes the residual offer to the TSO.	Yes – send offers to TSO
DSO calculates and communicates flexible connections to Aggregators?	No – local constraints are shared by EDB to TSO, and TSO dispatches Aggregators in line with them.	Yes	Yes
Can coordinate with non-market EDB-activated direct access control (eg hot water) contracted procurement and flexible connections?	Unlikely, unless EDB advises TSO of these and TSO can co-optimise	Yes, as long as EDB advises DSO of these and DSO can co-optimise	Yes for flex markets if EDB advises DSO of these and DSO can co-optimise. Uncertain for wholesale market.
Responsibility for coordinating Aggregator response to manage emergencies	TSO	DSO	Both – but TSO instructions for specific regions could be managed by the DSO

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5. Qualitative assessment of DSO model options

DSO models in New Zealand

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We are using 11 assessment criteria to assess each model, with no weightings applied to the criteria to enable a comparative and qualitative assessment

#	Assessment criteria	Short version
1	How far does the solution enable whole system value created	*Creates whole system value*
2	Required NZ Inc level investment for both capital and operational	*Cost to implement*
3	Clarity of roles between Total TSO, DSO / EDBs and retailers / aggregators	*Clarity of roles*
4	Change required to the existing regulatory environment	*Regulatory change required*
5	Speed to market / speed of implementation	*Implementation timeframe*
6	Stability and integrity of both the grid and distribution networks prioritised and maintained	*Network stability*
7	Resilience as climate change related weather events get worse	*Climate change resilience*
8	Simplicity & Standardisation for all stakeholders in the value chain	*Simplicity and standardisation*
9	Enabling choice for customers that allows them to achieve the benefits that are most important to them	*Enables customer choice*
10	Unlocking flexibility for the customer to achieve value stacking and multiple revenue/cost saving opportunities	*Unlocks flex value stacking*
11	Contribution to decarbonisation outcomes	*Contributes to decarbonisation*

All 3 DSO models have a range of strengths and weaknesses, differing across both benefit and cost and practicality related assessment criteria

Type	#	Assessment criteria	Model 1 Total TSO	Model 2 Total DSO	Model 3 Hybrid model
Cost/value	1	Creates whole system value			
	2	Cost to implement			
	3	Unlocks flex value stacking			
Practicality	4	Clarity of roles			
	5	Regulatory change required			
	6	Implementation timeframe			
	7	Simplicity and standardisation			
Benefit	8	Network stability			
	9	Climate change resilience			
	10	Enables customer choice			
	11	Contributes to decarbonisation			

The objective is not to identify a single best model but to inform the discussion around the relative merits of each DSO model.

5-point rating scale

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Baringa

Transpower/TSO will need to expand existing systems and operations to cover the distribution networks – this may be a significant task

Type	#	Assessment criteria	Commentary
Cost/value	1	Creates whole system value	Transpower/TSO can adopt a whole of system approach as the Total TSO – but only if the Total TSO can successfully factor whole-of-system resources and constraints into the dispatch. This is a major challenge – there are only 170 transmission substations but there are over 100,000 distribution substations across NZ, many of them serving only a handful of customers
	2	Cost to implement	The step change role for Transpower, having more responsibilities and requiring more resources, will have implications for its funding model. Transpower would need to understand flows on the distribution network and interpret the augmentation requirements of EDBs.
	3	Unlocks flex value stacking	While customers can have response aggregated to access revenue streams, the limited consideration of LV will limit the value they can receive for their flexibility.
Practicality	4	Clarity of roles	All market participants interact with a single interface, Transpower/TSO, that acts as a transparent market facilitator. Transpower also does not have a conflicting interest using DER flexibility from the distribution asset owners.
	5	Regulatory change required	Material regulatory change required as Transpower/TSO will need to expand system operations to cover new markets with the introduction of regulatory measures to ensure that it takes decisions which lead to the best whole system outcomes.
	6	Implementation timeframe	Due to the significant business change required from Transpower/TSO, as well as the speed at which technology and functional maturity develops, a staged approach is required to unlock the most value from a Total TSO model.
	7	Simplicity and standardisation	A central market allows for standardisation of processes and procedures, with procurement, dispatch and settlement of DER for system services organised and operated by a single entity.
Benefit	8	Network stability	EDBs will need to provide Transpower with a full view of network needs and constraints. Transpower will need to understand and respond to these, but given Transpower's remoteness from LV, there is some risk of 'tier bypass' where LV resources are dispatched without full understanding of LV constraints.
	9	Climate change resilience	There may be limited flexible resources to use at LV to help restore supply more quickly following a shock weather event, limiting the role which flexibility providers can play in providing network resilience under the Total TSO model.
	10	Enables customer choice	Transpower is unlikely to be able to actively procure flexible services directly from LV customers, reducing choice for small consumers to lower their energy bills through more flexible usage.
	11	Contributes to decarbonisation	Based on creating capacity on the transmission network for low carbon technologies, Transpower will be equipped to perform this on the transmission network, however it will be challenged to operate flexibility solutions to avoid augmentation at LV.

A Total DSO Model managing flexibility from DER can leverage value from distribution networks, and therefore the the TSO/DSO interaction is critical

Type	#	Assessment criteria	Commentary
Cost/value	1	Creates whole system value	The Total DSO will have a good view of all value in distribution networks, the challenge will be how that link into the Total TSO to capture whole-of-system value.
	2	Cost to implement	EDBs do not have any experience with real-time dispatch and would need to develop capability for the co-ordination mechanisms needed for managing DER dispatch and settlement by the DSOs. This will incur material costs for establishment and operation.
	3	Unlocks flex value stacking	Creating new local markets and facilitating more aggregators or flexibility service providers that can support multiple trading opportunities for DER, however capability needs to be developed to aggregate flexibility into wholesale markets.
Practicality	4	Clarity of roles	DSO is one-stop shop for aggregators. There could be a conflict of interest between market coordination for the DSO and optioneering during investment planning for the EDB. This can be mitigated with strong governance processes.
	5	Regulatory change required	Establishing the DSO as the one-stop-shop for DER aggregators would require significant regulatory changes and be contrary to current practice where aggregators can bid directly into wholesale markets.
	6	Implementation timeframe	Longer implementation timeframe due to the need for local infrastructure and systems, as well as the development of local markets.
	7	Simplicity and standardisation	Naturally more complicated as it is decentralised, but can be standardised with proper frameworks and coordination. Local variations may require tailored DSO solutions, requiring a seamless and coordinated process between DSOs and Transpower.
Benefit	8	Network stability	The DSO will be running local markets which may have many different requirements and participants, but with clear technical guidelines this complexity can be addressed.
	9	Climate change resilience	There is clear responsibility for network outages at the distribution level, which is likely to provide greater network resilience and recovery. The Total DSO can leverage the synergies between system and network operations to help restore supplies quickly in the event of system failure.
	10	Enables customer choice	Using EDBs existing relationships and network knowledge will enable development of local markets, access products and price signals which can provide a wide avenue for customer participation, particularly at the LV level.
	11	Contributes to decarbonisation	Based on contracting flexibility through services to create capacity on the distribution network for low carbon technologies, the Total DSO will excel with the ability to use historic knowledge of EDB networks to create additional headroom for EVs and heat pumps.

