Network Transformation Roadmap – Review of Progress

Jonathan Kay, chair of ENA's Smart Technology Working Group

The Smart Technology Working Group welcomes the independent review of progress with regard to ENA's Network Transformation Roadmap (NTR).

Undertaken by consultant Dr Allan Miller, the two-year progress review delivers on the commitment to review both the roadmap's founding assumptions and the general progress of the sector in achieving key actions.

With the knowledge that it's impossible to accurately predict the long-term future, the 2019 Network Transformation Roadmap was designed to be a living document, regularly reviewed, and eminently responsive to changing circumstances.

It is pleasing to see its original assumptions are still valid – if not even more so today. The NTR is based upon New Zealand achieving its decarbonisation goals and ensuring electricity networks fulfil their role as enablers of a low carbon future.

Two years into a 10-year journey, the review highlights the real progress made in some areas as well as identifying areas that require further focus.

While, for example, considerable effort has been undertaken on one of the priority areas identified by the NTR – greater visibility of low voltage networks – some other actions have been hampered through factors not fully within the control of electricity distribution businesses, such as access to smart meter data and progress on tariff reform. Dr Miller's review has highlighted the need to work closely with stakeholders to urgently solve issues related to access to information. This is the key that unlocks a wide range of other actions.

Some of the expected drivers of change, such as the mass uptake of electric vehicles, have not progressed as rapidly as anticipated in the NTR; nevertheless, distribution businesses have made constructive headway on some of the precursor actions necessary in readiness for more widespread adoption of electric vehicles.

ENA's members are fully aware of the importance of the work ahead to enable a transition to a low-carbon economy. The NTR was designed to guide and support this effort and make explicit the steps that must be taken to facilitate a successful transition.

It was pleasing to note that the review identified increasing levels of collaboration across the networks sector as companies share learnings and thinking to solve common problems.

A further benefit of having the roadmap in place is that it provides an invaluable framework for constructive conversations with a variety of stakeholders. The ENA will continue to work with relevant external stakeholders to find solutions to roadblocks and barriers.

This review will allow the Smart Technology Working Group to revisit the original NTR actions, adjust timetables and priorities to build on the current momentum and ensure progress continues to be made. We are considering publishing an updated roadmap based on the findings from the review.

I would like to thank Dr Miller, who was also the primary author of the original roadmap, for his timely review, as well as thanking all the distribution businesses who are committed to working towards electrification of New Zealand's energy needs.

ENA Network Transformation Roadmap

Progress Report

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Prepared for the Electricity Networks Association

Prepared by Dr Allan Miller

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Contents

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Abbreviations

Abbreviation	Meaning
ADMS	Advanced distribution management system
AMI	Advanced metering infrastructure (used synonymously with smart meters)
AMP	Asset management plan
BEV	Battery electric vehicle (a pure EV with only an electric motor)
Code	The Electricity Industry Participation Code
DER	Distributed energy resource, such as PVs, EVs, batteries, and home/business energy management systems.
DERM	Distributed energy resource management
DERMS	Distributed energy resource management system
DG	Distributed generation
DR	Demand response
DSO	Distribution system operator
EDB	Electricity distribution business
EEA	Electricity Engineers Association
ENA	Electricity Networks Association
EPR	The Government's Electricity Price Review dated 21 May 2019
EV	Electric vehicle
HEMS	Home energy management system
HILP	High impact low probability
LV	Low voltage (the 400 Volt / 230 Volt network that supplies residential and most business consumers)
MEP	Metering equipment provider
NDC	Nationally determined contribution – New Zealand's greenhouse gas reduction to be achieved by 2030 under the Paris Agreement, determined by New Zealand
NTR	The ENA's network transformation roadmap (https://www.ena.org.nz/resources/publications/document/483
PGP	Primary Growth Partnership

Abbreviation	Meaning
PHEV	Plug in hybrid electric vehicle (an EV with a battery that provides limited range up to about 50 km, and which is charged by plugging it in, and an internal combustion engine to provide greater range)
PV	Photovoltaic solar power
RAPS	Remote area power supply
SCADA	Supervisory control and data acquisition (system)
STWG	The ENA's smart technology working group, comprising representatives from 11 EDBs, the ENA and chaired by Jonathan Kay

Executive Summary

In April 2019, the ENA formally launched its Network Transformation Roadmap (NTR). It was developed over the previous 18 months by the ENA's Smart Technology Working Group (STWG) and was supported by briefings to electricity distribution businesses (EDBs) and stakeholders in November and December 2018.

A foundation of the NTR, and the scenarios from which it was drawn, was the presumption of the desire for a low carbon future – a future where electricity plays a vital role in decarbonisation by replacing fossil fuel use with renewably generated electricity.[1] In turn, New Zealand's greenhouse gas emissions would be reduced and its targets such as the Paris Agreement Nationally Determined Contribution (NDC) by 2030, and net zero emissions by 2050 met. The 20 actions identified in the NTR, grouped within seven programmes, represent 'least regrets' actions that distributors should take to prepare for this future. However, undertaking all actions by each EDB independently is not necessarily the optimal approach, and indeed several actions rely on contributions from, and collaboration with, other parties.

For this progress report, underlying inputs to the NTR and progress towards implementing the NTR actions by EDBs were assessed by interviewing 20 EDBs of different sizes, locations, ownership and STWG membership, as well as the ENA. This report assesses the underlying inputs to the NTR, how the NTR is being used by EDBs, and the progress towards implementing the NTR actions by EDBs. Thus, this report completes the 'monitor uncertainties' action within the Monitor Uncertainties and Adjust Roadmap programme of the NTR. The following sections set out key conclusions of the report.

NTR Inputs

It is concluded that the inputs to the NTR are still valid, with some uncertainties moving to more certain megashifts, and some megashifts taking on a greater prominence as set out below.

- A low carbon future and prospect of concentration of energy in one form (renewable electricity) is a risk, and likely to increase expectations of reliability of electricity supply and the need for resilience – this is related to the 'demand for greater reliability and services of electricity' identified in the NTR.
- 'Electric vehicle uptake' becomes a certainty and moves towards a megashift.
- 'Conversion of fossil fuel heating to electricity' becomes a certainty and moves towards a megashift.
- The development of renewable energy-dense fuels remains an uncertainty that may change the uptake profile, timing and location of demand for distributed electricity.
- The megashift of 'low-cost storage' has not yet become as low-cost as might have been expected, and it is clarified that this is short-term storage (intra-day) rather than long-term storage as might be required for system security over months or years.

[1] For example, by replacing coal and gas heating with electric heating and internal combustion engine vehicles with electric vehicles, where the electricity is from renewable generation. This includes hydro, wind, solar (large-scale and small-scale) and geothermal.

- The potential closure of the Tiwai Point Aluminium Smelter in the future, and New Zealand Battery Project are significant shifts that may aid accelerated electrification and decarbonisation.
- Low interest rates, particularly resulting from the Covid pandemic response, may give rise to rapid growth in some areas, such as housing development and result in electricity demand growth. Conversely, in some areas the timing of recovery of tourism and associated demand is uncertain.

Overall, there are no changes required to the NTR, but the above adjustments to NTR's inputs underscore the importance of the NTR and its implementation. Overall, the emphasis for the future is decarbonisation, as identified when developing the NTR, and electrification to achieve decarbonisation. Use of the NTR within EDBs, and other organisations, and progress towards achieving the NTR is then pivotal to achieving a low carbon future.

Use of the NTR

Since the NTR deals with actions vital to New Zealand's low carbon future, it is concluded that it needs more exposure and use at the executive and board levels. A version of NTR prepared for boards, that also highlights the connection between the NTR programmes and EDBs contributing to a low carbon future through electrification, may be useful in this respect. It may also be helpful to place the NTR in the context of the broader aspects of the EDB businesses and electricity industry that executives and boards must consider. For example: organisational purpose and strategy; risk management; how the NTR fits within EDBs contributing to a low carbon future and compliance with that; and how it relates to regulatory compliance such as asset management plans and pricing.

NTR Progress – Prioritisation and Pace

Priority actions

An assessment of all NTR actions shows that there is a small number of leaders working on a few actions with good collaboration (including sharing information for other EDBs to follow) and progress; a lot of activity on a few actions, with a variety of different approaches, but with progress still required; and no progress on some actions. Of the three priority actions established by the STWG prior to the NTR's launch in April 2019:

- The 'LV (low voltage) network monitoring and visibility' action in particular has attracted significant activity by almost all EDBs. Some reduced their efforts after finding themselves challenged by the installation requirements and data volumes produced, and three have taken a disciplined approach to LV monitor rollout by prioritising networks based on electric vehicle (EV) and photovoltaic solar (PV) hosting capacity. In general, a more strategic approach is required, thus minimising the cost, and combining it with 'Access to smart meter data' as demonstrated by a few EDBs.