A Hybrid Model could be the best of both Total TSO and DSO – avoiding duplication will be a key factor

Type	#	Assessment criteria	Commentary
Cost/value	1	Creates whole system value	Responsibilities are split between Transpower/NZX and DSO which provides a risk that neither party has the full information available to optimise from a whole system perspective. This can be mitigated through clear and robust co-ordination processes.
	2	Cost to implement	If done incrementally from status quo, a Hybrid model can keep costs manageable. But if major new systems are needed for coordination mechanisms, significant investment may be needed.
	3	Unlocks flex value stacking	Different commercial arrangements can exist for these functions to be fulfilled such as a shared service model could mean that several EDBs decide to leverage the same platform provider or outsource delivery of certain functions.
Practicality	4	Clarity of roles	The TSO and EDB/DSO roles align with their existing areas of expertise, but a seamless interface is required between the two to share information on real-time network constraints and coordinate on dispatch activities.
	5	Regulatory change required	Major regulatory changes may not be required up front, but updates to rules and regulations to manage the co-ordination between DSOs and Transpower across system planning, co-ordination and dispatch, including ring-fencing, will eventually be required.
	6	Implementation timeframe	May require less organisational change than other Models, with the main change being development of agreed co-ordination mechanisms needed for planning and system operation which can be implemented through updating industry codes.
	7	Simplicity and standardisation	Potentially the most complex, requiring DER aggregators to bid into multiple markets, although this is evolving as normal practice.
Benefit	8	Network stability	Offers a balanced approach, with both Transpower/NZX and EDBs working together to ensure grid stability. This model can leverage local flexibility while maintaining overall system stability.
	9	Climate change resilience	Like the Total DSO, there is clear responsibility for network outages at the distribution level which rests with the EDB. This can lead to greater network resilience and recovery due to faster response to network issues through better utilising flexibility resources.
	10	Enables customer choice	Can enable customer choice by providing a range of local and wholesale market choices. This model can offer the best of both models, with centralised coordination, reliability and local flexibility.
	11	Contributes to decarbonisation	Combines the strengths of both models, potentially offering the most comprehensive approach to decarbonisation. This model can integrate large-scale and local renewable resources for maximum impact.

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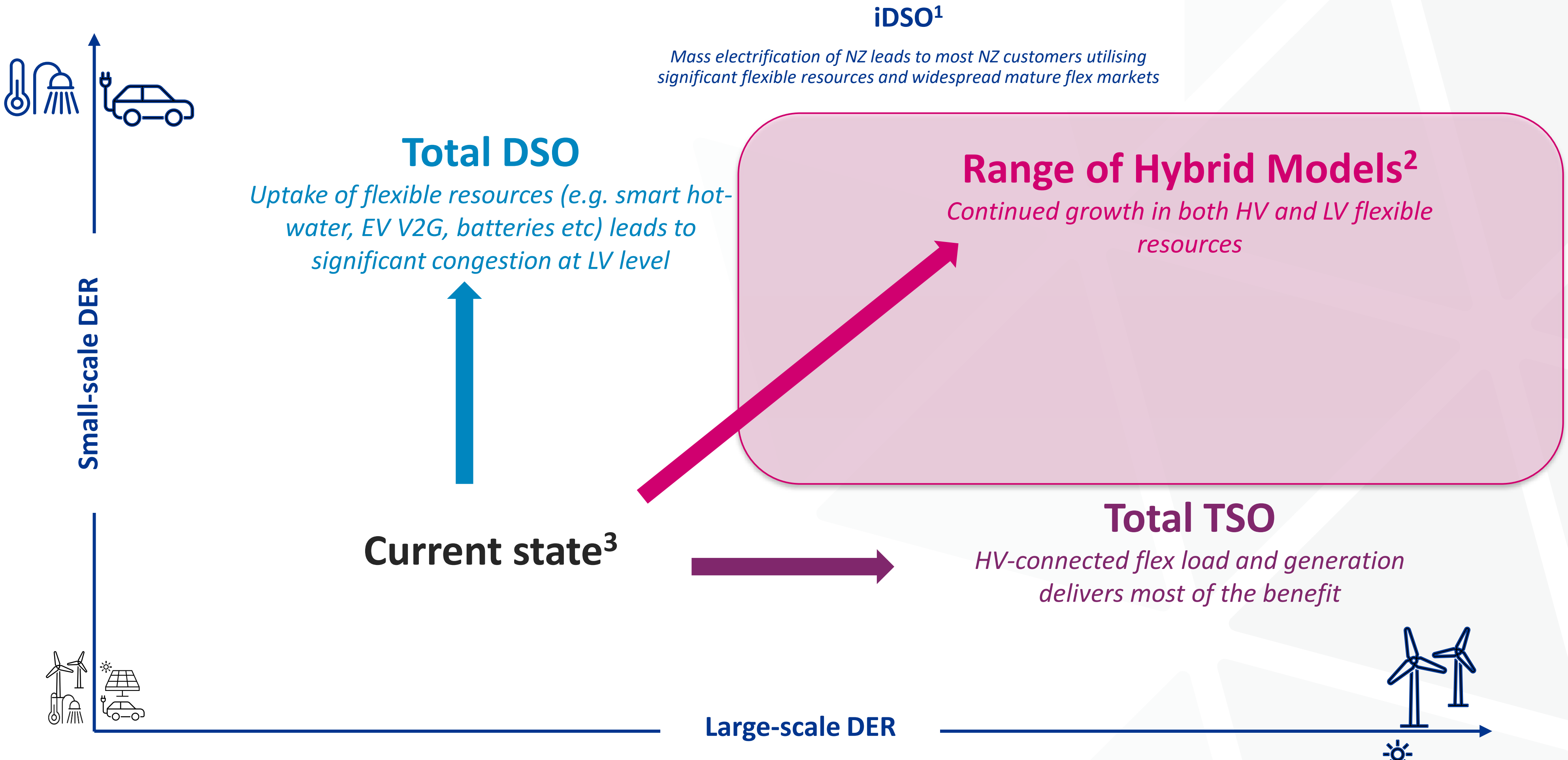
6. Pathways, independence and recommended near-term actions

DSO models in New Zealand

Potential long-term market evolution paths in NZ and a range of different worlds



[1] See following slides for more information on governance and independence issues related to the Independent DSO Model.
[2] While a single model has been identified and assessed in this report, the term "Hybrid Model" covers all possible model designs between Total TSO and Total DSO.
[3] Note this two-dimensional diagram does not capture how the best model for NZ could evolve over time. The initial path could trend towards Total TSO but then evolve towards Hybrid, even a Hybrid Model nearer Total DSO, over time. Conversely, if LV headroom issues are considered the priority challenge, the initial move could be towards Total DSO, with later moves towards some Hybrid Model features to improve management of HV-connected flex resources.

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Governance models are likely to evolve over time, monitoring the potential benefits and risks of functional independence should be a focus

Not set and forget

- Neither the Total DSO nor most Hybrid Models requires separation or independence of core DSO functionality from the EDB to realise its benefits (Total TSO does, which raises issues around associated responsibilities – see box below)
- The models do, however require principles of transparency and neutrality to be observed by the DSO, across the broad range of DSO functions
- Risks of conflicts of interest may arise if network operation, planning and market development are undertaken within the same entity
- There are already a range of mitigations in place, but the residual risk should be monitored and controlled, to ensure consumer benefits are being maximised, e.g. information disclosure requirements, rules around related party transactions, cost allocation methodologies and (draft) guidelines around distributor involvement in flexibility services
- A variety of 'independent' DSO models have been examined overseas, alongside the three models analysed in this report
- In New Zealand there are a number of existing controls in place under the Commerce Commission's and Electricity Authority's regimes

International learnings

- Independence risks are being addressed in various ways around the world. In the UK and Australia, regulators have not explicitly required separation of DSO functions, but in the UK the DSO incentive criteria create winners and losers based on how well DNOs are providing transparency
- Most UK networks have taken steps to provide transparency – with clear functional separation, decision governance, compliance and reporting – and have often found the process helpful in clarifying how to align the organisation to maximise non-network solutions
- Risks of conflicts of interest will differ across the various functions and sub-functions of DSO. The controls required will be different, depending on the function. For each of the emergent functional components of DSOs, regulators should identify the risks of conflicts emerging, the controls in place, and determine what outcomes would indicate further controls are required. "Conflict" here does not refer to friction or arguments, rather, simply identifying those outputs and decision points that embody the tension between a DNO's strategic planner vs. asset owner roles, and managing them
- Requiring independence of a particular function, or sub-function, of DSO, should be a last resort in each case. This report does not recommend this as a least-regrets step at this point in NZ's market evolution

For NZ, any split of core distribution-related DSO functionality from the control of EDBs will raise a host of regulatory issues:

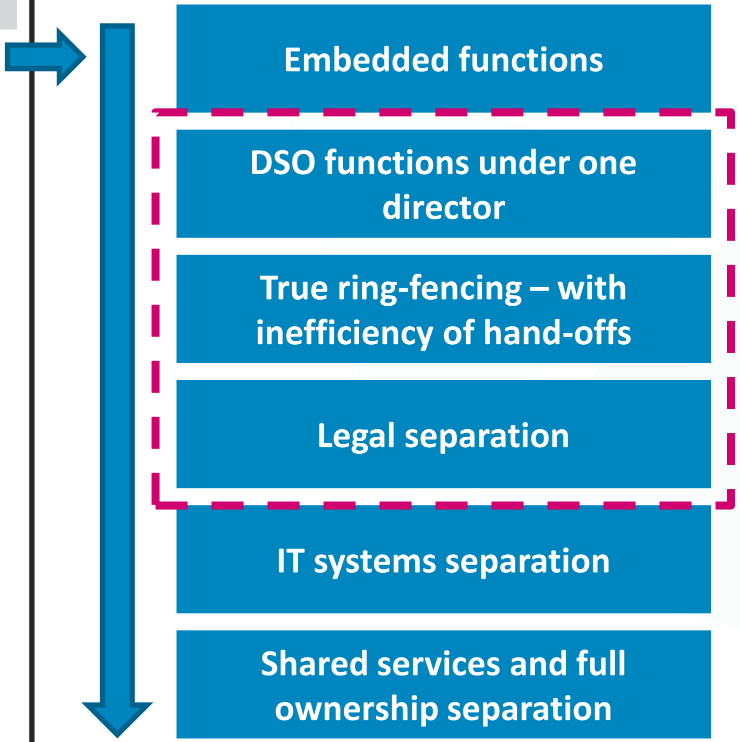
1. If DSO functions are fully independent of the EDB, would the separate DSO also need to be a fully regulated entity?
2. What are the rules for regulating it?
3. How would the independent DSO's interaction with the EDB be contracted, regulated and enforced?
4. Should the independent DSOs be held responsible for some of the performance obligations currently imposed on EDBs?

UK experience: separation drives transparency – but at a cost

GB DSOs: some separation steps

- Ofgem seeking clear and separate decision-making frameworks, supported by independent oversight, such as external auditing, to promote transparency and enable scrutiny.
- DNOs to set out conflict mitigation options
- DNOs are all proposing some form of business separation
- Clear, transparent and publicly available operational codes / agreements / processes
- Independent oversight
- Public reporting of outcomes
- Compliance and assurance

Depth of UK separation



In all UK DNO/DSOs the CEO retains ultimate legal decision-making authority

Implications for NZ?

- The GB experience is evolving towards more transparent DSO separation from DNO functions. However, the costs of full separation (iDSO) are significant. Even with the GB's:

1. scale of the DNOs; and
2. relatively long history and deep DSO-style flex markets the sector is still a significant way from having true iDSOs

- NZ markets and customers likely to be well served by a focus on oversight, reporting and compliance rather than separation.
- As outlined on the previous slides, a move towards iDSOs in NZ would seem to be best considered after the sector has evolved considerably from its current state.

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Near-term actions that are no/low regret will set the foundation for NZ to progress their path in the energy transition

Enabler	Value and relevance to DSO development
Continue collaborative development of DSO-like functions, do not delay action while waiting for the exact DSO model, roles & responsibilities to be set	• Regardless of the final DSO model adopted for NZ, EDBs and Transpower should focus on developing, in collaboration with relevant stakeholders, network planning, network operation and market development process to manage a world with more flexible resources • Continue to build clarity around roles/processes between TSO, DSO/EDBs and retailers / aggregators to make it easier in future to talk about DSO policy development. Collaboration via ENA will be helpful here. • Develop policy with awareness that the future for some functions is quite uncertain but for some it is more likely (e.g. overseas experience strongly suggests EDBs will remain responsible for real-time network operation)
Agree robust method for valuing costs and benefits of this system-wide transformation	• While this report undertakes a qualitative assessment only, in due course a quantitative assessment will be required • An agreed framework and approach for evaluating costs and benefits of the change will help ensure that stakeholders understand the net benefits (or not) of DSO implementation • This framework will be essential as the costs/benefits will have to be re-assessed as the reform evolves
Develop a **preliminary plan that maps milestones** and persist/exit decision points to avoid overspending	• By taking incremental actions now to enable flexibility, this provides optionality for NZ to take alternative approaches and to explore alternative models • Reform therefore should be staged with milestone checks, persist/exit decision points and monitoring of governance/conflict of interest issues that can adjust to new information over time, such as takeup of EVs with V2G capability and growth of HV-connected generation and flexible resources
Develop **good practice principles to improve data availability** across the network	• Data availability and quality are essential for DSO functions, with EDBs possessing a wide range of data capabilities • Developing some guidance on common approaches to data collection and management will lower costs and help accelerate how quickly DSO benefits are achieved • Leverage the high penetration of smart meters to explore DSO use cases such as: accurate and real time grid models and network visibility; automatic DER identification; short term forecasting