  It is concluded that the 'LV network monitoring and visibility' action two-year milestone set out in the NTR has been partially met. The reason for this is that not all EDBs have well developed data management systems for LV monitors and because smart meter power quality information is still not available to all EDBs. To meet the 2-5-year goal will require considerable

improvement in systems, resolving access to smart meter power quality data, and a clear plan for use of LV monitoring data to improve the distribution service. However, combined with smart meter power quality data access, there is innovation occurring by some EDBs. Sharing the lessons from this amongst EDBs would be beneficial.

- The 'Access to smart meter data' action has been slow to achieve traction, but the ENA has recently renewed efforts and is working with metering equipment providers (MEPs) and EDBs to achieve better access to smart meter data. There is a small number of EDBs who already have full smart meter power quality and consumption data access, with feature-rich applications to use that data to enhance their asset management practice. This illustrates the dichotomy between those EDBs that have access and applications, and those that do not. It sets a 'best practice' of what can be achieved and highlights the interconnected nature of the NTR – in this case smart meter data access and applications achieves LV network monitoring and visibility. The Government's Electricity Price Review dated 21 May 2019 (EPR) gave good reasons why access to smart meter data by distributors was important in its Recommendation E3. The dichotomy referred to above shows how accurate the EPR's rationale was, and how important it is that smart meter data be available to EDBs.

  In terms of the 'Access to smart meter data' milestone set in the NTR at the two-year mark, it is concluded that this has been met. Those SmartCo EDBs, WEL Networks, and Counties Power with smart meter ownership and consumption data access have met the NTR's 2-5 milestone. However, if all EDBs are to meet the 2-5 year milestone, efforts to gain advanced metering infrastructure (AMI or smart meter) data access need to continue at a pace for the benefit of all EDBs, their consumers, and ultimately to enable EDBs to better prepare for the low carbon future.

- 'DER connection standards' (distributed energy resource connection standards) has not made as much progress, mainly due to reliance on other parties such as regulators. An independent review commissioned by the ENA shows PV connection processes are generally in line with the Electricity Industry Participation Code (Code), with some updating of references required. However, some national installers are struggling with differences between EDBs. The EEA guide for PV connection is a guide that could assist in standardisation between EDBs, and is being implemented in full by Aurora Energy with Waipa Networks intending to implement it and Unison assessing it. This itself is only an interim guide while it waits for updates to the Code by the Electricity Authority and Electricity (Safety) Regulations by the Ministry of Business, Innovation and Employment, both requested over 4 ½ years ago.

  As identified above, there is a suitable standard available for small-scale PV connection, but it requires changes by regulators to enable it to be fully implemented, and EDBs need to implement it consistently. Following the practice developed by the leading EDB implementing it would be beneficial in gaining a nationally consistent process. This needs to begin now to meet the schedule set out in the NTR.

  Little has happened in the area of EV connection standards to date. Given the potential for LV network constraints from EV chargers – and recognising the important decarbonisation benefits from the increasing uptake EVs – this requires further progress, or at the very least encouragement to install smart chargers. Wellington Electricity through its EV Connect project

is making progress in this area, and Vector's smart charger trial illustrates the importance of smart chargers.

It is concluded that the 'DER connection standards' action two-year milestone has not been fully met. This means that substantial work and agreement between EDBs, and contribution from regulators, is required to implement distributed generation (DG) and EV standards to meet the 2-5-year milestone.

While progress on one of the priority actions identified by the NTR is on track with expected timelines, for various reasons two other priority actions have shown less progress than expected.

Access to smart meter data access needs to be expanded promptly for the benefit of all EDBs, their consumers, and ultimately to enable EDBs to better prepare for the low carbon future. EDBs cannot do this alone; assistance from regulators is required.

Other actions

Many EDBs are focused on the Consumer Insights NTR action 'understand new loads' by actively seeking out plans by industry to transition heating from fossil fuels to renewable electricity (including the Transpower, EECA and South Island EDB stocktake initiative). A few EDBs, especially in rural areas with dairy factories, are actively working with their customers to supply them after they transition to electricity. However, they have found themselves caught between their customers' relatively short timeframes to transition to electric heating, their own ability to meet those timeframes, and the longer timeframes to upgrade capacity at Transpower grid exit points (GXPs). Some EDBs (Powerco for example) are now assessing the transition from small-scale gas heating to electricity, and some EDBs (Vector for example) are assessing consumer EV charging behaviour.[2]

One EDB (Aurora Energy) has made headway with the Open Network Framework Programme 'third parties provide DERs and DR (demand response) for network support' NTR action.[3] It has made progress by calling for proposals to provide non-network support in a particular area of its network, and is proceeding with implementation. This area has been subject to rapid housing development and demand growth, but the Covid-19 pandemic cast doubt over future growth. Thus, a non-network solution, providing incremental capacity growth, was even more attractive while the post Covid-19 recovery and sub-transmission solutions are assessed more fully. Substantial knowledge has been developed from this experience and is shared in the report, a separate case study, and by Aurora Energy. This sharing contributes to the 'develop contracting for network support capabilities' in the Build and Adapt EDB Capability programme – also demonstrating the interconnected nature of the NTR. Powerco has also recently called for proposals for network capacity support.

[2] ENA Case Study, April 2021, Vector's EV Smart Charging Trial, https://www.ena.org.nz/resources/publications/document/826.
[3] ENA Case Study, April 2021, Aurora's Upper Clutha Project, https://www.ena.org.nz/resources/publications/document/825

The Open Network Framework 'demand response framework' action is an example where a collective industry effort is required. The Electricity Authority Innovation and Participation Advisory Group (IPAG) has been addressing this with Transpower, and it is hoped will provide guidance for the industry after it releases its recommendations later in 2021.

Powerco, Marlborough Lines and PowerNet, all with very remote network areas, have made progress with 'off-grid power supplies' and have gained many insights and experience from this.[4] This includes working within regulations, approaching customers and managing customers through the transition to a remote area power supply. Vector has also made progress by implementing four micro-grids in remote areas to improve supply reliability.

All EDBs have programmes in place around cost-reflective pricing, in part because the market regulator is requiring it. As a result, it is generally prioritised over other actions. Because the regulator does not require a collective industry approach, a variety of approaches and pricing structures are emerging. However, the ENA is leading an effort on behalf of all EDBs to remove the Electricity (Low Fixed Charge Tariff Option for Domestic Consumers) Regulations 2004, a major impediment to meeting the cost reflective pricing required by the regulator.

Prioritisation and pace by individual EDBs and as a whole

It was clear from the interviews that EDBs face a variety of issues which depend on their location, community demographic, local industry, and inherited management decisions. It is therefore expected that EDBs will come to NTR actions at different times when they have genuine business needs. This highlights that the NTR is not a linear set of actions for every EDB to follow in the same order. Actions are interconnected, with some more relevant to some EDBs than others, based on their unique circumstances. EDBs need to choose actions where there is a genuine business need, ideally derived from strategy developed by their executives and boards. While these may involve trials, it is unwise to conduct trials in the purest sense without a genuine business need, rather they should focus on making measurable progress. From the interviews with EDBs there were only three examples where there was a clear link from company strategy to NTR implementation: (1) Orion and its distribution system operator (DSO) strategy (based on the NTR) leading to carefully thought-out actions to achieve LV network visibility and where this would take it in the future; (2) Aurora Energy and its Network Evolution Plan (using the NTR as best practice) leading initially to its non-network support project and EEA PV guide implementation; and (3) Unison and its strategic initiative around the implementation of a least regrets DSO roadmap to ensure that the company establishes critical competencies to manage an uncertain future (endorsed by its board and based on the NTR). There may be other examples not discovered from the interviews or involving EDBs not interviewed.

The experience from the 'LV monitoring and visibility action' generally highlights the importance of proceeding more carefully and in collaboration with other EDBs, rather than all EDBs focusing on action in the same area and solutions with engineering and capital expenditure appeal. There is no doubt that activity is needed on the NTR actions, but there is a risk of all EDBs taking the same actions,

[4] PowerNet have implemented one and are actively planning more, Poweco have implemented several, and Marlborough Lines have a proposal to implement a site and have identified several others candidate sites.

experiencing similar pitfalls, and potentially not learning from others. Paradoxically, to achieve genuine progress it is sometimes necessary to slow down and take a well-considered approach. In this respect the actions in the Build and Adapt EDB Capability programme are important. Of the actions in this programme there is still progress required in 'Network understanding' and 'Asset management practice'. These highlight the importance of on-going and increased collaboration between EDBs, and continued focus on building EDB capability. Doing this collectively and learning from other EDBs will ensure a more effective NTR delivery, focused on achieving New Zealand's low carbon future.