Early investment in efficient enablers will allow for gradual scaling to the appropriate DSO model

Enabler	Value and relevance to DSO development
Develop **shared standards for:** • **DER control and management**, including the protocols for control signals • Passing **dynamic and static operating envelope** information • **Bid and offer structures for flexibility services**	• The diversity of existing EDB processes for managing DER means that there is unlikely to be a shared understanding about how to communicate data that is critical for DSO functions • There are some data types where the *what* (contents and format of the data), and *how* (communication processes and protocols) are model-agnostic • Developing shared standards for these data types will help align flexibility markets for participants and make launching NZ-wide DSO functions more straightforward • The ENA should consider exploring standards in open data provision across EDBs, but this needs to be carefully managed in consultation with consumers so that benefits and risks of data sharing are well understood
Explore technology partners and solutions for DSO functions/capabilities	• There are a range of technology providers emerging for DSO functions (e.g., flexibility marketplace, emergency solar switch-off, network nowcasting/forecasting) • Undertaking a preliminary scan of what solutions are in the market would help EDBs determine which functions can be bought 'off the shelf' or would need to be tailored the NZ context
Consider opportunities for shared services/joint DSO approaches	• Where appropriate, EDBs should explore jointly developing or contracting DSO services and functions to acquire some scale efficiencies and support standardisation without material structural or regulatory intervention • Exploring opportunities for a degree of centralisation through the ENA - drawing on international jurisdictions and their learnings to drive focus • Joint opportunities could include: asset registration, joint market enablement functions, joint flexible product standards and designs, regional/joint generation and demand forecasting with local authority input

7. Key roles for regulation and industry-led collaboration

DSO models in New Zealand

Each entity within the NZ electricity system has a key role to enable the future system

Entity	Role
Electricity Authority	• Establish policies to guide the development of DSO functions, ensuring alignment with national energy goals • Outline and design market structures and rules to incentivise efficient network operation and investment • Monitor compliance with regulations and enforce penalties for non-compliance
Commerce Commission	• Regulate the economic aspects of distribution, including pricing, incentives and investment related to DSO uplift capability • Monitor the evolution of joint DSO/shared services structures, the customer benefits delivered and any competition issues • Consider the concept of a DSO incentive, with an initial focus on the best ways to measure DSO performance • Encourage EDBs to adopt a ‘flex-first’ approach and consider if a TOTEX approach may deliver better results for NZ customers
Ministry of Business, Innovation & Employment	• Develop overarching energy policies that support the transition to a preferred DSO model such as common digital energy infrastructure • Work with industry to develop standards for data exchange and system interoperability
Transpower	• Continue to better integrate more distribution-connected generation, storage and flexibility into the NZ wholesale market • Evolve system-wide planning to better incorporate the impacts of distribution-connected resources • Continue engagement with EDBs to standardise where possible planning and operational approaches
EDBs	• Manage and operate the distribution network, maintaining reliability and efficiency • Developing network planning, operation and market development process to manage a world with more flexible resources • Develop local flex markets where they can defer need for network expansion
Retailers	• Engage with consumers to educate them about demand response programs and energy management • Work with EDBs to analyse consumer data to provide insights and tailor services
Aggregators[1]	• Deliver visibility of demand response and flexibility services that can balance supply and demand • Aggregate consumer loads and participate in energy markets to provide network services in collaboration with EDBs • While it will be valuable to let aggregator models evolve oganically, policymakers need to define a set of minimum level obligations aggregators must meet to ensure safe and effective system operation
Technology providers	• Develop technologies and solutions to support the preferred DSO model • Offer data analytics tools to optimise grid operations and enhance decision-making
Consumer groups	• Represent consumer interests in discussions about DSO models, with a focus on transparency to improve customer experience • Provide feedback on proposed changes and their impact on consumers and price impacts

[1] Retailers could also be aggregators, but many aggregators will not be retailers.

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Attachments

DSO models in New Zealand

International case study: Great Britain

Attachment A

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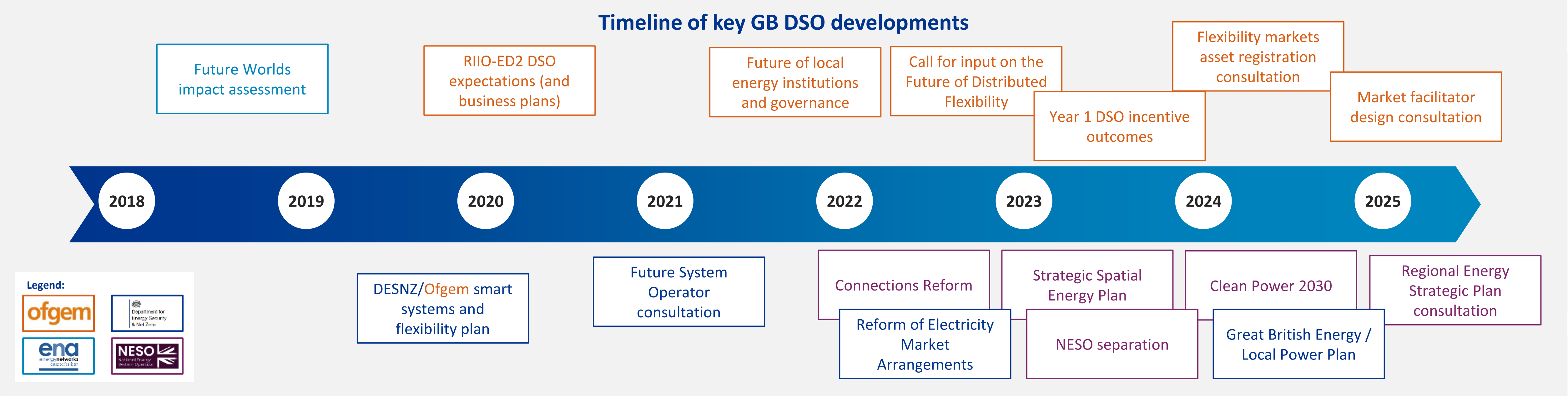
The RIIO-ED2 price control saw a formalisation of the DSO role, and ongoing reform is further embedding DSO into the industry model



- *The **ENA future worlds project** was well supported and provided input to Ofgem and DESNZ in subsequent reform*
- *The **RIIO-ED2 Price Control started the process of formalising DSO roles** across network planning, market development, and network operation, and a DSO incentive is now in place*

- ***Ofgem** has taken the lead in areas relating to the DSOs, whereas **DESNZ** and the **NESO** have led on wider related market and industry reforms*
- *Central change has focused on separation of the 'National Energy System Operator', reforms of the electricity market, a greater emphasis on top-down planning for net zero, and the role of the state in the energy system*

Key current DSO-related design areas include:

- ***Asset registration** – creating a single national database for flexibility asset registration*
- ***Regional Energy Strategic Planner** – regional whole system planner bodies under the NESO supporting forecasting and system planning roles*
- ***Market facilitator** – a body to drive market standardisation and technical integration*

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The emerging DNO/DSO splits are relatively consistent across UK, with the DNO accountable for safety and reliability, and the DSO for flexibility and cost of capacity

DSO vs. DNO roles across key process areas – noting the significant scale of UK network businesses

An overview of DSO vs. DNO roles across key process areas

	Planning	Connections	Markets	Network operation
DSO	Engages **regional stakeholders** and **forecasts** generation and demand Identifies **load-related system needs** **Assesses options** and proposes solutions Publishes **planning outputs**	Develops **access products** Reviews **flexible connections schemes** Manages alignment with **strategic regional development** plans Secures **capacity for connections**	Develops **flexibility products** offering Establishes **market access services** **Procures and settles** flexibility	**Schedules** flexibility **Dispatches** flexibility **day-ahead or earlier** Provides **flexibility options** in merit order for emergency real-time actions
DNO	**Provides asset options** and costs for load-related needs and **agrees solutions** Identifies **health and resilience-**related needs Creates **integrated needs plan**, capturing synergies Manages **investment plan**	Manages **quote, offer, accept** process Coordinates across the **T/D boundary** **Designs / delivers** connections	Provides input regarding **network needs**	**Outage planning** **Operational planning /** running arrangements Manages **real-time operations** **Dispatches** real-time flexibility for emergencies

Source: Electricity North West, *DSO DNO governance framework*, 2025

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The DSO incentive is 50% criteria-based to measure progress against delivery of Ofgem's 'baseline expectations', and 50% driven by a stakeholder survey

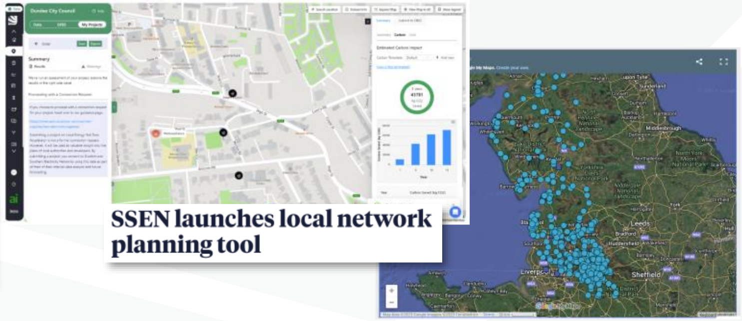
DSO incentive structure – RIIO-ED2

Delivery of DSO Benefits (30%)	Level of ambition
	Benefits realisation
Data and information provision (20%)	Scope, granularity and accuracy of data
	Accessibility of data
Flexibility market development (20%)	Design of flexibility products, contracts and processes
	Facilitation of market access
Options assessment and conflicts of interest mitigation (20%)	Assessment of network options
	Management of conflicts of interest
DER dispatch decision making framework (10%)	DER visibility and dispatch
Stakeholder survey	

DSO KPI dashboards

UKPN claims its separate DSO delivered £199m of benefits over first year

Data releases, value-added accessibility tools, APIs, etc.



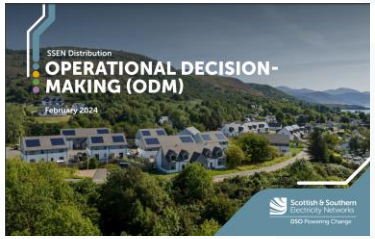
SSEN launches local network planning tool

Third party market partnerships

Electricity North West to adopt Electron's flexibility market platform

UKPN launches 'nation's first' independent DSO

Publication of methodologies and detailed outputs



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Transparency is required to drive confidence in markets and increase participation – in the UK, Ofgem and the DSOs are currently grappling what this form should take

Ofgem guidance: DSO conflict mitigation measures

- "Measures should include **demonstrable executive-level accountability and board-level visibility of key DSO decisions** across the planning, operation and market facilitation functions.
- This should also include **clear and separate decision-making frameworks, supported by independent oversight**, such as external auditing, to promote transparency and enable scrutiny.
- Additionally to support the justification of DNOs' proposals as proportionate, we expect DNOs to **set out conflict mitigation options** that were considered but not proposed, including legal separation if this is no part of the DNO's suite of proposals."

What does this mean in practice for DSOs?

- Some form of **business separation**
- **Clear, transparent and publicly available operational codes / agreements / processes** (e.g. DNOA process framework, DNO-DSO operational agreements)
- **Oversight by independent bodies** to assure stakeholders of transparency
- **Publication of outcomes** for key operational and strategic decisions
- **Compliance and assurance** roles and external audit

Depth of separation

- Embedded functions
- DSO functions under one director
- True ring-fencing – with inefficiency of hand-offs
- Legal separation
- System separation
- Shared services and full ownership separation

In all example in GB the CEO retains ultimate legal decision-making authority

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Current GB models and direction of travel suggest there are candidate functional areas that could be considered for a degree of centralisation

Activity		NESO	3rd party	DSO	DNO	Potential for centralisation of activities
Planning & Network Development	Local area energy planning (with stakeholders)	●		●		• Ongoing establishment of **Regional Energy System Planner role** under the TSO may see some aspects of regional planning centralised • Likely to be **limited to collaborative regional planning** – i.e. working with local authorities, business groups, etc. to develop a forecast of generation and demand asset volumes – and **owning standard central assumptions** for use in translating this to energy needs • **Strong preference for DNOs/DSOs to continue to be accountable for security of supply** will require continued strong local ownership of system needs identification and options assessment • **Potential for further shift of connections design activity into DSO** as requirement increases for design of smart local systems to integrate new loads at pace and capture flexibility at the point of connection
	Long-term generation and demand forecasting	●		●		
	Common planning assumptions	●		●		
	System needs identification			●		
	Asset options and strategic network planning				●	
	Network options assessment			●		
	Connections design			●	●	
	Asset delivery				●	
Market development	Market products and standards		●	●		• **Third-party platforms used for market operations** as outsourced providers can offer better service, and there is no value to the DSO of the activity • Ongoing reform is aimed at **driving standardisation** across DSO markets • **"Market facilitator" role** to own a level of product design and also coordinate across markets in operational timeframes via data exchange • **"Automated Asset Registration"** aimed at establishing central industry asset register
	Asset registration		●	●		
	Identify flexibility needs and procure flexibility			●		
	Market operations and settlement		●	●		
	Market coordination (DSO-DSO; DSO-TSO)		●	●		
Network operation	Operational planning			●		• Network operations **not seen as candidate for centralisation** • **Operational planning and scheduling requires close collaboration** due to dynamic nature of e.g. network configuration and outage planning • **Full systems and data separation would be costly** and is not seen as practical whilst benefits of DSO are being explored
	Scheduling and dispatch (up to day ahead)			●		
	Scheduling and dispatch (real-time)				●	
	Real-time operations				●	