It is concluded that the 2-year goals set for each action were about the right balance given the rate of adoption of DERs (PV and EVs in particular). However, the challenges for the future, as set out by the Climate Change Commission in its 31 January 2021 draft advice to the Government, indicate the importance of reaching the 2-5-year goals set out in the NTR. Given that some of the 2-year goals have still not been met means reaching the 2-5-year goals will be very challenging. Further, a number of these goals rely on initiatives from other agencies.

Progress towards meeting these milestones could be enhanced through increased collective action on the part of EDBs, and with other government agencies also both contributing to and being aligned with the Network Transformation Roadmap. A regulatory regime that favours capital rather than operating expenditure can also hinder progress. Both individual EDB's boards and the ENA board have a constructive role to play in ensuring progress is maintained, with the ENA able to play a critical coordinating role.

Finally, it was clear from the experience of EDBs with some actions that achieving these actions is not entirely technical in nature. Some actions require skills in dealing with customers and managing customers through transitions (such as transitioning to electric heating technology and transitioning to remote area power supplies or microgrids). Others require increased collaboration between EDBs and with other agencies. Thus, as EDBs build and adapt capability – the underpinning of the NTR – recognising the unique skill required to manage a technical transition with increased relationships is also important. Moreover, achieving some actions in the NTR are dependent on other agencies, such as regulators and Transpower.

1. Introduction

In April 2019, the ENA formally launched its Network Transformation Roadmap (NTR). It was developed over the previous 18 months by the ENA's Smart Technology Working Group (STWG), and was supported by briefings to electricity distribution businesses (EDBs) and stakeholders in November and December 2018.

A foundation of the NTR, and the scenarios from which it was drawn, was the presumption of the desire for a low carbon – a future where electricity plays a vital role in decarbonisation by replacing fossil fuel use with renewably generated electricity.[5] In turn, New Zealand's greenhouse gas emissions are reduced and its targets, such as the Paris Agreement Nationally Determined Contribution (NDC) by 2030, and net zero emissions by 2050 are met. The 20 actions identified in the NTR, grouped within seven programmes, represent 'least regrets' actions that distributors should take to prepare for this future. However, each EDB independently undertaking all actions is not necessarily the optimal approach, and indeed several actions rely on contributions from and collaboration with other parties.

After two years since its formal launch, and nearly 2 ½ years after EDB and stakeholder briefings, this report assesses the underlying inputs to the NTR and the progress towards implementing the NTR by EDBs. The approach taken was to review with EDBs the assumptions, uncertainties and megashifts used in developing the NTR, and assess whether changes to these affect any of the actions. At the same time, experience of EDBs in implementing the NTR was gathered, via interviews. This report outlines the results of the assessment and interviews, and reports on progress towards achieving the NTR.

The report is divided into five sections. Section 2 outlines the objectives of the study and methodology used to assess progress. Section 3 discusses the NTR inputs in terms of the underlying NTR assumptions, uncertainties and mega-shifts, changes to these, any new ones, and whether there are any material impacts on the NTR. Major issues identified by EDBs are also summarised in Section 3. Section 4 discusses how the NTR has been used by EDBs to date, and Section 5 discusses progress by EDBs towards implementing the NTR. Section 5 also gives a detailed analysis by action.

[5] For example, by replacing coal and gas heating with electric heating and internal combustion engine vehicles with electric vehicles, where the electricity is from renewable generation. This includes hydro, wind, solar (large-scale and small-scale) and geothermal.

2. Objectives and Methodology

The objectives set at the beginning of this progress report were:

1. Review any changes to the underlying assumptions in the original NTR and determine whether aspects of the NTR need revisiting.
2. Gauge progress in implementing the NTR across the distribution network sector, and identify any potential barriers inhibiting progress.
3. Share knowledge from work done to date amongst EDBs.

To achieve the above objectives, it was proposed to: (1) review relevant material since the NTR was developed to assess changes to the underlying assumptions; and (2) interview EDBs to gather relevant experience of EDBs in implementing the NTR.

A set of questions was developed as a basis for interviewing EDB representatives (given in the Appendix), which also included questions related to the EDB representatives' views on the inputs used in developing the NTR. While relevant material was reviewed to evaluate the inputs, insights from EDB representatives was used in particular, since they are practitioners with direct experience of many of the inputs. One question asked EDBs to name challenges in the industry, which proved particularly useful in identifying more detail on uncertainties – one of the NTR inputs.

In all, 21 EDBs and the ENA were interviewed. EDBs were selected to cover the range of EDB sizes, urban and rural locations, North and South Islands, and both STWG and non-STWG members. Including non-STWG members was of particular importance to understand implementation differences between members and non-members.

To protect confidentiality, interview responses are not detailed in this report verbatim, rather the responses are amalgamated.

3. NTR Inputs – Assumptions, Uncertainties, and Megashifts

The underlying presumption adopted in the developing the NTR and its scenarios was a low carbon future. Since launching the NTR, events have validated this presumption. These include:

1. Passing of the Climate Change Response (Zero Carbon) Amendment Act 2019, involving amongst other things: a contribution to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5°C above pre-industrial levels; reducing net emissions of all greenhouse gases (except biogenic methane) to zero by 2050; and the establishment of the new independent Climate Change Commission in December 2019.
2. The release of the Climate Change Commission's 31 January 2021 draft advice to the Government.
3. Globally important events such as Chinese President Xi Jinping's pledge at the United Nations General Assembly in September 2020 that his country would reach peak carbon-dioxide emissions by 2030, and achieve carbon neutrality before 2060; and the U.S.A. officially becoming a party to the Paris Agreement again on 20 January 2021, President Biden's first day in office.

In addition, there has been a focus on electrification to achieve climate change mitigation goals, recognising the potential to reduce greenhouse gas emissions by replacing the internal combustion engine vehicle fleet with electric vehicles, and replacing some commercial and residential coal and gas heating applications with electric heating.

There was unanimous agreement from all EDB representatives interviewed that the underlying presumption of a low carbon future has not changed and has instead strengthened.

3.1 NTR uncertainties, Megashifts, and Consumer Behaviours

The uncertainties, megashifts and consumer behaviours considered when developing the NTR and its underlying scenarios are shown in Figure 1. The consensus in discussing these with the EDBs interviewed is that they are still valid, with some uncertainties moving to more certain megashifts, and some megashifts taking on a greater prominence as set out below outlined below. Overall, there are no changes required to the NTR, but the events described above increase the importance of the NTR and its implementation.

Uncertainties	Megashifts	Consumer Behaviour
Gas price and international methanol price	Low cost storage	Active-passive spectrum of consumer behaviour
Carbon price	Low demand for central electricity	Due to barriers to uptake, such as complexity and high price, consumers' actions are not always consistent with the values they express
Development of renewable energy-dense fuels	Consumer interest in PV and PV cost reductions	
Collective electricity industry contribution to greenhouse gas reduction	Greenhouse gas reduction	
Demand growth for centrally-generated electricity	Demand for greater reliability and services of electricity	
Regulation	Non-traditional third-party management of consumer needs	
Central generation costs	Consumer distrust of electricity utilities (where utility refers to the collective traditional electricity supply chain)	
Development of technology for consumer participation	EV uptake	
Autonomous EV deployment		
Economic management of renewable variability		
EV uptake		

Figure 1: All uncertainties, megashifts and consumer behaviours considered in developing the NTR scenarios.

Of the uncertainties identified in developing the NTR, it is concluded that they are all still valid, but with 'EV (electric vehicle) uptake' moving from an uncertainty to a certainty and becoming a megashift. Not specifically identified, but implied and discussed in the NTR, was the uncertainty of 'conversion of fossil fuel heating to electricity'. This is becoming less of an uncertainty and more of a certainty and megashift, particularly after the release of the Climate Change Commission's 31 January 2021 draft advice to the Government raised accelerated conversion from gas heating. The development of renewable energy-dense fuels remains an uncertainty that may change the uptake profile, timing and location of demand for distributed electricity, but not necessarily centrally generated electricity (hydrogen produced by electrolysis for example). This therefore remains a critical uncertainty.

Of the megashifts, low-cost storage has not yet become as low cost as might have been expected, and it is clarified that this is short-term storage (intra-day) rather than long-term storage as might be required for system security over months or years. The combination of the prospect of the closure of the Tiwai Point Aluminium Smelter, and the development of Lake Onslow pumped hydro storage, or more generally the New Zealand Battery Project (which would effectively provide long-term storage) are significant shifts that may aid accelerated electrification and decarbonisation. Low interest rates resulting from the Covid-19 pandemic response may give rise to rapid growth in some areas, such as housing development and resulting demand growth, placing strain on electricity infrastructure. Conversely, in some areas the recovery of tourism and associated demand is unknown. Related to this, some EDBs in rural areas in particular have experienced rapid growth in some industries resulting from Government funding such as the Primary Growth Partnership (PGP) scheme.