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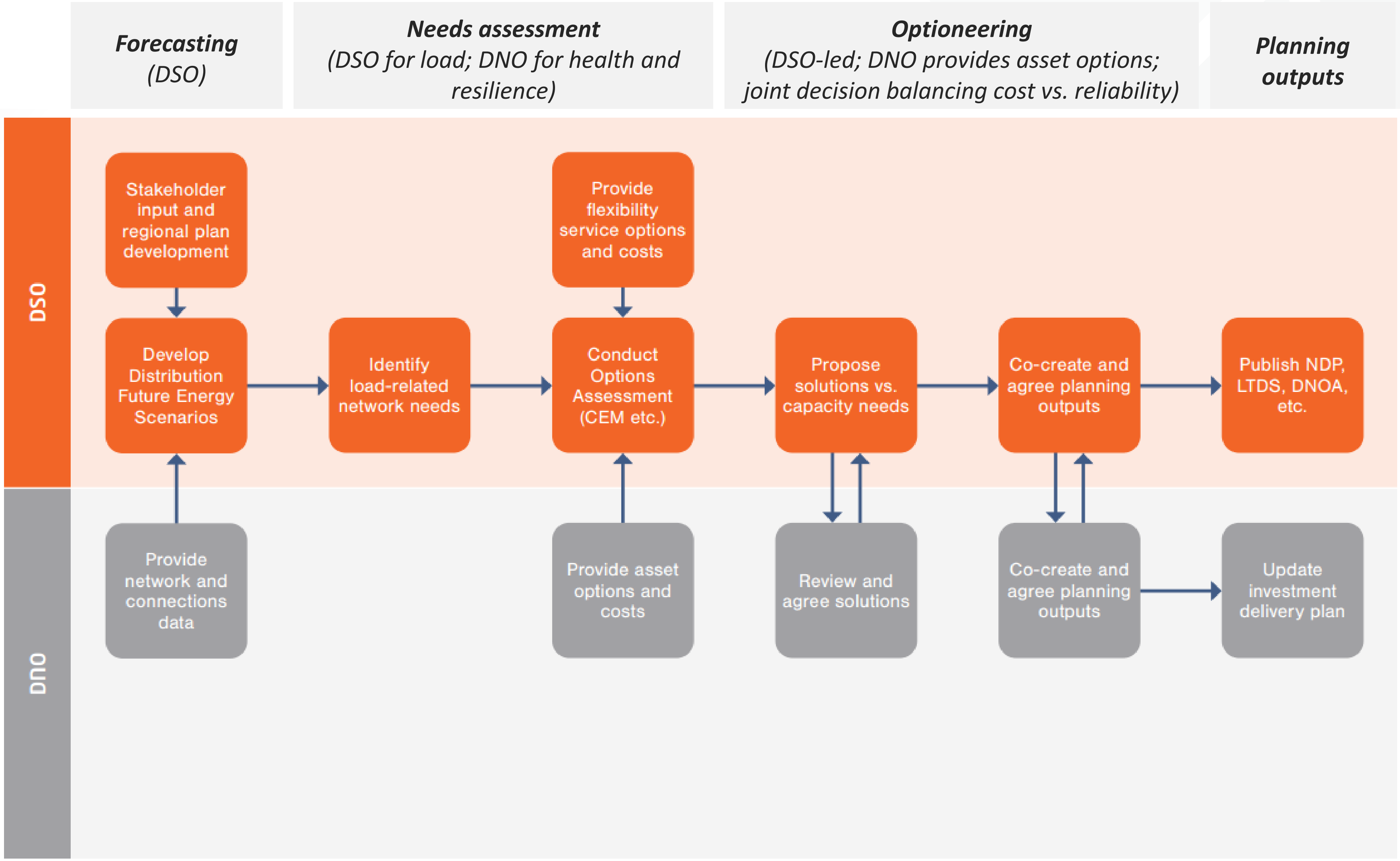
Example – Planning, needs identification and options assessment



Source: Electricity North West, *DSO DNO governance framework*, 2025

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International case study: Australia

Attachment B

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Open Energy Networks was a landmark project, however lack of agreement on direction has restricted DSO progress – despite endless growth in small-scale PV

Timeline of key Australian DSO developments

2018	Open Energy Networks - no final joint AEMO/ENA report
2019	Distributed Energy Integration Program Access & Pricing
2020	AEMC Access, pricing & incentive arrangements for DER
2021	Energy Security Board post-2025 review
2022	AER DER expenditure guideline and CECV
2024	Consumer Energy Resources Roadmap
2025	AEMC DSO roles review

> *While OpEN is a joint project undertaken with AEMO, any views in this position paper are those of Energy Networks Australia only, unless otherwise noted.*
>
> *Energy Networks Australia and our members continue to work actively with AEMO on a variety of DER integration projects and there may be a Final OpEN Report published jointly with AEMO in the future.*
>
> **- Open Energy Networks, Energy Networks Australia Position Paper, 2018**

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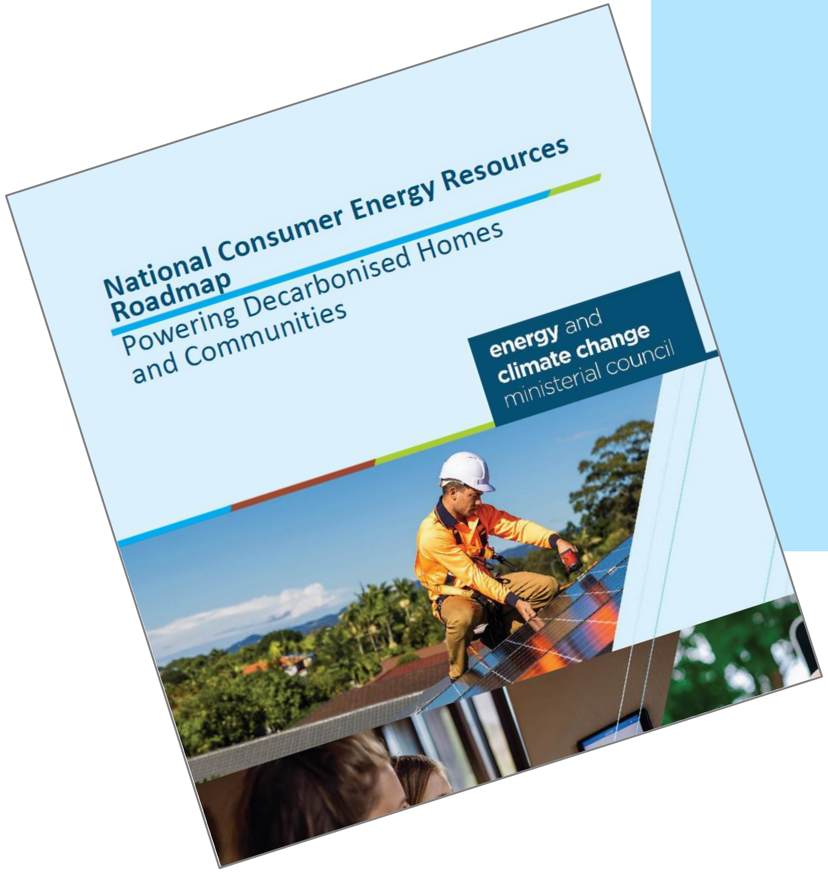
Plans now underway for some clarity on DSO roles & responsibilities via CER Roadmap projects



M.3 Redefine roles for market operations	1) Define the roles and responsibilities of distribution level market operation and drive alignment of incentives between market participants for CER integration.	CER Taskforce AEMC	In progress	2025
	2) Define the role of DNSPs to achieve equitable two-way market operations, including in owning/operating community batteries and kerbside EV chargers, and other distributed resources.	CER Taskforce	2025	2026
	3) Future work: Implementation of new roles and responsibilities. This may require legislative changes.	CER Taskforce	TBC	TBC

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Project EDGE trial

Jul 2020 - Oct 2023

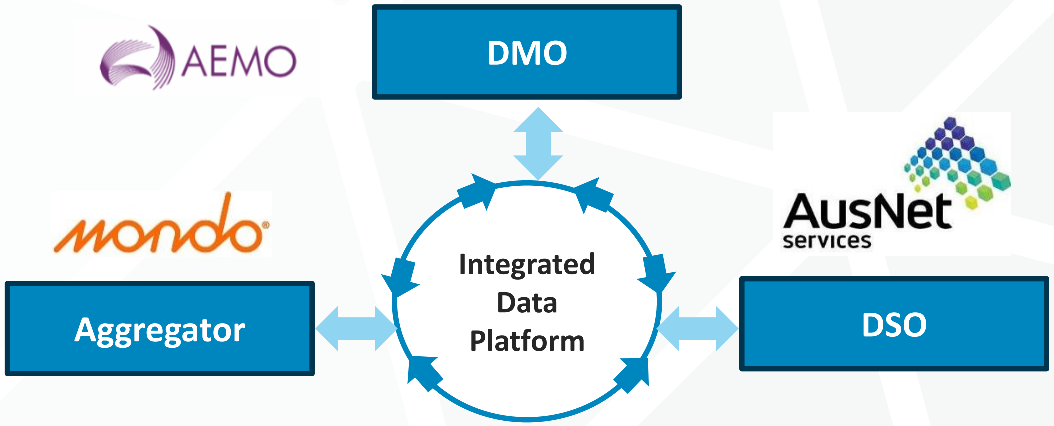
Key insights and Innovations

- A centralised data hub that connected aggregators, DSOs and DMO was trialled to determine the effectiveness of supplying market and network support services
- Consumer centric approaches are needed for CER value to scale with customers needing to believe they are benefitting more from VPP participation than aggregators
- Dynamic connection agreements and accelerating smart meter deployment are needed to enable the installation of larger PV systems and ensure compliance to DOEs
- Development of wholesale market capabilities of CER require optimisation of DOEs, data visibility in line with operation timeframes and reliable forecasting capabilities

Trial approach

- The project was designed to demonstrate how consumer participation in a CER marketplace could be facilitated through a common data exchange hub. There were 320 residential and commercial participants with 1000 CER involved with a participating payment of $1000 with financial rewards for participating in the VPP
- The trial tested wholesale bidding models aligned with the FTA and IESS rule changes including:
  - Allowing aggregators to bid load and generation in a single portfolio
  - Three dispatch models - visibility, self-dispatch and scheduled
  - Aggregated bids of capacity measured at the connection point or a measurement point representing all controllable CER
- A variety of methods to assign network capacity through DOEs was tested to:
  - Maximise aggregated service – maximises the total volume of imports and exports from active consumers with no equality between customers
  - Equal allocation – active consumer in a local area are allocated the same DOE limits or limits proportional to the installed DOE capacity
  - Weighted Allocation – biasing allocation between consumers based on a proximity such as maximising imports with low export price

Role and responsibilities



Implications

- Policy makers should implement a framework to manage DOE conformance and compliance alongside a national approach to implementing DOEs
- The integration of CER will require an evolution of the role of DNSPs to facilitate broader efficiency outcomes through the effective management of flexible capacity in network infrastructure using optimised and accurate DOEs
- Creation of dedicated aggregators with the capability to understand the requirements of specific markets and services to enable effective CER participation will be necessary

Sources: der-market-integration-trials-summary-report.pdf (arena.gov.au), project-edge-final-report.pdf (aemo.com.au), master-research-plan-edge.pdf (aemo.com.au)

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Project Converge

Aug 2021 – May 2024

Key insights and Innovations

- Trialling the use of SOEs and real time RIT-D to enable better participation of CER in the wholesale market and network support services
- SOEs bring overall system benefits by maximising the use of CER however these benefits require a high level of CER penetration indicating the current use of DOEs might only be sufficient in the short-term resulting in a need for better optimisation of market benefits from orchestrated CER
- The complexity associated with orchestrating resources and optimising market benefits and network services highlighted the need for greater coordination between AEMO and the DSO functions

Trial approach

- This project involved 1000 residential CER in the ACT, with participants receiving an incentive of up to $200 to participate
- Project Converge aims to test the application of SOEs for CER integration. Many DOEs are calculated ahead of time, generally 24hrs, which can result in an inefficient allocation of capacity and the potential for allocated capacity not being met. SOEs send network and support capacities every five minutes allowing for better use of available CER
- SOE operation:
  - Bids – aggregators inform the DSO of their capacity and provide their AEMO day ahead wholesale bids and network support availability
  - Envelope calculation – the DSO solves an optimisation problem to constrain the wholesale bids of aggregators and allocate SOEs to maximise value of bids in the wholesale market and network support
  - Final Rebids – aggregator submits their final rebids for the dispatch interval to the wholesale market
- RIT-D maximises the present value of the net economic benefit for participants in the NEM. This trial is exploring a real time RIT-D process which can more easily procure non-network solutions for small constraints

Role and responsibilities

evoenergy | evergen, reposit | AEMO

DSO
- SOE calculation

1. Bids
2. SOEs

Aggregator
- Determines DOE capacity
- Submits final rebids

3. Bids
Dispatch

DMO
- Operating DER in the market

Next steps

- Most of the challenges associated with the trial were associated the data quality particularly only having access to CER that was aggregated which does not allow for any granularity. The project is aiming to confirm the current availability of non-aggregated data and analyse options to obtain it. This will allow for better optimisation of the SOEs
- Determining a broadly accepted definition of fairness and equity within the SOE optimisation algorithm will be required for the best implementation of the technology with high customer satisfaction