With the prospect of greater electrification and concentration of New Zealand's energy in one form, namely renewable electricity, the risks and ramifications from renewable energy disruption are heightened and the megashift identified in the NTR of 'demand for greater reliability and services of electricity' becomes substantially more prominent. Solutions to generating more renewable electricity may involve more large-scale central generation, but solutions to reliability of supply to cover short-term interruptions, and resilience to high impact low probability (HILP) events may require more local solutions, with the distribution network at their heart. Most EDBs expect an increase in HILP events, such as severe weather events including flooding, high winds, and earthquakes. One example of a potential solution to a HILP event is dynamically forming micro-grids – currently only a concept.[6]

Therefore, the changes to the NTR inputs discussed do not change the NTR itself but increase the importance of the NTR and its implementation. Overall, the emphasis for the future is decarbonisation, as identified when developing the NTR, and electrification to achieve decarbonisation. Use of the NTR within EDBs, and other organisations, and progress towards achieving the NTR is then pivotal to electrification to achieve a low carbon future.

3.2 Key issues identified by EDBs

While not directly related to uncertainties and megashifts identified in the NTR, all EDBs identified access to appropriate people with specialist skills and experience related to network transformation as a major challenge for the future, especially EDBs in more remote areas and smaller EDBs. Resourcing the NTR implementation was also a challenge for some EDBs, given that business as usual demands, and the binding need to meet regulations, tended to place activities such as the NTR at a lower priority. This reinforces the benefit of all EDBs working collectively and sharing knowledge, capabilities, resources and expertise.

Some EDBs specifically identified as an issue the resource requirements to run advanced distribution management systems (ADMSs), especially the duplication of these across several larger EDBs. Also identified was the lack of resource to run ADMSs by smaller EDBs, who typically use smaller, less functionally rich, SCADA systems. Most small-mid size EDBs identified systems in general as an issue – these included SCADA systems, asset management systems, geographical information systems, works management systems, and financial management systems. Some EDBs, in their distribution system operator (DSO) plans, have identified how sharing operational systems across EDBs might reduce some overheads.

Several EDBs also identified regulatory uncertainty as a major issue for the future – as identified in the NTR. Examples include: will regulators resolve the long-standing issue of access to smart meter data?;

[6] For example, during an acute supply interruption, an LV network, or section of a distribution network, isolates from the main supply, and switches to the solar and battery storage on that network that can supply all consumers for a short period. This provides a more secure supply to all consumers, including those without solar/batteries, but would presumably require some incentive for those with solar/batteries to 'share' their energy if such a micro-grid means of continuing supply for all were to be relied upon. Further, this is purely an idea at present, and untested in terms of the practicalities of isolating sections of the network and the energy requirements over interruption timeframes. If this is practical, it may prove more economic that building distribution networks that are resilient to all HILP events.

and how might Transpower's demand response (DR) programme and their reaching directly to consumers conflict with EDBs own carefully managed DR? This is discussed further against the 'Demand response framework action'.

Almost all EDBs indicated the challenge of forecasting the future, and the impact of uncertainty in policy and regulation on developing their own plans. For example, whether regulators maintain a relatively 'hands off' approach to how EDBs should behave to meet the future (other than price-quality and information disclosure by the economic regulator, and pricing and Electricity Industry Participation Code (Code) compliance by the market regulator) or will they be more prescriptive? In the absence of anything prescriptive, a variety of approaches is emerging by different EDBs. This highlights the importance of EDBs working together to agree and implement the NTR actions. Other examples of regulatory uncertainty is the lack of resolution of several important findings by the Government's Electricity Price Review dated 21 May 2019 (EPR).

It was clear that EDBs face a variety of issues depending on their network size, location, customer base. For example:

- Rural EDBs in intensive dairying areas with dairy processing are likely to have the challenge of large-scale electrification of process heat. Understanding of new loads and supplying those loads will be a priority.
- EDBs that supply rural areas with industries such as wood processing, aquaculture and horticulture have highly seasonal demands, with some having experienced high growth from PGPs for example.
- Urban EDBs in areas with reticulated gas are likely to have the challenge of small-scale electrification of process heat. Understanding new loads and supplying those loads from existing low voltage (LV) networks will be a priority.
- Rural and urban EDBs in areas with high solar resource and comparatively wealthy consumers are likely to experience higher photovoltaic solar (PV) uptake. Therefore, PV standards and network understanding will be a priority.
- Urban EDBs are more likely to experience high EV uptake and concentration. Supplying energy to those EVs and managing capacity with existing LV networks will be a priority.
- EDBs with networks that supply very remote areas are more likely to need to consider remote area power supplies / micro grids.
- EDBs with networks close to major roading infrastructure are likely to face pressure to supply EV fast charging infrastructure in rural areas, which may require expensive upgrades to their networks. This raises equity issues in terms of the beneficiaries of the upgrades not necessarily being the main consumers within the network who may fund such upgrades.
- EDBs in areas with rapid population growth face ongoing pressure to provide network services and may look for non-network solutions to manage expansion while they shore up transmission and/or sub-transmission capacity to their areas (such as Aurora Energy and Eastland Network). By contrast EDBs in areas with static or declining population and/or industry will likely not need to consider non-network solutions and may have excess capacity and encourage transitioning to electrification (such as the west coast of the South Island). Further, other EDBs, such as Orion and Vector may have ample sub-transmission capacity and are instead focused on LV network support for electrification.

Finally, Vector, Unison and Powerco raised affordability and equity issues related to decarbonisation. While some megashifts might be reducing barriers for consumers to transition to low carbon technologies, it will still be more affordable for some than others. Those who cannot afford to transition may end up subsidising those who can (the current situation with solar for example). Thus, pricing for distribution is crucial, and removal of barriers to achieving cost reflective pricing, such as the Electricity (Low Fixed Charge Tariff Option for Domestic Consumers) Regulations.

4. Use of the NTR by EDBs

Many EDBs have not used the NTR across their businesses, rather they have referenced parts of it in their asset management plans (AMPs).[7] In these cases, they are mostly using the NTR at the engineering and operational level. Two EDBs have referred to the NTR extensively in developing their own roadmaps or network evolution plans.[8] Further to this, one EDB based its DSO roadmap on the NTR.[9] Only a few EDBs have visibility of the NTR at the executive level, and almost no EDB boards have visibility of the NTR. That is, boards are not aware of the NTR and/or have no focus on the NTR and/or are not asking their executives to use the NTR. Since the NTR deals with actions vital to New Zealand's low carbon future, it is concluded that it needs more exposure and use at the executive and board levels. A version of NTR prepared for boards, that also highlights the connection between the NTR programmes and EDBs contributing to a low carbon future through electrification, may be useful in this respect.

The cost of the transition to renewable electricity needs to be managed carefully, and this responsibility falls upon the electricity industry. An example is managing the cost of gaining visibility to the LV network, which attracted a lot of action but is an NTR action only partially met at the 2-year mark. EDBs with access to smart meter power quality data (such as WEL Networks and some SmartCo members) have demonstrated the value of using that data with functions to give visibility of their networks and to improve asset management.

[7] Network Waitaki for example discuss the NTR in their AMP, and show their own interim roadmap in their AMP based on the NTR.

[8] Orion's DSO / functionality and capability roadmap is roughly 60-70% based on the NTR. Aurora Energy's Network Evolution Plan is built on the actions and programmes contained in the NTR, with emphasis on actions to address some of the unique challenges that Aurora Energy faces. Aurora Energy also use the NTR as an industry best practice roadmap to show alignment with it.

[9] Unison and its strategic initiative around the implementation of a least regrets DSO roadmap to ensure that the company establishes critical competencies to manage an uncertain future. This was endorsed by Unison's board and based on the NTR, with key focus areas around LV visibility, future proofing of design standards, flexibility trials, and tailored pricing signals.

5. EDB Progress Towards NTR Implementation

5.1 The main actions being implemented

Prior to the NTR's launch, the ENA's STWG began the process of prioritising actions, and identifying which actions could be undertaken collectively by EDBs, and which needed external support and/or leadership. Three actions were then chosen as priorities to progress, with some other actions progressed by individual EDBs based on their needs. The three actions chosen by the ENA were generally recognised to be pre-requisites for other actions. They are: (1) Access to smart meter data; (2) Low voltage (LV) network monitoring and visibility; and (3) Distributed energy resource (DER) connection standards.