Sources: der-market-integration-trials-summary-report.pdf (arena.gov.au), social-science-report-1-intermediary-insights-on-dynamic-and-shaped-operating-envelopes.pdf (arena.gov.au), shaped-operating-envelopes-technical-design-implementation-report.pdf (arena.gov.au)

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Baringa

Project Edith

Sep 2021 - Ongoing

Key insights and Innovations

- Tested dynamic network pricing that reflects the level of network congestion at different locations to encourage price responsive CER to be more flexible, as a result the DOEs act more as guardrails to network operation rather than determining available network capacity. The dynamic network pricing was only experienced by the aggregator as the trial incentive for consumers was the waiving of electricity costs
- There is considerable variety in how flexible CER are used for network support with the activation mechanism, payment type and recurrence, firmness and pricing types the most important for understanding how effective the services provided are

Trial approach

- The trial initially involved 300 residential customers who paid for the installation of a rooftop solar and battery system. In exchange Reposit Power waives electricity costs for 5 years
- In the trial, the DSO does not explicitly allocate distribution network capacity through DOEs to connection points but instead provides price signals that are used by the customer to optimise the capacity used. DOEs are instead used as guardrails to ensure network security
- The dynamic network pricing is made up of three key elements:
  - Fixed charge – comparable to a network access charge
  - Subscription charge – based on the minimum export and import limit each customer can comply with. Customers capable of optimising or curtailing their load and generation can save money through lower subscriptions encouraging greater flexibility
  - Dynamic pricing – 5-minute intervals matching the wholesale market will be calculated by the DSO. Considering the spare network capacity, prices will be set that encourage aggregators to optimise CER imports and exports for each customer. Greater flexibility will be rewarded as high import prices can be avoided with the opportunity to take advantage of higher export prices

Role and responsibilities

Ausgrid — reposit — AEMO

DSO
- Setting network tariff
- Allocate DNPs & DOEs

DOEs → DNPs

Aggregator
- Optimisation of DER assets
- Develop customer offers

Bids → / ← Dispatch

DMO
- Operating DER in the market

Next steps

- Key areas identified for future investigation:
  - Explore to what extent multiple approaches for network support could run in parallel within a larger network
  - Quantify the value that new approaches to managing network constraints unlock and assess how this is shared with customers
- Following winning the Industry Innovation award, the project was expanded to include an additional 700 customers

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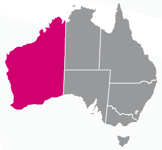
Sources: der-market-integration-trials-summary-report.pdf (arena.gov.au), Project-Edith-2022.pdf (ausgrid.com.au), Project-Edith-Knowledge-Sharing-Report-2.pdf (ausgrid.com.au)

Project Symphony



Jul 2021 - Jun 2024

Key insights and Innovations

- The development of three integrated platforms to manage the different functions of aggregating DER, creating DOEs and dispatching in the wholesale market
- Testing the ability of CER to provide network support services by having the DSO forecast capacity shortfalls before entering bilateral contracts with aggregators for that service. Network support will be dispatched through the market operator providing them full visibility of the services that aggregators will be delivering
- Effective operation of DOEs will be even more important in the WEM as it is an isolated system that will experience more extreme network conditions with higher solar penetration

Trial approach

- Project Symphony was developed as a key action in the Western Australian government's DER Roadmap to help develop methods and regulations surrounding the integration of CER. Involves 500 residential and commercial participants with 900 CER
- Involves three integrated platforms performing different orchestration functions. The DSO platform is responsible for identifying renewable hosting capacity and consumer generation to create DOEs, the DER integration platform will receive bids for aggregated CER and dispatch them in the wholesale market and the aggregator platform will manage CER at the meter
- The scenarios and market services being tested by Project Symphony include:
  - Bidirectional Energy: aggregators buy or sell energy into a balancing market whilst adhering to a DOE provided by the DSO to increase the renewable hosting capacity
  - Network Support Services: contracted service provided by an aggregator to manage local network constraints
  - Constrain to Zero: the ability of the AEMO platform to constrain energy output to zero through the aggregator platform
  - Essential System Services- contingency raise: response to local frequency deviations during contingency events

Role and responsibilities

western power | synergy | AEMO

DSO
- Forecast network load
- Allocate DOEs

DOEs →

Aggregator
- Optimisation of DER assets
- Dispatching DER

Bids → / ← Dispatch

DMO
- Operating DER in the market

Next steps

- Integration of CER with technology and between platforms used in the pilot has been an ongoing limitation with existing resources unable to be easily added to the technology platforms for orchestration. Contingencies will be developed to enable product enhancements to ensure compatibility with the system alongside ongoing platform integration trials
- Given the consumer cost associated with installing CER, the ongoing benefits of participating in VPPs are not well reflected in pricing so more cost reflective pricing and tariffs will be needed ahead of large-scale deployment of VPPs

Sources: der-market-integration-trials-summary-report.pdf (arena.gov.au), project-symphony-lessons-learnt-report-1.pdf (arena.gov.au) project-symphony-lessons-learnt-2.pdf (arena.gov.au) project-symphony-platform-functional-and-non-functional-requirements-report.pdf (arena.gov.au) Western-Power-Project-Symphony-Combined-Platform-Report.pdf (arena.gov.au)

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Baringa

About Baringa

Attachment C

We combine deep global energy industry expertise with strategy, commercial, operating, technology, modelling, policy and regulatory advice to support our clients

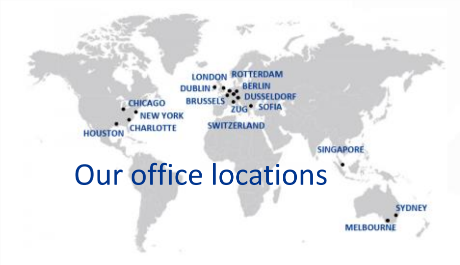
>800 energy experts

300+ clients

60 countries where we model the energy system

$150bn of capital advised on into low carbon

A sample of our global DSO and energy network transition experience



UK Power Networks, Endeavour Energy, Ausgrid, SA Power Networks, SP Energy Networks, Electricity North West, Essential Energy, Western Power, Scottish & Southern Electricity Networks, CitiPower, Powercor

A sample of our New Zealand energy experience

MBIE	Regulatory advice on public EV charging stations and EDBs
EA	Regulatory advice on EDB network tariff reform
QIC	Powerco sale – Sell-side demand due diligence
Client confidential	Vector smart metering sale – Buy-side commercial, technical & technology due diligence

Our DSO and energy network transition advisory services includes the following areas

- Economic regulation
- Cost-benefit analysis
- Planning and load forecasting
- Network resilience (climate, cyber)
- DSO transition
- Network pricing and tariff reform
- Regulatory business planning
- Data analytics
- CER / DER integration
- Network trials and innovation
- Dynamic export limits and dynamic operating envelopes
- Non-network solutions
- Business case and strategy

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