An assessment of all actions shows a small number of leaders in a few actions with good collaboration (including sharing information for other EDBs to follow), a lot of activity in a few actions, with a variety of different approaches, and no progress in some actions. The following sections discuss the actions further, with an analysis and reporting against timeframes in Section 5.3.

Priority actions

LV network monitoring and visibility

The 'LV network monitoring and visibility' action in particular has attracted significant activity by almost all EDBs. Different approaches were taken, with an array of different equipment trialled, and one EDB (Westpower) developing, trialling, and marketing its own device.[10] Several EDBs have since stepped back from activity in this area, realising that they needed to carefully plan any LV network visibility before proceeding (after inundation with data for example). Three EDBs are approaching LV network visibility by using EV and PV hosting capacity to prioritise placement of monitors.[11] In turn, this is reducing the cost of rollout since fewer monitors are required. This is because EV and PV hosting capacity analysis identifies the LV networks most likely to experience congestion first, and thereby allows an EDB to prioritise which LV networks (transformers and/or points of supply) to monitor.[12] A number of EDBs have accessed advanced metering infrastructure (AMI or smart meter) power quality and consumption data rather than purchase and install separate equipment (LV monitors).[13] Interviews highlighted a dichotomy between EDBs with AMI power quality data access and advanced applications built using that data to enhance their asset management, and EDBs who do not have such access.[14]

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[10] ENA Case Study, April 2021, Westpower's low voltage monitoring technology trial, https://www.ena.org.nz/resources/publications/document/827

[11] Orion (as identified in the DSO roadmap), Aurora Energy (as identified in its Network Evolution Plan), and Nelson Electricity.

[12] Congestion determined by hosting capacity being either overloading of a transformer, conductor, or voltage moving outside the limits set in the Electricity (Safety) Regulations.

[13] SmartCo members who own smart meters.

[14] Three examples of applications using AMI power quality and consumption data that enhance asset management include: (1) use of smart meter voltage recordings to identify faulty neutrals, and thereby more efficiently dispatch maintenance crews to repair them – this also has important implications for improving safety; (2) identifying where adjustments to distribution transformer tap changes from the default settings can be made to the default 'boost' tap settings to improve voltage management in response to high concentrations of PV in local networks, and thereby avoid network upgrades and/or allow higher penetration of PV; and (3) outage identification and narrowing in on fault locations.

The ENA has commissioned a report that provides guidance on LV monitoring and business case development.[15, 16]

Access to smart meter data

Smart meter (or AMI) data access was identified early on by the ENA as one of its three priorities, with the ENA recently renewing its efforts for EDBs to gain access to AMI consumption and power quality data. The ENA has made some progress in working with metering equipment providers (MEPs) and EDBs to achieve better access to smart meter consumption data in particular, but there is still progress to be made, requiring further collaboration between multiple parties in the industry. In terms of the 'Access to smart meter data' milestone set in the NTR at the two-year mark, it is concluded that this has been met. Those SmartCo EDBs, WEL Networks, and Counties Power with smart meter ownership and consumption data access have met the NTR's 2-5 milestone. However, if all EDBs are to meet the 2-5 year milestone efforts to gain AMI data access need to continue at a pace for the benefit of all EDBs, their consumers, and ultimately to enable EDBs to better prepare for the low carbon future. The Government's EPR gave good reasons why access to smart meter data by distributors was important in its Recommendation E3. The dichotomy referred to above shows how accurate the EPR's reasons are, and how important it is that smart meter data be accessed by EDBs.

The experience from the 'LV monitoring and visibility action' generally highlights the importance of proceeding more carefully, and in collaboration with other EDBs rather than all EDBs focusing on action in the same area. There is no doubt that focus is needed on the NTR actions – that is why it was developed. Paradoxically however, to achieve genuine progress it is sometimes necessary to slow down and take a well-considered approach. This is as opposed to all EDBs doing the same actions but all making the same mistakes and not learning from others.

DER connection standards

Of the three actions prioritised by the ENA, the 'DER connection standards' has not made as much progress. A large part of the reason for this is its reliance on other parties, such as regulators. The ENA's assessment of small-scale distributed generation information packs and application processes shows that EDBs generally cite the correct standards and follow the process prescribed by the Code, with some needing updating (to update standards and Code references). However, anecdotal information from some solar installers indicates barriers around processes and lack of commonality between EDBs, which the ENA is exploring further. Two distributors (Aurora Energy and Waipa Networks) are implementing the interim 'EEA Guide for Connection of Inverter-Based Small-Scale Distributed Generation', with Unison considering it. This was developed to bring about standardisation between EDBs. However, adoption of this has been hampered by: (1) the need to change the Electricity Industry Participation Code, which has still not been changed 4 ½ years after the change was requested by the EEA; and (2) citing of the 2005 inverter standard in the Electricity (Safety) Regulations, despite new Australian/New Zealand standards being released in 2015/2016 and now superseded by a 2020 standard. It is concluded that there is a suitable standard available for PV, but

[15] David Reeve and Ben Barton, Sapere, October 2020, Low Voltage Monitoring – Primer and Guideline, https://www.ena.org.nz/resources/publications/document/805

[16] David Reeve, Gary Blick and Ben Barton, Sapere, November 2020, Business Case for Investment in Low Voltage Network Monitoring – Prepared for the Electricity Networks Association, https://www.ena.org.nz/resources/publications/document/806

that it requires changes by regulators to enable it to be fully implemented, and that EDBs need to implement it consistently. Following the practice developed by the leading EDBs implementing it would be beneficial in gaining a nationally consistent implementation. This needs to happen imminently to ensure timing meets that set out in the NTR.

Another distributor (Wellington Electricity) is leading an 'EV Connect' project that aims to gain insights and identify options to continue to equitably support EV-owing and non-EV-owning customers in their network. Ultimately this will lead to a roadmap on how to further enable the uptake and accommodation of increased EVs and EV charging infrastructure in New Zealand.[17] Stakeholder feedback indicates support for EV standards such as protocols for EV technologies and a national EV and EV charger data registry. Little has happened in the area of EV connection standards to date and given the decarbonisation benefits of EVs and their increasing uptake, this requires further progress.

Other actions

The only actions addressed below are those where there has been activity and some progress made.

Understand new loads

The 'Understand new loads' action within the 'Consumer Insights' programme is an example, where the electrification of process heat has taken on more prominence. Many EDBs are actively tracking the potential for customers in their networks to convert and the implications of this. Transpower, EECA and South Island EDBs have been undertaking a decarbonisation stocktake to quantify potential electrification and engage with customers about their plans.

Some EDBs are actively planning for the process heat transition to electricity where customers have indicated plans to electrify heating. However, some of those EDBs actively planning for the transition to electric heating have been caught between the customer's process heat conversion timeframes being quite short and the EDB being able to meet those, but Transpower's timeframes to upgrade the associated GXP being slower. The concern is that the opportunity is then missed.

Other EDBs are now actively assessing the impact of residential customers moving from piped gas to electric heating (Powerco for example has identified the potential for electricity load growth, including peak growth, as consumers transition from small-scale gas heating applications to electric heating).

Some EDBs are also investing in understanding EV uptake and charging behaviour of consumers, such as the Vector EV Smart Charging Trial. [18]

Understand DER deployment and Understand new Distributed Generation (DG)

These relate to EV connection (where, as discussed above, all EDBs have the challenge of not knowing the location of mainly domestic EV chargers) and PV connection. Wellington Electricity has raised the challenge of not knowing predominantly residential EV charger locations via its EV Connect Project.

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[17] EV Connect – Customer Benefits and Secure Networks through Industry Collaboration. Stakeholder Consultation Document, 7 October 2020 and EV Connect – Stakeholder Consultation Responses, March 2021.
[18] ENA Case Study, April 2021, Vector's EV Smart Charging Trial, https://www.ena.org.nz/resources/publications/document/826.

They have recently collated feedback and are developing a roadmap, aligned with and contributing to this NTR.

Third parties provide DERs and DR for network support and Develop contracting for network support capabilities

One EDB (Aurora Energy) has sought third party support in a part of their network and has contracted that party.[19] In doing so Aurora Energy has made headway with the Open Network Framework Programme 'third parties provide DERs and DR for network support' NTR action. This region has been subject to rapid housing development and demand growth, but the Covid-19 pandemic cast doubt over future growth. Thus, a non-network solution, providing incremental capacity growth, was even more attractive while the post Covid-19 recovery and sub-transmission solutions are assessed more fully. Substantial knowledge has been developed from this experience and is shared via a case study. This contributes to the 'develop contracting for network support capabilities' in the Build and Adapt EDB Capability programme – also demonstrating the interconnected nature of the NTR.

The Aurora Energy example is useful in establishing best practice for a number of reasons: (1) it defined non-network support (which it now terms flexibility) as neither belonging to Aurora Energy nor being operated by Aurora Energy; (2) allowing suppliers to participate in other markets; and (3) not prescribing a solution, and instead presenting Aurora Energy's carefully considered capacity support (flexibility) requirements to the market and asking the market to propose solutions. This third point led to a solution Aurora Energy had not previously considered and engaged the 'many minds' principle to find a solution. Allowing suppliers to participate in other markets was important in achieving an economic solution (flexibility providers can value-stack) but did require Aurora Energy to consider how this should be coordinated, contributing to the 'Demand response framework' action.

In searching for non-network support, Aurora Energy has developed a comprehensive set of requirements and undertaken a contestable procurement which revealed a range of solutions. Based on this experience, Aurora Energy is now developing their processes further for on-going contestable procurement of network support. This contributes to the Build and Adapt EDB Capacity NTR Programme action 'Develop contracting for network support capabilities'.

Demand response framework

The IPAG has been studying this with Transpower and will release its recommendations in the middle of 2021.

Cost reflective pricing and regulation

Every EDB has begun implementation of cost reflective pricing in response to the Electricity Authority's cost reflective pricing principles and scorecard assessment and publishing . This has generally been prioritised over NTR actions.

Network understanding

A number of EDBs have undertaken hosting capacity studies over their networks to understand their ability to host PV and EVs. Some have studied sub-sets of their networks, while others have considered

[19] ENA Case Study, April 2021, Aurora's Upper Clutha Project, https://www.ena.org.nz/resources/publications/document/825

every LV network. This has been combined with LV monitoring by some to minimise the cost of LV monitor rollout.

Off grid power supplies

Three EDBs in particular (PowerNet, Powerco, and Marlborough Lines) have been trialling remote area power supplies (RAPS), due to very remote parts of their networks.[20] They have gained many insights and experience from this, particularly around the regulations, approaching customers, and managing customers through the transition. Vector has established four micro-grids in remote areas of its network to reduce the cost of supplying those areas but provide adequate capacity and energy.

5.2 Prioritisation and pace by individual EDBs and as a whole

During the process of interviewing EDBs it was clear that EDBs face a variety of issues depending on their location, community demographic, local industry, and inherited management decisions – set out in Section 3.2. It is therefore expected that EDBs will come to the various NTR actions at different times when they have genuine business needs.

This highlights that the NTR is not a linear set of actions for every EDB to follow in the same order. Actions are interconnected, with some more relevant to some EDBs than others based on their unique circumstances. EDBs need to choose actions where there is a driving, genuine business need. While these may involve trials, it is unwise to conduct trials in the purest sense without a business imperative behind them. Rather they should focus on making progress where it is needed most.

If EDBs all try to implement the same action at once, there is a high probability that it will slow down progress. Conversely, if EDBs focus on areas where they have a genuine business need, and share knowledge and insights from this, there is a higher probability that real progress will be made.

Regarding pace of implementation of the roadmap as a whole, when it was originally released in April 2019 the perception by some was that the 2-year timeframes were not ambitious enough. This was given the view that changes, such as PV and EV uptake would only accelerate. While the STWG authors were aware of this tension, they took care to not over challenge EDBs – which might be counterproductive. In the two years since publishing the NTR, PV uptake has continued at a roughly linear rate. EV uptake has also continued at a roughly linear rate (notwithstanding disruption from the Covid-19 pandemic) to a total light-vehicle plug in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV) fleet of 25,887 at March 2021.[21] This is well short of the goal of 64,000 EVs on New Zealand roads by the end of 2021. Balancing this is the on-going increase of on-board BEV charger size, now typically greater than 6 kW.[22]

These numbers would indicate that the pace of the NTR in the 2-year goals may have been the right balance. However, the challenges for the future, as set out by the Climate Change in its 31 January

[20] PowerNet have implemented one and are actively planning more, Powerco have implemented several, and Marlborough Lines have a proposal to implement a site and have identified several others candidate sites.
[21] Figures from Te Manatū Waka Ministry of Transport, Monthly electric and hybrid light vehicle registrations. The year-on-year percentage increase declined each year from 2018.
[22] The Gen 1 leaf and Gen 2 leaf have 3.6 kW on-board chargers (a 16 Amp circuit), whereas the new leaf has a 6.6 kW on board charger, the Hyundai Kona has a 7.2 kW on-board charger (a 32 Amp circuit), the Renault Zoe has a 7.4 kW on-board charger, and the Tesla Model 3 and BMW i3 have 11 kW on-board chargers.

2021 draft advice to the Government, indicate the importance of reaching the 2-5-year goals set out in the original NTR. Given that several of the 2-year goals have still not been met means reaching the 2-5-year goals will be very challenging. Further, a number of these goals rely on initiatives from other agencies.

Possibly the most concerning action not met is the development of 'DER connection standards', which requires initiatives and input from the whole industry. The 2-5-year goal is that all EDBs are regularly using the connection standards and codes for DERs developed in the 2-year goal. However, no such standards exist yet. A proliferation of DERs not connected to a standard will reduce EDBs' ability to have such devices contribute to managing network peaks, and potentially give rise to new peaks and therefore require LV network upgrades. Ultimately this could be at greater cost to consumers. At the very least it would be prudent to introduce a requirement that, for example, requires EV chargers above 10 Amps to be smart chargers, with functionality to be defined by EDBs and standard across EDBs. Such a requirement is in line with the Vector EV smart charging trial conclusions. This requirement would start to embed functionality in network that would enable distributors to, in some way, manage peak loading on LV networks, and thereby avoid additional expenditure on LV networks in the future as the EV uptake rate increases.

Progress against the 10-year milestone is not assessed in this report, given the focus on the 2-year and 2-5-year milestones. It is considered that 10-year milestones are all aligned with a future of increased renewable electricity delivery to reduce greenhouse gas emissions. As the 10-year milestones are stated in the NTR, they are significant changes from when the NTR was written, and from now. Striving to meet the 2-5-year goals for all actions will therefore be crucial in meeting all 10-year milestones, and crucial to achieving a low carbon future. Progress towards meeting these milestones could be enhanced through increased collective action on the part of EDBs, and with other government agencies also both contributing to and being aligned with the Network Transformation Roadmap. Both individual EDB's boards and the ENA board have a constructive role to play in ensuring progress is maintained, with the ENA able to play a critical coordinating role.

5.3 Summary of NTR progress by action and milestone

The following tables assess progress towards meeting the 2-year milestones set out in the NTR. For this reason, the 2-year milestones are repeated here, and the four-tier classification set out below is used. The tables also give a commentary on each action, including on the 2-year status and what is required to meet the 2-5-year NTR milestone. Hence, the 2-5-year NTR milestone is also repeated in the tables, except for Monitor Uncertainties and Cost Reflective Pricing and Regulation.

2-year Status	**Meaning with regard to the 2-year NTR Milestone**
Met	The 2-year NTR milestone has been met in full.
Partially met	The 2-year NTR milestone has only been partially met.
Minor/partial progress	The 2-year NTR milestone has not been met, despite activity having taken place.
Action required	The 2-year NTR milestone has not been met, nor has any activity aimed at meeting the milestone taken place.

Table 1: Consumer Insights programme actions versus time and status.

Action	2 years	2-5 years	2-year Status	Commentary
Access to smart meter data	Addressing barriers to access half-hourly consumption data	Provision of half-hourly consumption data to understand emerging Behaviours	Met	The ENA has provided information to EDBs on how to work with the DDA and has a renewed effort to work with MEPs. In this respect the 2-year milestone has been met. Only SmartCo members and EDBs such as WEL Networks and Counties Power who own meters have full access to consumption data, whereas other EDBs do not. EDBs such as some SmartCo EDBs and WEL Networks with good access to smart meter power quality data have gained substantial improvements to asset management and operational cost reductions (for example: reducing 'truck rolls' to deal with power quality issues, proactively addressing potential safety issues, and optimising PV capacity in LV networks). These EDBs have met the NTR's 2-5 milestone. This is also closely related to the 'LV network monitoring & visibility' action (Table 6). If all EDBs are to meet the 2-5 year milestone, efforts to gain AMI data access need to continue at a pace for the benefit of all EDBs, their consumers, and ultimately to enable EDBs to better prepare for the low carbon future. Gaining this access requires work across many industry groups.
Understand DER deployment	Develop requirements to access data for all DER Types	Data for all DER types being gathered and analysed	Partially met	While PV and exporting battery deployment is known via the Code application process, EV locations are still challenging - every EDB is aware of and grappling with the challenge of not knowing EV locations. Wellington Electricity has raised this via its EV Connect project, from which it has recently collated feedback and is developing a roadmap, aligned with and contributing to this NTR. In this respect the two-year plan is only partially met.

Action	2 years	2-5 years	2-year Status	Commentary
Understand new loads	EDBs connecting new load types or converted loads	EDBs are able to plan their network to be able to connect future new loads	Partially met	Many EDBs are actively tracking the potential for customers in their networks to electrify process heat to and the implications of this, including the Transpower, EECA and South Island EDB stocktake initiative. Some EDBs are actively planning for it where customers have indicated plans to electrify heating. Differing timeframes of shorter customer process heat conversion versus longer Transpower GXP upgrade timeframes is leading to challenges. Since no major heating applications have connected yet the 2-year milestone is only partially met. EDBs appear to be on track to meet the 2-5 year milestone, however this relies on contributions from other parties such as Transpower. Other EDBs, such as Powerco, are now actively assessing the impact of residential customers moving from piped gas to electric heating. Some EDBs are also investing in understanding EV uptake and charging behaviour of consumers, such as the Vector EV Smart Charging Trial, and Westpower conducting a survey of consumers. The Wellington Electricity EV Connect project has raised, for all EDBs, the challenge on not knowing the location of primarily domestic EV chargers. Potential for other forms of transport electrification is also being investigated (for example ferry electrification by Wellington Electricity and Marlborough Lines). State highway charger location is also understood by EDBs, but with challenges over the need for network upgrades to service some very remote areas (such as Network Tasman's network) and how those would be funded given the beneficiaries are not necessarily the consumers in the EDBs area. One EDB (Waipa Networks) has undertaken trials with home energy management systems (HEMS) to understand consumer engagement with HEMS.

Action	2 years	2-5 years	2-year Status	Commentary
Understand new DG	Develop and trial consistent DG connection approach and connection and operation standard for small- and large-scale DG. Designed to collate information on new small- and large-scale DG	Implemented and practicing DG connection approach and connection and operation standards for small- and large-scale DG. Potential DG connections are understood	Minor/partial progress	The Code provides a process for understanding the location of new DG, because DG must apply to connect to an EDBs network. However, understanding likely connections is still a challenge. Two EDBs in particular (Marlborough Lines and Top Energy) are facing substantial challenges with very large-scale solar (greater than 1 MW). See also Standardise Technical Arrangements where a standard small-scale connection process is discussed. Since a standard connection process has not been agreed, the 2-year milestone of this action is considered to have not been met.

Table 2: Monitor Uncertainties and Adjust Roadmap programme.

Action	2 years	2-year Status	Commentary
Monitor uncertainties	Monitor uncertainties, megashifts, and consumer behaviours and periodically feed into roadmap programmes where necessary (where there are significant changes in uncertainties that will affect one or more roadmap programmes).	Met	Part of the purpose of this review is to assess and update uncertainties and megashifts. It is concluded that the inputs to the NTR are still valid, with some uncertainties moving to more certain megashifts, and some megashifts taking on a greater prominence. Overall, there are no changes required to the NTR, but the adjustments to NTR's inputs underscore the importance of the NTR and its implementation.

Table 3: Open Network Framework programme actions versus time and status.

Action	2 years	2-5 years	2-year Status	Commentary
Enable distribution network trading	Consulting on access requirements to the distribution network for delivery of energy from alternative sources and trading of energy and capacity. This will involve engaging with regulators and their consultations	Distribution networks start to open up as a stable, effective platform for delivery of energy and trading of alternative energy from producer to consumer	Minor/partial progress	No substantive progress on this action. This requires a cross-industry effort. The IPAG's December 2019 'Advice on reducing barriers to customer access to multiple electricity services' covered many of the barriers to this and gave recommendations to addressing them. That IPAG work also related to numerous other NTR actions, which are essentially precursors to this action, such as the need for EDBs to have a *standard* DER connection standard, standard pricing principles, and access to smart meter data. It also identified the need for Code changes. At the current rate the 2-5 year milestone will not be met, meaning consumers will miss out on new services. While this does require EDB input, it hinges on cross-industry effort, including Code changes.
Third parties provide DERs and DR for network support	Trialling DERs in certain constrained areas for network support	Process and systems in place to consider DERs and DR for network support	Partially met	One EDB, Aurora Energy, has sought third party support and has contracted that party. This may allow processes and systems to be agreed and shared. Other EDBs (such as Powerco) are now going to market for solutions.
Demand response framework	Challenges of multiple users of demand response understood, transition plan under development	Trialling multiple users of demand response; incorporating home and business automation; developing experience into standards/codes	Minor/partial progress	Aurora Energy, as part of the above action, is also dealing with making DERs available for other uses, and has proposed solutions for managing access. The IPAG has been studying demand response coordination with Transpower, partially in an effort to allay concerns that Transpower's ownership of a DERMS will give them first access to DERs and consumers. The IPAG's report is due in mid-2021. Since no resolution has yet been achieved the two-year goal of this action is considered to have not been met.

Table 4: Cost Reflective Pricing and Regulation programme actions versus time and status.

Action	Commentary
Cost reflective pricing	All EDBs are actively pursuing cost reflective pricing in response to the Electricity Authority's cost reflective pricing principles and scorecard assessment and publishing. Since the ENA's Distribution Pricing Working Group is leading EDB cross-industry efforts to reform pricing, reporting on progress to milestones remains with that working group.

Table 5: Standardise Technical Arrangements programme actions versus time and status.

Action	2 years	2-5 years	2-year Status	Commentary
DER Connection Standards	Developing and implementing new connection standards and frameworks/ codes derived from this roadmap for DERs	All EDBs regularly use 'the' connection standards and codes for DERs	Minor/partial progress	There has been no progress in developing DER connection standards. However, Aurora Energy is implementing the EEA Guide for Connection of Small-Scale Inverter-Based Distributed Generation in full, with Waipa Networks also implementing it and Unison considering it. In this respect a potential standard for small-scale DG does exist but requires EDBs to agree that it is a suitable standard / modify it to a suitable standard and needs to be implemented consistently and in full without variation. Aurora Energy's implementation has been frustrated by the Code not being changed to include hosting capacity (as requested by the EEA in December 2016), nor the Electricity (Safety) Regulations being updated to include the latest inverter standards (published in 2015/2016). While the EEA guide is a potentially suitable standard for DG, since there has been no acknowledgement of this as a standard, nor any progress towards developing any other standard, this action is considered not met. This means that substantial work and agreement between EDBs is required to implement DG and EV standards to meet the 2-5-year milestone.
Appliance and DER equipment standards	Distribution industry group set up to assess and contribute to international equipment standards to ensure they are appropriate to NZ	Standards appropriate to NZ, with test houses to approve equipment as compliant before being allowed on the network. Consistency across all EDBs	Action required	Since there is no distribution industry group set up it is considered that this action made no progress. However, EECA may separately have made progress on equipment standards.

Action	2 years	2-5 years	2-year Status	Commentary
Network engineering	Investigate how best to achieve consistent network engineering	Trialling consistent network engineering across EDBs	Action required	There are no known initiatives across all EDBs aimed at gaining consistent network engineering approaches. Thus, it is considered that no progress has been made to achieving this milestone. However, it is noted that some EDBs are adopting the design standards of other EDBs (for example, Top Energy are using Powerco standards). This has challenges around historic equipment and design philosophies which need to be incorporated into those standards. Other EDBs also have carefully considered standards for LV network design to support contractor development of LV reticulation by developers which may not necessarily align with other EDB standards. Significant effort would be required to bring about such alignment.
Cyber security and autonomous DERs	Research appropriate cyber security standards and standards for autonomous DERs	Research and trial implementation of new cyber security standards and contribute to autonomous DER standards	Action required	While some EDBs are very focused on cyber security (Vector for example) this has been at an enterprise and enterprise systems level. This action refers specifically to autonomous DERs. The market appears to be some way off autonomous DERs, but this action is important in terms of identifying and agreeing standards prior to large-scale uptake. There is a high risk that the 2-5-year milestone will also not be met.

Table 6: Network Operation, Monitoring, and Stability programme actions versus time and status.

Action	2 years	2-5 years	2-year Status	Commentary
LV network monitoring & visibility	Actively rolling out LV monitoring systems with data management systems. Provision of available AMI operational data to assist network management	Improve quality of LV monitored data and AMI data. New indices (data types) added. E.g. move from just voltage levels to energy and power flows, and eventually other voltage quality metrics and harmonics	Partially met	As discussed almost all EDBs have installed LV monitors (mostly as trials). Only a few EDBs have a plan for use of their LV monitoring data in the future; all EDBs were clear that the data was to be used to understand power quality (such as voltage levels) on the LV network but only a few had developed plans or roadmaps for where this data would lead. For example, Orion's goal is to connect real-time LV monitors with the 'ADMS Live' module for operations and use in non-real-time planning (to achieve more efficient operation by field crew for example), and Aurora Energy's Network Evolution Plan identified the use of hosting capacity combined with LV monitoring information to identify where non-network support might be needed, eventually leading to automatic calling for non-network support (ultimately via a price signal). An innovative way of gathering LV network power quality information emerged from some EDBs (such as Electra and Wellington Electricity) who were working with Telcos, whose base stations and street side cabinets are capable of measuring power quality. An obvious way to achieve LV network monitoring and visibility is via smart meter data, as discussed earlier. Vector make the point that the regulatory model is more supportive of installing LV monitor hardware than it is of using smart meters as a service, which ultimately does not benefit the consumer. Since not all EDBs have well developed data management systems for LV monitors *and* since smart meter power quality information is still not available to other EDBs the 2-year milestone is considered partially met. To meet the 2-5-year goal will require considerable improvement in systems, resolving access to smart meter power quality data, and a clear plan for use of LV monitoring data to improve the distribution service.

Action	2 years	2-5 years	2-year Status	Commentary
Network stability	Researching the implications of numerous autonomous DERs and methods of control to ensure stability and avoid new load peaks	Trialling control systems for numerous autonomous DERs to ensure stability and avoid new load peaks	Partially met	EDBs are aware of the possibility of new peaks occurring from EV charging (such as identified by Vector in its EV smart charging trial for EVs on fixed charging schedules). Wide ranging trials of other autonomous DERs have yet to be undertaken. Some EDBs have identified the need to contribute to this understanding in their roadmaps / plans. For these reasons, the 2-year milestone is considered partially met. To meet the 2-5-year milestone will require actual trials and coordination between EDBs. There is also a philosophical divide occurring between those EDBs who believe that direct control of DERs is required versus those who believe that they can and should operate autonomously, in response to the greatest value. The IPAG's current work with Transpower on DR may shed some light on this.
Provision of network information	Investigating and trialling provision of network information to operator(s)	Provision of available network information to operator(s)	Partially met	Some EDBs such as Orion and some SmartCo members are investigating providing LV network information to operators for real-time system management and non-real-time planning information. Orion have a roadmap showing where their LV network understanding, monitoring from LV monitors (with placement prioritised by hosting capacity), combined with advanced distribution management system functions will lead to. Because a few EDBs are actively working in this area the action's 2-year milestone is considered partially met. To reach the 2-5-year milestone will require much more activity by all EDBs.

Table 7: Build and Adapt EDB Capability programme actions versus time and status.

Action	2 years	2-5 years	2-year Status	Commentary
Network understanding	Starting to understand LV network capabilities, performance and constraints	Most EDBs are starting to collect extensive data about their LV networks and their Operation	Met	The 'LV network monitoring and visibility' action discusses three EDBs using hosting capacity to prioritise the rollout of LV monitors (and thereby minimise the cost of this). Network understanding refers to better understanding of LV network technical parameters to be able to undertake accurate assessment of hosting capacity (rather than approximate and sometimes very inaccurate methods such as just assuming transformer capacity sets the hosting capacity or using models that do not consider network topology.) This action is considered met, although to meet the 2-5-year milestone will require a lot more activity in understanding networks.
Develop contracting for network support capabilities to support Action 2 of the Open Network Framework	Trial framing of EDBs requirements for network support and introduce contestable procurement to discover a range of solutions	Develop the necessary processes and systems for contestable procurement of network support from trial experience	Met	Through its non-network project Aurora Energy developed a comprehensive set of requirements and undertaken a contestable procurement which revealed a range of solutions. Based on this experience, Aurora is now developing the process further for on-going contestable procurement of network support. For this reason, this action is considered met. To meet the 2–5-year milestone there is a substantial effort required to standardise this amongst all EDBs.
Asset Management practice	EDB industry exploring improved asset management practices and consistent frameworks	Improving asset management practice across most EDBs, with regular information sharing	Minor/partial progress	While each EDB has a substantial focus on asset management and practices, there has been no consistent framework adopted, other than a few adopting ISO 55000. While the EEA is active in asset management, from interviews there appears to be no collective effort by EDBs towards standard asset management practice.

Action	2 years	2-5 years	2-year Status	Commentary
Off grid power supplies	Trial remote area power supplies	Implement remote area power supplies in areas where it is less costly than traditional networks	Met	Three EDBs in particular have been trialling RAPS (PowerNet have implemented a site, Poweco have implemented several sites, and Marlborough Lines have a proposal to implement a site) and have gained considerable insight and experience from this, particularly around the regulations, approaching customers, dealing with local terrain, topology, and site access, and managing customers through the transition. Vector has built four micro-grids that maintain supply using batteries in areas subject to supply interruption, predominantly due to weather events. Hence this action's 2-year milestone is considered met, but there is still a lot of work required to meet the 2-5-year milestone.

6. Appendix One – EDB Interview Questions

6.1 General Background

1. At what level has the NTR been used (board, Senior Management, Engineering?)
    a. What might improve its usefulness at each level?
2. Has your organisation developed its own NTR or Network Evolution Plan?
    a. If so, to what extent was the ENA's NTR used in developing that (e.g. did you consider the same assumptions, scenarios, and/or actions/programmes)? Is there any other input you have used?
    b. What is the status of implementation of your organisation's plan?
3. What are the top three issues/challenges for your organisation?

6.2 NTR Assumptions and Scenarios

4. The NTR gave a number of uncertainties and mega-shifts as its inputs. Do you feel there have been any changes to these (increased relevance, no longer relevant, new ones)? FYI they are listed below (* = additional to the Australian Future Grid Forum):

Uncertainties	Megashifts	Consumer Behaviour
Gas price and international methanol price	Low cost storage	Active-passive spectrum of consumer behaviour
Carbon price	Low demand for central electricity	*Actions not always consistent with expressed values
*Development of renewable energy-dense fuels	*Consumer interest in PV and PV cost reductions	
*Collective electricity industry contribution to greenhouse gas reduction	Greenhouse gas reduction	
Demand growth for centrally-generated electricity	*Demand for greater reliability and services from the grid	
Regulation	*Non-traditional third-party management of consumer needs	
Central generation costs	*Consumer distrust of electricity utilities	
*Development of technology for consumer participation	*EV uptake	
*Autonomous EV deployment		
*Economic management of renewable variability		
*EV uptake		

5. Do you believe any of the scenarios (Set and Forget, Rise of the Prosumer, Backup Grid, and Leaving the Grid) have changed? The scenarios are outlined on Page 9 of the NTR Report (https://www.ena.org.nz/dmsdocument/483).
6. Underpinning all NTR scenarios and the NTR itself was a move to a low carbon future. Is this still relevant?
7. Are there any other factors or changes in the industry that are likely to affect EDBs in the future? If so what and how?

6.3 Specific NTR Projects

8. Has your organisation used or adopted any aspect of the NTR (e.g. are there actions from the NTR that you have implemented or placed particular importance on)? FYI the actions and programmes are listed below.
    a. Explore each in more detail, including:
        i. why this particular programme (its relevance to your business);
        ii. status on implementation of it;
        iii. any barriers to implementing it;
        iv. useful information that can be shared to assist other EDBs;
        v. your expected actions in the future with it; and
        vi. benefits gained from implementing it, if relevant.
9. Why have you chosen to focus on these particular actions or projects?
10. Are there any other aspects of the NTR that we should consider in this progress report?

	Action	
1.1	Access to smart meter data	1. Consumer insights
1.2	Understand DER deployment	
1.3	Understand new loads	
1.4	Understand new DG	
2.1	Monitor uncertainties	2. Monitor uncertainties
3.1	Enable Dx network trading	3. Open network framework
3.2	3rd parties provide DERs and DR for NW sup	
3.3	DR framework	
4	Cost reflective pricing and regulation	4. Cost reflective pricing and regulation
5.1	DER Connection Standards	5. Standardise technical arrangements
5.2	Appliance and DER equipment standards	
5.3	Network engineering	
5.4	Cyber security and autonomous DERs	
6.1	LV network monitoring & visibility	6. Network operation, monitoring, and stability
6.2	Network stability	
6.3	Provision of network information	
7.1	Network understanding	7. Build and adapt EDB capability
7.2	Develop contracting for NW support cap.	
7.3	Asset management practice	
7.4	Off grid power supplies	

6.4 Other projects not necessarily in the NTR?

11. If you have other projects that may not fit within the above NTR actions, but are related to network transformation and/or preparing your company for the future, we are interested in learning more about those.